CONSUMER PREFERENCES FOR ELECTRIC VEHICLES IN JAPAN: BEST-WORST SCALING

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Overview

An electric vehicle (EV) shift is dramatically drawing attentions in Asian countries. Widespread adoption of alternative fuel vehicles may contribute to the alleviation of climate change and air pollution (Liao et al. 2017). In China, strong public policies to promote zero emission vehicles in order to mitigate air pollution in urban areas have been implemented. In Japan, although Nissan has sold a world bestselling electric car LEAF, the yearly sales of new cars of 100%EVs was 0.4% in 2016. On the other hand, the yearly sales of hybrid vehicles such as PRIUS was 30.8% in 2016. Japanese consumers still remain hesitant to purchase EVs even though central and local governments offer subsidies and tax exemption schemes in order to achieve alternative fuel vehicles goals in 2030.

Choice modelling approaches are useful tools to reveal consumer preferences for a new commodity. In this study, best-worst scaling (BWS) was applied to investigate consumer preferences for EVs. Although EVs are still unfamiliar to most of the Japanese consumers, BWS has advantages in obtaining rich information and data on consumer preferences by identifying "best" and "worst" options for each respondent.

An online questionnaire survey was conducted in 2018, and 448 samples of Japanese consumers were collected. Object case and multi-profile case BWS were both applied in the survey. Results of object case BWS revealed that purchase price as the most important factor to change consumers' attitude toward EVs. In addition, operation cost and driving range were similarly important factors. On the other hand, it was demonstrated that the reduction for carbon dioxide and air pollutants were far less appealing factors for Japanese consumers. Multi-profile case BWS revealed that different scenarios for operation cost, i.e., yen/100 km and annual saving, were both considered properly when purchasing EVs. Random parameter logit estimates of both object case and multi-profile case BWS demonstrated the preference heterogeneity of every attributes of EVs. The results suggest that consumer preferences and purchasing behaviors are much diverse. In conclusion, more public programs to reduce the vehicle price and to inform the environmental advantages adequately are necessary to promote EV shift in Japan.

Methods

The BWS has three categories: the object case (case 1), profile case (case 2), and multi-profile case (case 3). Although BWS is a type of choice modeling, it characteristically obtains the best and worst (or most and least) answers at the same time. This research applies two types of BWS, the object and multi-profile cases. These two BWS types ask about the respondent's preferences for specific characteristics of EVs.

The object case BWS presents multiple questions for respondents, and encourages them to choose "best/most" and "worst/least" options. We used 9 items (attributes) which are characteristic of EVs (Liao et al. 2017; Tanaka et al. 2014): (1) purchase price; (2) operation cost; (3) driving range; (4) charging availability (infrastructure); (5) charging time; (6) reduction of carbon dioxide; (7) reduction of air pollutants; (8) driving performance; and (9) battery life and warranty. Balanced incomplete block designs (BIBDs) were applied for the above 9 items, and 12 choice sets were prepared, with each comprised of 3 items.

The multi-profile case BWS encourages respondents to choose the “best/most” and “worst/least” profiles. The orthogonal fractional factorial designs in the multi-profile case BWS allowed us to prepare 16 choice sets, each comprising 4 profile types with 6 attributes and 4 levels. Respondents were presented with the form of the choice sets, and each respondent was given different 8 choice sets; these were divided into two groups. As the hypothetical scenario projected by the BWS requires respondents (car drivers) to bear an additional financial burden to purchase EVs, the purchase price was established at up to plus 1,250 thousand yen, at 250-thousand-yen intervals.

Two hypothetical scenarios were prepared for the multi-profile case BWS, and comparative experiments were performed. The hypothetical scenarios differed in operation cost. Two measures of operation costs were prepared, as follows: (Scenario A) yen per 100 km; (Scenario B) annual saving from 10,000 km drive. Either of the two scenarios was presented to either half of the respondents to experimentally compare the scenarios about whether both designs for cost per 100 km and annual saving from 10,000 km drive.

For data collection of BWS experiments, an online questionnaire survey for Japanese consumers was conducted in January 2018. We only included respondents who own a car and drive on a regular basis. 448 samples were collected by the online survey.

The object case and multi-profile case BWS are analyzed with random parameter logit models, and the coefficient are estimated. The model is generally referred to as the maximum-difference (maxdiff) model. If a choice set includes a total of J items, the combination of the best and worst choices totals $J(J-1)$. The object case, however, must excluded one item from the independent variables.

Results

The results of the object case BWS from the estimation with the random parameter logit model demonstrated that all the mean parameters were statistically significant except battery life and warranty, while its standard deviation parameter was statistically significant in 10%. Operation cost, reduction of carbon dioxide, reduction of air pollutants, and driving performance had negative mean parameters, indicating low importance, but individual preferences varied.

The results of the object case BWS revealed that purchase price (Best/Worst = 7.62) was valued the most, operation cost (1.97) and driving range (1.92) were the second and third most valued, respectively. Charging availability (1.60) and battery life & warranty (1.20) were positively valued. The items that received negative values included charging time, reduction of carbon dioxide, and reduction of air pollutants.

The data obtained from the multi-profile case BWS was analyzed with the random parameter logit model. All the mean and standard deviation parameters were statistically significant. The results of standard deviation parameters indicated the existence of various consumer preferences for EVs. Different results for operation cost attribute, negative and positive coefficients, were obtained between the scenario A (yen/100 km) and the scenario B (annual saving from 10,000 km). The different signs, however, are in accordance with theory as predicted. Since the multiple-profile case BWS includes price attributes, marginal willingness to pay (MWTP) of each attribute can be estimated. MWTP of charging time was -1.6 thousand yen per minute, and driving distance was 0.19 thousand yen per km.

Conclusions

This experimental research has applied object and multi-profile cases BWS to analyze Japanese consumer preferences for EVs. Many studies have applied choice modelling approaches for alternative fuel vehicles, but few have applied a BWS in their research. The object case BWS compares only the importance of each item of EVs. The multi-profile case BWS allows the use of a price attribute, and thus enabling an estimation of MWTP. The estimation results demonstrated the preference heterogeneity over all of the characteristics of EVs. Japanese consumers have a different level of knowledge and information on EVs. The implementation of stronger promotion activities and policies by automobile companies and governments will be necessary to accelerate EV shift in Japan.

The IEA global electric vehicle outlook 2018 (IEA 2018) provides a comprehensive look at the state and projection of EVs. The development of EVs aims at increasing energy security, improving air quality, reducing noise pollution, and reducing greenhouse gas emissions. EVs had record sales in 2017, and over 1 million electric cars were sold in 2017 with more than half of global sales in China. In terms of share, Norway was the most advanced market for electric car sales, with over 39% of new sales in 2017. Iceland follows at 11.7%, Sweden at 6.3%, China at 2.2%, Germany at 1.6%, United States at 1.2%, then Japan at 1.0%. The study results indicated that Japanese consumers had lower concerns about reduction of air pollutants and carbon dioxide. The environmental benefits from the diffusion of EVs were likely to be ignored by consumers. Global challenges to overcome the environmental pollutions should be supported by changing consumers' attitude toward EVs as well as government policies.

References

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