

# ***APPLYING BEST-WORST SCALING TO ASSESS CONSUMER PREFERENCES FOR ELECTRIC VEHICLES IN JAPAN***

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## **Overview**

The shift to electric vehicles (EV) is drawing attention globally. Widespread adoption of alternative-fuel vehicles (AFV) may contribute to the alleviation of climate change and air pollution (Liao et al. 2017). In China, strong public policies have been implemented to promote new-energy vehicles to mitigate air pollution in urban areas. In Japan, although Nissan has sold a globally bestselling electric car called LEAF, the yearly sales of new 100% battery EVs were 0.4% in 2016. By contrast, the yearly sales of hybrid vehicles (HEV) such as the PRIUS were 30.8% in the same year. Japanese consumers remain hesitant about purchasing EVs even though central and local governments offer subsidies and tax-exemption schemes to achieve AFV goals by 2030.

Choice modelling approaches are useful for revealing consumer preferences for a new commodity. In this study, best-worst scaling (BWS) was applied to investigate consumer preferences for EVs. Although most Japanese consumers are unfamiliar with EVs, BWS can help obtain rich information and data on consumer preferences by identifying the “best” and “worst” options for each respondent. An online questionnaire survey was conducted in 2018, and 448 responses from Japanese consumers were collected. Both object case and multi-profile case BWS were applied in the survey.

The results of the object case BWS revealed purchase price to be the most important factor in changing consumers’ attitude toward EVs. In addition, the operation cost and driving range were similarly important. Conversely, it was demonstrated that CO<sub>2</sub> and air pollutant reduction were far less appealing. Multi-profile case BWS revealed that two different scenarios for operation cost, yen/100 km and annual saving, were both significant considerations when purchasing EVs. Random parameter logit estimates of both object case and multi-profile case BWS demonstrated the preference heterogeneity of every EV attribute. The results suggest that consumer preferences and purchase behaviors are diverse. Thus, more public programs that reduce the vehicle price and adequately disseminate the environmental advantages are necessary to promote the shift to EVs 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 EV characteristics.

The object case BWS presents multiple questions for respondents, and encourages them to choose “best/most” and “worst/least” options. Nine items (attributes) which are characteristic of EVs were used with reference to Liao et al. (2017) and Tanaka et al. (2014): (1) purchase price; (2) operation cost; (3) driving range; (4) charging availability (infrastructure); (5) charging time; (6) reduction of CO<sub>2</sub>; (7) reduction of air pollutants; (8) driving performance; and (9) battery life and warranty. Balanced incomplete block designs were applied for the above nine items, and 12 choice sets were prepared, with each comprising three 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 four profile types with six attributes and four levels. Respondents were presented with the form of the choice sets, and each respondent was given eight different choice sets; these were divided into two groups. As the hypothetical scenario proposed by the BWS requires respondents (car drivers) to bear an additional financial burden to purchase EVs, the purchase price was established at up to an additional 1,250,000 yen, at 250,000-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. Other attributes were driving range, charging availability of quick charge stations, and charging time.

Data collection for BWS was conducted by means of an online questionnaire survey in January 2018. When conducting the online survey, 448 samples were selected by pre-screening. Specifically, the conditions of “driving with a certain frequency,” “car license holder,” “car owning household (not personal ownership, but possession by family members).” Only respondents who satisfied all these requirements were selected to continue answering questions in this survey.

The object case and multi-profile case BWS are analyzed with the 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 at 10%. Operation cost, reduction of CO<sub>2</sub>, 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 and warranty (1.20) were positively valued. The items that received negative values included charging time, reduction of CO<sub>2</sub>, 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 scenario A (yen/100 km) and 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

In this study, object and multi-profile case BWS methods were applied to assess Japanese consumers' preferences for EVs. As a result of the relative importance of items characteristic to EVs in the object case BWS, the purchase price was given the highest importance. Although there was a big difference, the operation cost, the maximum driving distance, and the availability of the charging facility were the next. By contrast, the importance of the reduction of greenhouse gas and air pollutants, which is an important social benefit of EVs, was evaluated to be rather low. In Japan, there was little interest in social benefits from the introduction of EVs, and the result showed that emphasis was placed on the high purchase price of the vehicle. Consumers were likely to value cost attributes, whereas the alleviation of environmental damages were emphasized for incentive programs targeting consumers. This is a suggestive result for public policy encouraging the future shift to EVs and automobile company strategy.

Considering a low evaluation on reduction of greenhouse gas and air pollutants, the multi-profile case BWS analyzed five attributes such as purchase price. The results show that both the mean parameter and the standard deviation parameter were statistically significant for all attributes. Although respondents emphasized all the attributes applied in this study, it was confirmed that consumer preferences for those attributes were diverse.

The current Japanese EV market is only 0.1% of the number of domestic passenger vehicles owned, it is still at the innovation stage. However, the HEV market has already reached the majority even under the present circumstances. It is difficult to verify whether EVs will proliferate in the same way as HEVs. The EV shift to the early-adopter stage may be the next milestone in Japan.

## References

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