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The influence of vehicle body type in shaping behavioural intention to acquire electric vehicles: A multi-group structural equation approach

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ABSTRACT

The study presents a multi-group structural equation modelling exercise to identify differences in the mindset of individuals towards electric vehicles (EVs) across seven vehicle body types in Canada. The study utilizes a sample of 15,392 households and grounds the psychographic orientation of potential EV adopters on an extended version of the Theory of Planned Behaviour. Specifically, the study measures the impact of five latent constructs; environmental concerns, attitude, subjective norm, personal moral norm, and perceived behavioural control on the intention to adopt EVs along with socio-economic-demographic (SED) variables. The results highlight that both attitude and perceived behaviour control are the strongest factors influencing individual intention to adopt EVs. However, the multi-group invariance analysis indicates that the psychographic orientation and the SED traits of potential adopters of different EV body types are significantly different, with particular standouts in the luxury and pickup truck classes. We follow this up with an analysis of mindshare towards EVs over the seven vehicle types. Insights derived from the analysis can help define potential submarkets for EVs and accelerate their adoption.

1. Introduction

There is a growing interest in identifying potential markets for electric vehicles (EVs) in almost all developed countries. As evidenced by generous financial incentives and governmental support (Bjerkan et al., 2016; Gallagher and Muehlegger, 2011; Mersky et al., 2016; Sierzchula et al., 2014), EVs are considered by many governments as an essential tool for mitigating global greenhouse gas (GHG) emissions. Currently, 14% of global GHGs are emitted from the transportation sector (IEA, 2016), and in line with population growth around the world, the demand for auto-oriented mobility is increasing (Offer, 2015; Sierzchula et al., 2014). Although there are valid concerns about the environmental benefits of electric mobility under different electricity generation profiles (Holland et al., 2015), Kennedy (2015) has provided a clear blueprint for the accepted thresholds for GHG emission intensity from the electricity generation required to realize the environmental benefits of EVs at both macro and micro levels. Almost all developed countries currently meet these thresholds.

Much of the evidence surrounding the promotion of EVs has come from the academic literature (Beggs et al., 1981; Beggs and

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Cardell, 1980; Bunch et al., 1993). Recently, research activities associated with EV focus on several aspects such as: powertrain technology (Çağatay Bayindir et al., 2011); battery advancement (Burke, 2007; Majeau-Bettez et al., 2011); and life cycle environmental and cost models (Bartolozzi et al., 2013; Bauer et al., 2015; Huo et al., 2015). However, the focus is increasingly geared towards consumer market analysis to understand EV adoption patterns (Liao et al., 2016; Rezvani et al., 2015). It is evident in the literature that there is a strong interest in understanding the consumer's perspective towards EVs to promote market penetration. This includes understanding the heterogeneity in consumer preferences and tastes, which is an essential aspect for a comprehensive evaluation of consumers' willingness to adopt EVs.

Attempts to investigate preference heterogeneity as it relates to EVs can be broadly classified into two theoretical platforms: theories of preference utilitarianism and behavioural theories. Theories of preference utilitarianism focus on the utility maximization concept, which users seek to achieve through a rational choice-making process. In this respect, EV adoption is often assessed through the utility of various vehicle attributes. Constituents of the utility are often translated into monetary terms using willingness-to-pay calculations and overall vehicle powertrain choice is expressed in a probabilistic manner (Ferguson et al., 2018). Liao et al. (2016) offers a comprehensive review of the applications of choice models in EV research.

Behavioural theories relate the adoption of EVs to behavioural aspects such as: beliefs, attitude, and identity, as well as to the societal norms and lifestyles. Various theoretical approaches could be classified within this platform such as: the diffusion of innovation theory (Schuitema et al., 2013), normative theories (Moons and De Pelsmacker, 2012), lifestyle theories (Axsen et al., 2012), and the theory of planned behaviour (Egbue and Long, 2012; Mohamed et al., 2016; Moons and De Pelsmacker, 2012; Wang et al., 2014). Although Anable et al. (2011) and Rezvani et al. (2015) offer different classifications of the EV theoretical platforms, the two broad preference utilitarianism and behavioural categories accommodate their classifications.

Based on the volume of published studies, it is clear that theories of preference utilitarianism and the application of choice models are dominating the EV literature (Rezvani et al., 2015). That said, such an approach is often limited in explaining behavioural heterogeneity that is not associated with a rational choice, and it does not consider the psychographic orientation of the consumer in the choice process. In response, attempts have been made to accommodate behavioural constructs in choice models associated with EVs, such as the works of Hidrue et al. (2011), Bolduc et al. (2008), Axsen et al. (2015), and Ferguson et al. (2018). Nevertheless, although both theoretical platforms are complementary, Anable et al. (2011) and Mohamed et al. (2016) argued that behavioural constructs garner the lion's share in explaining consumer EV purchase intention.

Despite the established literature on consumer preferences and the adoption of EVs, some gaps still exist. In particular, the EV literature has generally treated potential adopters of EVs as one homogeneous group of consumers with respect to their preferred vehicle class. Exceptions to this include the recent work of Hardman et al. (2016) that highlighted a significant variation amongst current EV owners, who were classified based on vehicle class into high-end and low-end owners. Each class was associated with significantly different socio-economic and demographic traits as well as different opinions and preferences towards their EVs. Mohamed et al. (2016) worked from a psychographic perspective to examine how behavioural factors influence the intention to buy EVs among those interested in an economy-class vehicle. They identified three distinct segments of consumers interested in an economy-class EV. Furthermore, Higgins et al. (2017) worked from a utility maximization perspective and highlighted significant variation between potential car owners in general, and potential EV adopters in particular, based on their preferred vehicle body type. The study illustrated that consumers have different stated preferences towards EVs based on their ideal next vehicle body type. That said, Higgins et al. (2017) relied on a choice model and did not investigate the influence of preferred vehicle body size on the intention to adopt EVs from a behavioural point of view. Also using a choice model, Ferguson et al. (2018) found that vehicle body type preference, alongside a host of other important factors including psychographics, played some role in shaping powertrain preferences.

From this, one can see the importance of understanding preferences across different vehicle body sizes by looking at the current traditional auto market, which is made of various vehicle sizes. Higgins et al. (2017) classified the auto market into seven broad vehicle sizes/types: economy, intermediate sedan, full sedan, luxury sedan, minivan/crossover, sport utility vehicle (SUV), and pickup truck, and we utilize this classification here. Each vehicle size offers different attributes as they relate to cargo space, performance, acceleration, styling, emissions, fuel economy, and price, and these bundles of attributes are designed to respond to the heterogeneous preferences and tastes of different consumers.

In response, we seek to first understand whether the 'mindset' of potential EV adopters differs across vehicle body types by examining how attitudes, norms, environmental concern, and perceived behavioural control influence individual intention to adopt EVs across the seven vehicle classes. Second, we work from this base to examine how the 'mindshare' (the pool of potential EV buyers across each vehicle type) varies over the vehicle segments as a means of identifying potential EV market share and the most promising vehicle types for electrification. Taken together, the identification of the composite of individual mindset and mindshare towards EVs stands to offer important information for understanding the market for EVs in Canada.

In this respect, the present study advances the work of Higgins et al. (2017) and offers an additional layer of behavioural-based analysis of EV mindset and mindshare that compliments their utilitarian-based approach. In addition, the present study offers means to identify the variations, or the lack thereof, in the outcomes of the two theoretical platforms. That said, both studies should be seen as two polar of the same sphere.

The paper proceeds as follows: we first discuss current applications of behavioural models in the EV consumer literature. Second, we utilize a national dataset of 15,392 Canadian households in seven structural equation models, each of which corresponds to one vehicle body size, to identify the factors contributing to an EV-oriented mindset. Next, we examine how the EV mindshare differs across vehicle body types. The paper concludes with a discussion of the key characteristics of potential EV adopters in each vehicle segment.