APPLYING BEST-WORST SCALING TO ASSESS CONSUMER PREFERENCES FOR ALTERNATIVE FUEL VEHICLES IN JAPAN

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Overview

The shift to alternative fuel vehicles (AFV) has been drawing considerable attention globally. The widespread adoption of AFVs may contribute to alleviating climate change and air pollution (Liao, Molin, and van Wee, 2017). According to the International Energy Agency's global electric vehicle outlook 2018 (IEA 2018), electric vehicles (EV) have shown record sales in 2017 with more than half of global sales taking place in China. In Japan, Nissan introduced a bestselling electric vehicle, LEAF, of which more than 100,000 have been sold in the domestic market and 400,000 in the international market. The yearly sales percentage of new battery EVs in Japan, however, was still at 0.4% in 2016, and plug-in hybrids (PHEV) was at 0.8%. However, the percentage of yearly sales of electric/gasoline hybrid vehicles was at 30.8% in 2016. Currently, Japanese consumers seem to prefer hybrid vehicles over other AFVs. EVs and fuel-cell vehicles (FCV) are still in the early stages of market expansion and both central and local governments offer subsidies and tax exemption schemes to achieve their AFV goals by 2030 and to reduce CO_2 emissions.

The choice modelling approach is a useful tool to assess consumers' preferences for unfamiliar goods. A number of studies have applied choice modelling approaches concerning AFVs (Liao, Molin, and van Wee, 2017; Tanaka et al., 2014) but few have applied best-worst scaling (BWS). This study applied BWS to assess consumer preferences for AFVs compared with gasoline vehicles. Japanese consumers are still unfamiliar with most AFVs that are currently available. The BWS method has advantages that include investigating consumers' preferences for certain goods by identifying both the best and the worst profiles in the experimental design. For data collection, an online questionnaire survey was conducted in February 2019. Data from 3,100 Japanese drivers were collected.

A multi-profile case BWS method was applied to assess consumer preferences for vehicles with different engine types and to obtain marginal willingness to pay (MWTP). The attributes of the profile in question are engine type, reduction of CO_2 emissions, purchase price, fuel/electricity cost per 100 km drive, and maximum driving distance. The engine types used for this analysis were gasoline, hybrid, clean diesel, PHEV, and EV.

The estimation results demonstrated that all of the respondents were likely to choose AFVs compared with normal gasoline vehicles in an environmentally-friendly hypothetical scenario. Specifically, the hybrid engine was highly preferred. The results also demonstrated that all attributes significantly affected consumer preferences. The results concerning consumers' MWTP was virtually double for BWS than what it was for choice experiments (CE). By identifying consumers' preference for the least attractive goods, the results of economic valuation using choice modelling approaches could possibly be different.

Methods

BWS is a choice modelling approach and although it is similar to conventional choice experiments, it characteristically obtains information concerning the best and worst profiles simultaneously. BWS consists of three categories: object case (case 1), profile case (case 2), and multi-profile case (case 3). This study applies a multi-profile case BWS to assess consumer preferences for AFVs. The multi-profile case BWS encourages respondents to choose the best/most and worst/least profiles presented to them. In the current Japanese vehicle market, the diffusion of AFVs—excluding hybrids—is still limited. Obtaining the worst choice as well as the best could result in robust coefficient estimations, because the worst choice could reveal a preference for goods that were not usually chosen.

The orthogonal fractional factorial design of the BWS multi-profile case allowed us to prepare 16 choice sets, each comprising of five profile types with five attributes and four levels. Respondents were each presented with eight different choice sets and one common profile that had the same price level for each profile. Attributes of the profile are engine type, reduction of CO_2 emissions, purchase price, operation cost (fuel/electricity) per 100 km drive, and maximum driving distance after filling up or at full charge. Engine types were gasoline, hybrid, clean diesel, PHEV, and EV. The hypothetical scenario projected by the BWS analysis requires respondents to bear an additional financial burden to purchase AFVs compared with purchasing a conventional gasoline car, which has the lowest purchase price. The purchase price range of AFVs was established at up to 1.1 million yen.

The multi-profile BWS model is analyzed with a conditional logit model and the coefficients of the individual attributes are estimated. If a choice set includes a total of J items, the combination of the best and worst profiles totals $J(J-1)$. There are $5 \times 4 = 20$ combinations of the best and worst profiles in this BWS analysis.

Respondents with a valid driver's license were pre-selected and 3,100 samples were collected through this survey. The gender ratio and age groups with intervals of 10 years were normalized. Of the respondents, 81.5% had at least one vehicle in their household. AFVs (hybrid, clean diesel, PHEV, and EV) accounted for 16.7% of the vehicles that was owned by respondents.

Results

The data obtained from the multi-profile BWS was analyzed with a conditional logit model. The coefficients of all attributes were statistically significant. The alternative-specific constant (ASC) for hybrid was 0.718, the ASC for clean diesel was 0.103, for PHEV it was 0.367, and for EV it was 0.167. This indicated that all of the AFVs were likely to be chosen by respondents as opposed to a normal gasoline car in this hypothetical scenario, in which the attribute of environmental performance was emphasized. The preference for the hybrid engine was the highest. The coefficients of purchase price, and fuel/electricity cost were negatively significant. Conversely, the reduction of CO_2 emissions and maximum driving distance were positively significant.

For a comparison of the performance of BWS and CE, MWTP values for the reduction of CO_2 emissions and maximum driving distance were calculated. When only the best profile is extracted for estimating coefficients, the estimation process of MWTP is similar to a CE task. As for the 1% reduction of CO_2 emissions, MWTP of BWS was 7,779 yen per percentage point and that of CE was 3,636 yen per percentage point. Concerning maximum driving distance, the MWTP in BWS was 655 yen/km and that of CE was 1,299 yen/km. This confirms that the estimation results of BWS and CE were significantly different.

The first choice set was the same for all respondents. The level of purchase price of each engine type was made equal, and the environmental performance of AFVs was maximized. The aggregate result of the common BWS task showed a higher preference for AFVs, especially for EV, and a lower preference for a gasoline car. The percentages of the best engine type as chosen by the respondents were gasoline (13.2%), hybrid (23.6%), clean diesel (10.3%), PHEV (21.5%), and EV (31.4%). Concerning the worst engine type, the percentages were gasoline (39.6%), hybrid (6.2%), clean diesel (21.0%), PHEV (9.0%), and EV (24.1%).

Conclusions

This experimental study applied a multi-profile BWS to analyze Japanese consumers' preferences concerning AFVs. The estimation result demonstrated that all of the different types of AFV were likely to be chosen by respondents as opposed to a normal gasoline vehicle in an environmentally-friendly hypothetical scenario. Specifically, the hybrid engine was highly preferred by Japanese consumers, possibly because Japanese consumers are familiar with hybrid engine cars. The coefficients of purchase price, fuel/electricity cost, reduction of CO_2 emissions and maximum driving distance were significant. When comparing BWS and CE, the MWTP values when using BWS were twice that of the CE method. By identifying consumers' preference for the least attractive goods, it can be said that the results of economic valuation could be changeable.

The results showed that Japanese consumers valued the reduction of CO_2. However, the diffusion of AFVs are still limited in the current Japanese car market. The results suggested that general consumers would change their attitudes toward AFVs if the environmental performance and price was more ideal and acceptable for consumers. Additionally, some Japanese consumers have a different level of knowledge and information concerning AFVs than others. The implementation of stronger promotion activities and marketing strategies by automobile companies and governments is necessary to accelerate the shift from gasoline vehicles to AFVs in Japan.

References

IEA (2018) *Global EV outlook 2018*, OECD/IEA.

Liao, F., E. Molin & B. van Wee (2017) Consumer preferences for electric vehicles: A literature review, *Transport Reviews*, 37(3): 252-275.

Tanaka, M., T. Ida, K. Murakami, & L. Friedman (2014) Consumers' willingness to pay for alternative fuel vehicles: A comparative discrete choice analysis between the US and Japan. *Transportation Research Part A*, 70: 194-209.