



Identifying and characterizing potential electric vehicle adopters in Canada: A two-stage modelling approach



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ABSTRACT

This article presents a two-stage structural equation modelling and segmentation process to identify likely electric vehicle adopters in Canada. Using a sample of 3505 households who have expressed an interest in the future purchase of an economy car, the paper operationalizes an extended version of the Theory of Planned Behaviour in a structural equation model to quantify the impacts of personal beliefs on individual adoption intention towards electric vehicles. Model results show that attitude, perceived behavioural control, and norms (moral and subjective) have significant direct impacts on behavioural intention, while a household's concern for the environment has an indirect impact. Age, level of employment, and employment status are identified, among other variables, to significantly influence the adoption intention. Collectively, findings indicate that beliefs vary across socioeconomic and demographic characteristics. To best characterize the most likely group of early adopters, we then conduct a Two-Step cluster analysis on households with a high demonstrated intention to adopt EVs. This results in three distinct socio-economic and demographic segments: Typical Early Adopters, Emerging Early Adopters, and Interested Retirees. Each have their own unique socioeconomic and demographic profile. Insights derived from this work can help tailor marketing strategies that are important for accelerating the adoption of electric vehicles in the future.

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1. Introduction

Emissions from private vehicles contribute approximately 12 per cent to global greenhouse gas (GHG) emissions worldwide, and combined with other vehicle types, the transportation sector on the whole contributes approximately 22 per cent (IEA, 2012; Mahmoud et al., 2016; Sierzchula et al., 2014). Accordingly, efforts to curtail emissions from the transportation sector are increasingly at the forefront of the global political agenda (Bunce et al., 2014; Krupa et al., 2014; Wang et al., 2014). In general, two parallel solutions have been advocated: reducing emissions from private automobiles and other vehicles, or discouraging their use altogether (Klößner et al., 2013). Regarding the latter, despite significant efforts to reduce car use through the promotion of a behavioural shift towards more sustainable modes of travel, such as public or active transportation, the private vehicle remains the dominant mode for travel across much of the developed world (Mahmoud and Hine, 2013; Mahmoud and Hine, 2016). In fact, the

demand for auto-oriented mobility is estimated to double by 2035 and triple by 2050 (Offer, 2015; Sierzchula et al., 2014).

As for the former, attempts to reduce transportation emissions through the enforcement of tougher emissions standards are unlikely to meet stated targets (Conti et al., 2015). But electric vehicle (EV) technology, coupled with renewable sources of electricity generation, has come to be seen as a potential solution for mitigating an acceleration of global transportation GHGs as travel by private vehicle increases. Although there are debates at the macro level about the sensitivity of the environmental benefits of EVs to the characteristics of the electricity grids powering particular cities or regions (Kennedy, 2015), there is little doubt about the benefits of EVs for both energy and emissions savings at the micro level (Klößner et al., 2013).

However, achieving the environmental benefits of EVs relies on their adoption by end users, and better understanding the factors that influence the diffusion of EVs is of great importance for achieving policy goals associated with reducing transportation-related GHGs. In this respect, three dominant factors govern the promotion of electric vehicles: governmental support, technological advancement, and consumer acceptance (Hoen and Koetse, 2014; Moons and De Pelsmacker, 2012; Sierzchula et al., 2014; Wang et al., 2014; Ziegler, 2012). Combined, both governmental

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support and technological advancements are regarded as the core of EV diffusion (Conti et al., 2015). To that end, various governmental schemes/initiatives are already in place that provide price subsidies, tax reductions, and other non-monetary incentives for EV consumers (Sierzchula et al., 2014), and the EV technology is satisfying, to some extent, the operational demands of daily travel.

Consumer acceptance is at the heart of widespread market penetration (Al-Alawi and Bradley, 2013; Bunce et al., 2014; Jensen et al., 2014; Wang et al., 2014), yet the market share of EVs remains very small. In Norway for example, the leading market for EV adoption, only 5.7% of vehicle sales in 2013 were EVs (Klößner et al., 2013). In Canada, a total of 10,782 EVs were sold between 2011 and the start of 2015 and although the market share of EVs among all new sales has grown over time, this was still only 0.27% of the new car market in 2014 (Klippenstein, 2015).

In response, there is great interest in achieving a more detailed understanding of EVs from a consumer perspective. At a high level, such low market penetration has been seen as an outcome of factors such as negative stereotypes associated with EVs, including the frequent perception that they are less convenient than traditional internal combustion engine vehicles (Bunce et al., 2014; Jensen et al., 2014; Krupa et al., 2014; Moons and De Pelsmacker, 2012; Wang et al., 2014). However, several market analysis models have emerged to investigate socioeconomic, behavioural, and technical barriers for EVs adoption, and to obtain a more detailed understanding of EV preferences (Al-Alawi and Bradley, 2013; Hoën and Koetse, 2014; Klößner et al., 2013; Krupa et al., 2014).

Market models could be broadly classified into two main streams of research: objective and subjective (Ben and Potter, 2007; Hidrue et al., 2011; Plötz et al., 2014; Yetano Roche et al., 2010). Objective-based models, which are the dominant research tool (Jensen et al., 2014; Rezvani et al., 2015), focus on identifying the key objective features, characteristics, and attributes of EVs that shape the preferences of consumers in the choice of a new vehicle (Hoën and Koetse, 2014; Krupa et al., 2014; Potoglou and Kanaroglou, 2007). Such models work from the foundation of Rational Choice Theory. In contrast, subjective-based models utilize measures such as attitude, perception, lifestyle, emotion, and habits and investigate their impacts on the behavioural intention to adopt EVs (Bunce et al., 2014; de Bruijn and Rhodes, 2011; Jensen et al., 2014; Klößner et al., 2013; Wang et al., 2014). Although both streams are integral components of market analysis (Abotalebi et al., 2015; Jensen et al., 2014; Wang et al., 2014), only a few studies have developed subjective-based models of the EV market (Al-Alawi and Bradley, 2013; Anable et al., 2011; Jensen et al., 2014). Therefore, it is of significant importance to provide an evidence-based subjective analysis of the EV market to complement the well-established objective-based models.

In this respect, the present study develops a psychographic segmentation analysis of the market for electric vehicles in the economy size class based on the attitude-behaviour relationship. The study utilizes an extended version of the Theory of Planned Behaviour (TPB) to profile the characteristics of potential adopters of electric vehicles. Two specific objectives are addressed: first, we develop a model that examines the relationship between an individual's concern for the environment, their attitudes, personal norms, subjective norms, and perceived behavioural controls and their behavioural intentions towards adopting an electric vehicle. Second, we utilize model output to identify the main homogeneous sub-groups of those in the EV market most willing to adopt. Compared to traditional market segmentation models that work from assessments of groups based on socioeconomic and demographic characteristics, this approach provides new insight into the role of subjective attitudinal constructs on behavioural intentions towards EVs in Canada.

As noted earlier, the share of vehicles sold in Canada that are plug-in electric remains tiny. It can easily be argued that these

households, having the unique characteristics of early adopters, are not ultimately representative of the mainstream Canadian EV market. Accordingly, we contend that substantial insight can be gained from an analysis of the much larger mass of future potential adopters and in fact our survey has focused on this group of people. We will not be surprised if the mainstream and early-adopter groups differ in many ways, but for the larger group we must rely on analysis of behavioural intention rather than actual purchase behaviour (Wang et al., 2014).

The approach implemented in this study is to investigate the intention to buy plug-in electric vehicles including both plug-in hybrid (PHEV) and battery electric (BEV). Although a distinction between consumer preferences/perceptions toward PHEV, BEV and hybrid electric vehicles (HEV) is highlighted in the literature, we argue that this approach will yield to understanding the salient characteristics of the more holistic segment of plug-in potential adopters.

The remainder of this study is organized as follows. The following section reviews the current practice of EV market segmentation, and the applications of both choice and behavioural segmentation models, as well as the theory of planned behaviour. The methodology section details the data collection/analysis procedures, and introduces the hypothetical model of the extended theory of planned behaviour. Findings on factors influencing the behavioural intention to adopt EVs and psychographic segmentation of EV market are detailed in the results section. Lastly, we conclude with a discussion of the practical relevance and the implementations of these findings and extensions for policy.

2. Literature review

2.1. Current practice in EV market segmentation

The successful diffusion of any product in a market primarily depends on meeting or accommodating the demands/desires of different consumer groups (Wedel and Kamakura, 2012). The purpose of market segmentation is to define manageable, homogeneous sub-groups of individuals that could be targeted with the same marketing strategy within a sub-group (Mahmoud et al., 2012; Teichert et al., 2008; Wedel and Kamakura, 2012). Typically market segmentation is carried out in two forms: *post-hoc* and/or *a priori*. *Post-hoc* segmentation extracts segments based on the relationships among several measured variables while *a priori* models begin with predefined segments (i.e. income, gender, or age) and then the characteristics of each are profiled by several measured variables (Teichert et al., 2008; Wedel and Kamakura, 2012). Both approaches share a common aspect of defining a “segmentation theme” based on the measured variables (i.e. socioeconomic, demographic, psychographic). Accordingly, different segmentation models could be estimated to illuminate the different market characteristics of individuals on a continuum of observed characteristics and better inform the decision making process around a product (Anable, 2005; Mahmoud et al., 2012).

The status of EVs as an emerging product with promising environmental benefits makes market segmentation an important tool for exploring and further guiding their wider adoption, and there is a literature emerging around this theme (Abotalebi et al., 2015; Anable et al., 2011; Hidrue et al., 2011; Plötz et al., 2014). Several studies have investigated the purchase profile of the EV market using a variety of segmentation themes, including choice models, trip characteristics, psychological theories, and economic models. From this, each approach has advocated a set of characteristics for EV early adopters. From an economic perspective, Biere et al. (2009) identified early adopters via driving habits that are suited to the mobility profile of EVs. They argued that

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