WHAT DO PEOPLE THINK ABOUT THE WIRELESS ROADWAY CHARGING SYSTEM FOR ELECTRIC VEHICLES?

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Overview

Along with the knowledge that typical EV acceptance barriers include driving range and charging times, technological advancements in wireless charging roadways or dynamic inductive power transfer (DIPT) roadway systems have been emanating. The technology can transfer power to EVs over an air gap without physical contact, which enables EVs to be energised wirelessly while travelling in motion via embedded pads/transmitters beneath the roadway and receivers under the vehicles (Nagendra *et al*., 2014; Sheng *et al*., 2020). DIPT charging can be offered to light-duty, medium to heavy-duty vehicles, and/or other fleets, so they can always be on the move. This technology can potentially mitigate previously listed barriers that discourage the consumer from purchasing an EV. At present, charging at public charging stations in New Zealand can take approximately 30 minutes. Dynamic wireless charging, on the other hand, offers a more convenient experience for the consumer regarding driving range and charging time (Sun *et al*., 2018). Additionally, this technology can remove the cumbersome task of plugging in and lower operating costs and the cost of EV batteries, among others. Researchers from the University of Auckland (UoA) explain that installing IPT is a potential game changer for EV uptake due to its potential to alleviate barriers other than upfront costs, such as driving range anxiety, or the inconvenience of interrupting a journey to plug in and recharge (Poland, 2021). Nonetheless, providing a viable DIPT system remains challenging, especially given the potential uncertainties of the existing/prospective EV consumers. Both the technology around EVs themselves and their associated charging options remain largely unfamiliar to the general population. Gaining a better understanding of the consumer decision-making process and preference for EVs and the associated charging options is crucial if New Zealand continues to increase EV uptake. Hence, this research aims to understand the perceived economic and environmental benefits of DIPT technology or named dynamic wireless charging, and how that might impact EV adoption in New Zealand. At the hand of discrete choice modelling (DCM), a better understanding of how consumers value dynamic charging capabilities was possible. Multinomial Logit (MNL), Heteroscedastic Logit (HL), and Mixed Logit (MXL) models were fitted to stated preference data. Furthermore, DCM allowed the willingness to pay (WTP) for dynamic charging capability to be measured indirectly. The main finding was indeed that dynamic charging capability has a significant positive impact on vehicle choice.

Methods

A survey was designed to understand how the typical New Zealand commuter feels toward EVs and their economic benefits, whether they would consider the wireless dynamic charging technology, and if so, how much they would be willing to pay if the technology is in place. Respondents were collected from three organisations: New Zealand Automobile Association (AA), the NZ EV owner Facebook group, and the UoA, after attaining approval from the University of Auckland Human Participants Ethics Committee (UAHPEC). The data collection method aims to achieve a representative sample of New Zealand's population conditional on time and cost constraints. The survey is organised into five sections. The first collects information on respondents' type of personal vehicle usage and their general travel patterns. Second, respondents are asked to share their general attitudes toward pure EVs (battery electric vehicles). The following section then collects information on respondents' attitudes, knowledge, and usage of EV charging systems. This particular section divides the sample into pure EV users, and non-pure EV users dependent on how they answer an ownership/lease question in section one. Next, respondents are presented with a choice experiment, each facing eight choice questions where they choose their most preferred EV option out of two available alternatives or an opt-out alternative (your classic combustion engine vehicle). Each EV alternative is described by five attributes: purchase price, driving range, recharge time, emission reduction, and dynamic charging capability. The last two attributes are of particular interest to the research objective. In terms of levels for each attribute, the purchase price has four, driving range, recharge time, and emission reduction have three, and dynamic capability is described by two levels. The number of attributes and their associated levels was carefully chosen to gather enough information for a plausible analysis. At the same time, the complexity of the survey design is minimised given the risk of cognitive overload for the respondent and therefore precludes the quality of the data. Much of the literature has included an opt-out alternative like this survey. The reason for the inclusion of an opt-out option is that the main objective is to understand the impact of the dynamic charging capability on the choice between EV types and whether it can impact the choice to adopt an EV.

For this choice experiment, three blocks are generated, each containing eight choice questions. Therefore, 24 choice questions make up a complete set. Before respondents were presented with the choice experiment, a 'cheap talk' script was included to increase the realism of the choice. In the final section, respondents were asked several socio-demographic questions, including, gender, household type, age, ethnicity, time spent living in New Zealand, work status, education, income, and region. The survey closes with some demographic questions. DCM techniques are applied to estimate the WTP for dynamic wireless charging was measured both directly and indirectly.

Results

After cleaning the data, the final sample consisted of 1238 individuals, 1029 from AA members, 99 from the NZ EV owner Facebook group, and 110 from the UoA students. Because each respondent faced eight choice questions, the total number of observations would be 9,904 for the discrete choice analysis. However, due to some incomplete decisions, the total number of observations ended up being 9,887. Six main DCMs were specified, however, the final model specification is the MXL. Here the independence from the relevant alternatives assumption is relaxed, the panel structure of the data is accounted for, and it is also possible to specify whether the random parameters are correlated or not. MXLU represents the MXL model with uncorrelated random parameters, whilst MXLC represents the MXL model with correlated random parameters. The MXL models obtain higher log-likelihood values compared to all previous models. To consider whether these model specifications are better suited than the MNL model, the Wald and log-likelihood ratio tests were performed to assess the existence of random parameters. More specifically, MNL was tested against MXLU and MXLC, and in all cases, there was strong evidence against no random parameters. Regarding the WTP estimates, for MNL, since the sign of the coefficient estimate was negative, the WTP is interpreted as follows: to reduce the dynamic charging capability to essentially being incapable, the individual is willing to pay at most about $6,900 more. On the other hand, the sign of the coefficient estimate is positive for all other specifications with MXLC being the most sensible. Therefore, the interpretation becomes that to increase the dynamic charging capability to essentially being capable, the individual is willing to pay $6,600 more at most.

Conclusions

This research aims to understand the perceived economic and environmental benefits DIPT can provide for EVs. Overall, the results are promising and align with the literature on the benefits that DIPT can provide. Although the familiarity with this technology is low, there exists a positive weighting in attitude toward dynamic wireless charging. Through DCM, it was observed that an EV with dynamic charging capabilities has a highly significant positive impact on EV choice. Moreover, the WTP for dynamic charging was positive. In terms of the environmental feature, the response was mixed. There was no specific attitude that dominated. Additionally, the emission reduction and the environmental attribute in the discrete choice analysis had a negative impact on vehicle choice. Future research should explore extensions from probabilistic utility functions to linear utility by using a more complicated survey design.

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