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Comparing high-end and low-end early adopters of battery electric vehicles

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Battery electric vehicle adoption research has been on going for two decades. The majority of data gathered thus far is taken from studies that sample members of the general population and not actual adopters of the vehicles. This paper presents findings from a study involving 340 adopters of battery electric vehicles. The data is used to corroborate some existing assumptions made about early adopters. The contribution of this paper, however, is the distinction between two groups of adopters. These are high-end adopters and low-end adopters. It is found that each group has a different socio-economic profile and there are also some psychographic differences. Further they have different opinions of their vehicles with high-end adopters viewing their vehicles more preferentially. The future purchase intentions of each group are explored and it is found that high-end adopters are more likely to continue with ownership of battery electric vehicles in subsequent purchases. Finally reasons for this are explored by comparing each adopter group's opinions of their vehicles to their future purchase intentions. From this is it suggested that time to refuel and range for low-end battery electric vehicles should be improved in order to increase chances of drivers continuing with BEV ownership.

1. Introduction

The automotive sector is moving towards a transition from primarily petrol and diesel fuelled internal combustion engine vehicles (ICEVs) to more sustainable plug-in hybrid vehicles (PHEVs) and battery electric vehicles (BEVs) (Poullikkas, 2015; Sierzchula et al., 2014). BEVs are considered to be the most beneficial of these due to them having zero emissions, high efficiencies and having the potential to be fuelled entirely off renewable electricity (Helveston et al., 2014; Nordelöf et al., 2014; Offer et al., 2011; Schneidereit et al., 2015; Sierzchula et al., 2014; Thomas, 2009). In order for these vehicles to have the greatest effect on improving urban air quality, reducing carbon emissions and reducing energy use they need to be deployed in larger numbers than they are at present. Therefore a greater understanding of how to increase market penetration needs to be developed. It is possible to achieve this through understanding early adopters of BEVs (Schuitema et al., 2013). This will lead to an understanding of where the market for these vehicles lies and also how to ensure that BEVs appeal to these markets. This will inform policy makers and automotive OEMs on how best to grow the market of BEVs such that the societal benefits can be maximised. At present the market is at a very early stage of development with recent market introductions beginning in 2008–2010. Since then the BEV market has developed and grown both in terms of the numbers of

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vehicles available and the numbers being adopted by consumers. At the end of 2014 there were 665,000 BEVs deployed globally, with the top three markets for BEVs being the US (39%), Japan (16%) and China (12%). The market shares of BEVs in these nations are still low and of these only in the US did BEVs achieve a 1% share of 2014 vehicle sales. The highest market shares in terms of yearly sales are in Norway (12.5%) and the Netherlands (4%) (IEA, 2015). These numbers are promising for an early market but are still insignificant compared to the entire transportation market (Rezvani et al., 2015), clearly greater effort is needed in order to increase these numbers.

A significant change in the landscape of the BEV market occurred in 2012 with the introduction of the Tesla Model S. Prior to this all BEVs on the market where what are considered here to be low-end electric vehicles (Hardman et al., 2014, 2013). These vehicles all have prices of $30–40,000 and ranges of <100 miles (Nissan, 2014). The Tesla Model S, which is considered here as a high-end BEV costs $70,000–105,000 and has a range of 270 miles (Tesla Motors Inc, 2014). Therefore the introduction of this vehicle resulted in a new market segment being created. So far, within the literature, adopters of BEVs have been considered as one homogenous group, with studies overlooking potential differences between high and low-end adopters. Existing studies have investigated barriers to the adoption of electric vehicles (Browne et al., 2012; Egbue and Long, 2012), how experience of an BEV relates to intention to adopt (Bühler et al., 2014; Franke et al., 2012; Graham-Rowe et al., 2012), purchase intentions and preferences of potential adopters (Chorus et al., 2013; Koetse and Hoen, 2014; Sierzchula et al., 2014) along with studies that identify potential early adopters of BEVs (Campbell et al., 2012; Plötz et al., 2014). Further literature investigates people with first hand experience with a BEV, such as (Lane et al., 2014). An insightful study by Caperello et al. (2014) used workshops involving BEV adopters and ICEV drivers in order to understand how to bridge the gap between early and later adopters.

At the beginning of this study it was hypothesised that the two groups of adopters would be different. This is due to the significant differences in the price and features of the vehicles (Table 1). It was believed that adopters would have different socio-economic and psychographic profiles. It was also believed that they would have differing opinions of their vehicles owing to their different attributes and features, which can be seen in Table 1. Further to this, an understanding of future purchase intentions of actual BEV adopters was needed. This should be in relation to the attributes of each vehicle in order to understand what circumstances lead to a high likelihood of continued adoption. Consumer intent to purchase a BEV has been investigated in some detail within the literature (Bühler et al., 2014; Chorus et al., 2013; Koetse and Hoen, 2014; Sierzchula et al., 2014). These studies investigate the intent of ICEV drivers to adopt a BEV and not BEV driver's future intention to continue with BEV ownership. In order for the market to grow early adopters will be required to remain users of BEVs and not abandon the technology. Repeat purchases are more important than initial purchases in maintaining long term growth of any new product (Crawford and Benedetto, 2011; Rogers, 2003). The overriding aim of this paper is to explore and understand the difference between adopters of low and high-end BEVs. This distinction between two different adopter groups of BEVs is the major contribution of this paper. The hope is that policy makers can use the results of this study to make more informed policy decisions and that OEMs are able to develop cars that are properly positioned for each market, in order to ultimately grow the BEV market.

1.1. Literature review

BEV adoption research has been on going since the early 1990s (Golob et al., 1997; Kurani et al., 1994, 1996), since then the body of literature has grown considerably with authors in many countries looking towards understanding the complexities of BEV adoption. The vast majority of the literature gathers empirical data from persons who are not adopters of BEVs, often sampling the general public and asking them questions about BEV perception (Egbue and Long, 2012; Krupa et al., 2014; Plötz and Gnann, 2011; Plötz et al., 2014). Only recently has literature begun to report samples of people who have actual experience with BEVs. This data can be more insightful as it is more representative of an actual decision to adopt a BEV, rather than a hypothetical one. Studies that involve actual adopters of BEVs include (Caperello et al., 2014; Lane et al., 2014; Tal and Nicholas, 2013; Tal, 2014; Turrentine et al., 2011). Whilst these studies are becoming more numerous they are still not abundant within the literature, and more studies are needed in order to guide the transition from ICEVs to BEVs. Indeed, a 2015 review by Rezvani et al. (2015) calls for more studies that use data from actual adopters.

Table 1
Comparison of the Nissan Leaf (low-end BEV), of which there were 152 in this study, and the Tesla Model S (high-end BEV), of which there were 153 in this study (Nissan, 2015; Tesla Motors Inc, 2015).

	Nissan Leaf	Tesla Model S
Price	$29,000–35,000	$70,000–105,000
Range	75 miles	270 miles
Acceleration (0–60 mph)	9.9 s	3.1 s
Top speed	93 mph	155 mph
Fastest charge time (0–100%)	4 h	1 h 15 min
Electric motor	80 kW	515 kW
Battery	24 kW h	85 kW h
Length	4.4 m	4.9 m
Width	1.7 m	1.9 m