Case Studies on Transport Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

Combining samples to offset nonresponse and respondent biases

Fakhra Jabeen[a], Doina Olaru[a,b], Brett Smith[a,b,*]

[a] The University of Western Australia, 35 Stirling Hwy, Nedlands, WA, 6009, Australia
[b] The Planning and Research Centre, 35 Stirling Hwy Crawley, WA, 6009, Australia

ARTICLE INFO

Keywords:
Electric vehicles
Transport survey
Respondent bias

ABSTRACT

What if probabilistic-based sampling does not result in a representative sample? How can researchers overcome low respondent engagement and hypothetical choices that are perceived as being socially desirable? These questions are relevant regardless of the way primary data collection is conducted.

A statistically sound sampling strategy still depends on individuals volunteering their participation. Even with extrinsic rewards, there is no guarantee the respondent will contribute an honest effort. This research reports on the data collection for a study investigating the acceptance of electric vehicles (EV) in Australia. Complementing the Western Australian Electric Vehicle Trial, this research focuses on household preferences and attitudes towards EV. The data set represents the last stage of data collection with four surveys (initially delivered to trial participants and later aimed at the broader community).

An initial sample showed high interest in EV and environmentally friendly technologies, but higher education levels and higher socioeconomic status households were overrepresented. To compensate for the bias, a second sample was collected from an online panel (PureProfile). Although neither sample is representative of the population, the results from the pooled data are deemed more appropriate for understanding drivers of EV uptake in Western Australia and informing policy making accordingly.

1. Introduction

1.1. Background

Increased cost of non-renewable fuel sources (Lidicker et al., 2010; Lieven et al., 2011; Ziegler, 2010) and higher levels of pollution due to increased traffic and congestion (Mierlo et al., 2006) provide the motivation for exploring alternative energy sources for transport. However, the market penetration of alternative fuel vehicles for personal travel remains low: in Australia, less than 5% of vehicles on the road use fuel technologies other than petrol or diesel (ABS, 2013). Whilst the electric vehicle (EV) driving experience is similar to that of an internal combustion vehicle (Jabeen et al., 2012), recharging the battery is different from refuelling at the pump. The EV offers lower operating costs, lower emissions and the opportunity to recharge overnight at home. However, higher purchase price, lower driving range and a finite battery life have proved to be barriers for EV uptake (Hess et al., 2006).

1.2. Aim

The Western Australian Electric Vehicle Trial (http://www.therevproject.com/waevtrial/) was implemented to investigate driving and charging behaviours of EV owners (Jabeen et al., 2012); the relative trade-offs between charging at home, work or a (currently non-existent) fast charging station (Jabeen et al., 2012); and the factors and attitudes affecting EV uptake. This research involved a stated preference inquiry of the factors and attitudes affecting EV uptake. The responses from a mail-out survey (sent to a representative segment of the population) overrepresented men and people with higher-than-average levels of income and education. In addition, the results indicated a very high concern for the environment and a high perception of usefulness of new technology coupled with a strong preference for EV over other fuel technologies. We believe that the response bias was due to the respondents having high engagement with environmental and fossil fuel depletion issues, in the same way that surveys about “socially and morally charged” topics may lead to response bias in attitudes and behaviours and a lower response rate from those uninterested in the matter (Bonsall, 2009: 59). Therefore, we administered a second quota-based survey to an online panel (PureProfile) to help balance the initial respondent and response bias. The online panel respondents were also self-selected, but with regard to their engagement in EV technology. The current study reports the differences in attitudes and responses in the stated choice instrument and investigates whether a pooled sample could be considered a second-best option to a representative sample

* Corresponding author at: The University of Western Australia, 35 Stirling Hwy Nedlands, WA 6009, Australia.
E-mail addresses: fakhra.jabeen@research.uwa.edu.au (F. Jabeen), doina.olaru@uwa.edu.au (D. Olaru), brett.smith@uwa.edu.au (B. Smith).

https://doi.org/10.1016/j.cstp.2018.02.001
Received 30 October 2015; Received in revised form 19 December 2017; Accepted 11 February 2018

when a segment of a population exhibits overenthusiasm for a given topic.

1.3. Outline of the paper

We organise the remainder of the paper as follows: Section 2 presents a short literature review on factors affecting EV uptake and research methodologies applied to understanding these factors. Section 3 presents the methodology used in this research, describes the samples and offers an overview of the survey instrument used. In Section 4, we compare the samples in terms of demographics, stated attitudes and choice results. Section 5 concludes with a discussion of the results.

2. Literature review

2.1. Factors affecting adoption of electric vehicles

Commonly acknowledged benefits associated with EV include energy conservation, zero tailpipe emissions, reduced noise (Mierlo et al., 2006), home charging (Kurani et al., 1996) and low running costs (iMiEV, 2012; Lidicker et al., 2010), and major automobile manufacturers have announced plans to bring EV technology into the mainstream. Lieven et al. (2011) find price ranked as top priority for both conventional and EV cars, with range ranked second. Of 1152 buyers, 4.2% chose EV as the "first vehicle for all uses". These buyers rated price and range as a lower priority than potential non-EV buyers.

Golob and Gould (1998) suggested that EV is likely to be competitive with petrol only if the household vehicle's average mileage is less than 45 km per day. This requirement would be met in most cities; for example, in Perth, the average daily driving distance is 30 km per day, well within the limit. Although EVs are technically competitive at low driving ranges, it appears that consumers are less accepting: Hess et al. (2006) reported an acceptable range for EV adoption as being closer to 460 km (Hess et al., 2006), equivalent to one recharge every week using Perth's average daily travel.

The time it takes to recharge an electric vehicle represents a substantial change in the way drivers would repower their cars. Home charging may be an attractive alternative (Kurani et al., 1996) to those with private garages, and EV charging at the workplace would be popular for those who have the option open to them (Jabeen et al., 2012). However, even with fast charging stations, an owner cannot pull over, refuel and go as they do with petrol or diesel.

From an environmental perspective, the use of conventional vehicle technologies in Australia remains a major source of carbon dioxide (CO_2-e) and noxious pollutant emissions. Mierlo et al. (2006) suggested that EV is an optimum solution for urban mobility with no exhaust fumes. A study of the full lifecycle of vehicle and fuel greenhouse gas emissions shows that EVs have a positive balance when compared with internal combustion vehicles or hybrid EVs (Ma et al., 2012). Ziegler (2010) also found that younger men favour environmentally friendly products, showing a preference for hydrogen vehicles or EVs over petrol-fuelled vehicles.

Finally, a current challenge for EV uptake is their high purchase price, which is largely determined by the battery cost (mainly the cost of lithium). To address this concern, Ritchie (2004) discussed improvements in the characteristics of lithium-ion batteries that would reduce cost and increase safety. These advancements could decrease the cost of battery packs gradually in the future, which would make an EV a cost-efficient vehicle, especially in the long run. Even at current prices, Mullan et al.'s (2011) cost analysis of EV batteries indicated that over a period of eight years, the reduction in travel cost offsets the added battery cost. While range anxiety, charging time and high purchase price remain consumers' main concerns, Hidrue (2010) noted that a reduction in the cost of the EV battery would appreciably increase EV acceptance.

2.2. Methodological approaches applied in examining EV uptake

Although various methodologies have been applied in investigating EV uptake, we can broadly categorise them into three classes:

- Adoption and multivariate models (Ahn et al., 2008; Egbue and Long, 2012; Schuitema et al., 2013);
- Discrete choice models (Axsen et al., 2009; Bolduc et al., 2008; Brownstone et al., 2000; Dagsvik et al., 2002; Ewing and Sarigollu, 2000; Hidrue, 2010; Jensen et al., 2013; Lieven et al., 2011; Ziegler, 2010);
- Other approaches (e.g., agent-based modelling (Zhang et al., 2011); decision trees (Moura et al., 2012)).

Many consumer behaviour models for technology adoption incorporate psychological and marketing factors that influence purchase decisions (Son and Han, 2011; Yang, 2012). However, this practice is not common in models that address adoption of new fuel and vehicle technologies (Egbue and Long, 2012; Kuwano et al., 2012; Schuitema et al., 2013). Kurani et al. (1996) were among the first scholars to incorporate attitudinal data in their research. Their findings indicated that environmental concerns may not have had much influence on the market initially, though they are a motivating feature for choosing EV. Heffner et al. (2007) used semiotics as a basis to explore consumers' preferences. Less than half the buyers in their study indicated that the vehicle they purchased *"makes a statement about who they are"*. Their interview results showed that current hybrid EV owners were influenced to purchase their vehicles by such factors as *"preserving environment, opposing war, saving money, reducing support for oil producers, and owning the latest technology"* (ibid: 411–412). Schuitema et al. (2013) tested the relationship between perceived instrumental attributes and intention to adopt EVs and found that EV attributes are significant, even though the amount of variance explained by their regression model was only 27%.

3. Methodology and data collection

3.1. Stated choice experiments

Many Australian households use more than one car (ABS, 2013) so that the range limitation of EVs may not be considered an issue when there is a second car available for long distance trips. The low travel cost means EVs can be used for all short trips within the city, but the charging requires considered trip planning. The location of charging stations is therefore crucial to ensure that the destination is reached, when unexpected detours become necessary. These elements were investigated through stated choice experiments where drivers and households were asked to compare a set of optimally designed scenarios with various vehicle and fuel alternatives (including the EVs) and choose the preferred alternative.

We presented respondents with four vehicle alternatives—petrol, diesel, plug-in-hybrid (PIH) and EV—from which to choose their most and least preferred options. We chose the nine attributes that had emerged as most relevant in previous scholarly work (and were validated in the Australian context using focus groups) for use in the experimental designs: purchase price, running cost, engine size, driving range, emissions, noise, battery charging time, the availability of charging infrastructure and the battery capacity after 10 years of use. The design was D-p optimised using genetic algorithms (Olaru et al., 2011), and we obtained the prior parameters from a pilot study with 22