



# Size matters: How vehicle body type affects consumer preferences for electric vehicles



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## ABSTRACT

Electric vehicles (EVs) hold great promise for reducing greenhouse gas emissions, yet achieving their environmental benefits depends on greater market uptake. While a growing body of literature has sought to offer information on consumer stated preferences for EVs, to date no research has examined how preferences for hybrid, plug-in hybrid, and battery electric vehicles are shaped by vehicle body size or type. The automobile market is differentiated with vehicle attributes that respond to heterogeneous consumer demands. We hypothesize that each bundle of attributes as it relates to vehicle body size also shapes demand for EVs. Using a large primary dataset, we segment respondents according to their preferred next vehicle body type (economy, intermediate, full-size sedan, luxury, minivan, sport utility, and pickup). Multivariate analysis of variance (MANOVA) results show significant differences in the socioeconomic, demographic, and psychological profile of consumers across the seven vehicle segments. From this, discrete choice models detail how vehicle type plays a significant role in the choicemaking behaviour of potential EV consumers. While factors like age, education, and the importance of fuel economy and reduced or eliminated emissions generally play a consistent role in improving the utility of EVs, our results also reveal significant heterogeneity in choice of powertrain across vehicle segments, with luxury and pickup buyers among the most distinct. The results offer useful information for marketing, policy, and research.

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## 1. Introduction

Electric vehicles (EVs) hold great promise for reducing greenhouse gas (GHG) emissions in the transportation sector. However, while the market for electric vehicles continues to grow, they still make up a small proportion of all vehicles sold around the world (Rezvani et al., 2015). As of 2016 there were over 1.2 million EVs in the global vehicle fleet, with the highest intra-market shares in Norway (23.3%), the Netherlands (9.7%), Sweden (2.4%), France (1.2%), the United Kingdom (1%) and China (1%). The North American market share of EVs lags in comparison, with 0.7% in the United States and 0.4% in Canada (IEA, 2016).

While registrations are increasing, achieving the environmental benefits of EVs requires a greater market share of these vehicles. In the interest of examining the factors that influence the adoption of EVs among consumers and offering useful information for marketing and policy, a growing body of literature has sought to study the market for EVs in several different ways. In general, this body of work can be divided into two perspectives: economic and psychological (Liao et al., 2016).

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The psychological perspective focuses on EVs with respect to user lifestyle, attitudes, symbolism, and perceived evaluations of vehicle attributes (e.g. Mohamed et al. (2016), Morton et al. (2015), Schuitema et al. (2013)). Rezvani et al. (2015) offer a comprehensive review of this research. However, the psychological perspective is not a primary focus of the present paper.

The economic research consists of stated-preference or discrete-choice studies that estimate the preferences and willingness to pay of potential EV adopters with respect to vehicle powertrain technology or fuel choice. A comprehensive review of research in this area can be found in the work of Liao et al. (2016). In general, research on consumer preferences for EVs has gradually moved beyond estimating 'global' models across a sample to offer a more disaggregate view of how different segments of the automobile market behave with respect to the choice of alternative fuel or powertrain vehicles (Table 1).

Taste or preference heterogeneity has been captured both endogenously and exogenously. Of the endogenous methods, latent class choice models capture discrete classes of preference profiles based on selected respondent-specific variables, such as their socioeconomic and demographic characteristics. Mixed logit models assume taste parameters are random, but cannot offer policy- or marketing-relevant explanations of this variety. Hybrid choice models incorporate latent psychological constructs to control for taste variation. Finally, multiple discrete-continuous extreme value methods make assumptions about parameters to capture consumer heterogeneity.

Exogenous segmentation of the automobile market can also occur through survey design or *a priori* modelling decisions guided by theory. Daziano and Achtnicht (2014) for example estimate consumer response to low-emission alternative fuel vehicles among potential light-duty vehicle buyers. Chorus et al. (2013) estimate preferences for alternative-fuel vehicles among company-car drivers. Mau et al. (2008) employ an *a priori* segmentation of respondents by different levels of alternative-fuel vehicle market share to capture the "neighbour effect" of social and technological diffusion while Helveston et al. (2015) and Tanaka et al. (2014) segment their samples by country. Others have captured different socioeconomic and demographic segments using interaction terms (e.g. Musti and Kockelman (2011), Potoglou and Kanaroglou (2007)), although Liao et al. (2016) argue this approach is explorative and has little theoretical basis.

However, reflecting on past work, Hardman et al. (2016) has argued that current studies continue to be limited by their treatment of potential or actual EV adopters as one homogeneous group of consumers with respect to different sizes or classes of vehicles within the same powertrain type. Their research examines battery electric vehicles (BEVs) from the perspective of "low-end" and "high-end" BEV owners, and found that each segment exhibits different socioeconomic and psychographic profiles, opinions of their vehicles, and purchase intentions. In the study, high-end BEV adopters viewed their vehicle prices as being more in line with internal combustion engine (ICE) vehicles, while low-end BEV owners viewed them as comparatively more expensive. High-end owners also expressed a stronger preference for their new vehicles and were more likely to continue purchasing EVs in the future.

From this, although previous research has increasingly sought to segment individuals to capture variations in preferences or tastes, it is surprising that to date, no studies have segmented consumers based on the vehicle body type or size class they are most interested in purchasing. To see why this is problematic, one need only look at the established ICE automotive marketplace, where the diversity of vehicles available for purchase points to a multitude or spectrum of user tastes and preferences among the consumer population.

The ICE auto market consists of a variety of 'bundles' of different vehicle sizes and attributes. These bundles could be discretized into seven broad vehicle types: compact or economy, intermediate-size sedan, full-size sedan, luxury sedan, mini-van/crossover, sport utility vehicle (SUV), and pickup truck. Each of these vehicle body types has a constituent profile of vehicle attributes (e.g. size, cargo capacity, performance, styling, fuel economy, emissions) that make them attractive to certain market segments. Essentially, consumers hold a variety of preferences for the design characteristics of vehicles, and the auto industry responds to this heterogeneity by designing vehicles to meet the demands of different market segments. It seems plausible that such heterogeneity in preferences for different vehicle body size options is also affecting consumer preferences for EV powertrains.

Recognizing this, not all previous EV research has been insensitive to vehicle type; Achtnicht et al. (2012) and Hess et al. (2011) utilized a respondent's preferred vehicle to customize choice scenarios while Potoglou and Kanaroglou (2007) incorporated different vehicle options into their choice scenarios. However, these studies do not report findings according to those body type variables and instead group all data into a general model or slice results by socio-economic segments. There is also a history of studies that have modelled household choicemaking behaviour as it relates to vehicle type. Choo and Mokhtarian (2004) for example model choices among nine vehicle sizes ranging from small and economy to SUV and pickup truck, Kitamura et al. (2012) model six vehicle types, Lave and Train (1979) model ten types, and Baltas and Saridakis (2013) incorporate twelve vehicle body choices. These studies however were not concerned with different vehicle powertrains.

In response to the limitations of previous research, the present paper seeks to answer two questions. First, are there significant differences among potential buyers of different vehicle types? Second, if there are significant differences, how does the choicemaking behaviour of consumers vary across different vehicle body size segments? Put another way, we hypothesize that consumers can be segmented based on their preferred vehicle body size, and that preferences for different types of vehicles will affect choicemaking behaviour with respect to EVs. To answer these questions, the present paper proceeds over two analyses. Utilizing a primary survey of Canadian households, we first test for differences among market segments using a multivariate analysis of variation (MANOVA) and employ discrete choice techniques to model choicemaking behaviour for each segment with respect to hybrid electric (HEV), plug-in hybrid electric (PHEV), BEV, and ICE vehicles.

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