CONSUMER PREFERENCES FOR ALTERNATIVE FUEL VEHICLES AND AUTONOMOUS DRIVING TECHNOLOGY

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Overview

Alternative fuel vehicles (AFVs) and autonomous driving technology have 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. 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 (HEV) was at 30.8% in 2016. Currently, Japanese consumers seem to prefer HEVs 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. In addition to the promotion of AFVs, the Japanese government is currently developing legislation regarding automated driving because major automobile companies are investing in R & D of autonomous technologies.

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) but few have applied best-worst scaling (BWS). This study applied a multi-profile case BWS to assess Japanese consumer preferences for AFVs and autonomous driving technology. For data collection, an online questionnaire survey was conducted in March 2019. Data from 1,048 drivers who lived in Japan were collected. The attributes of the profile in question are engine/motor type, reduction of CO_2 emissions, purchase price, fuel/electricity cost per 100 km drive, autonomous driving levels and maximum driving distance. The engine/motor types used for this analysis were gasoline, HEV, clean diesel (CDV), PHEV, EV, and FCV.

The estimation results demonstrated that respondents were likely to choose HEV, EV and PHEV compared with normal gasoline vehicles in an environmentally-friendly hypothetical scenario. Specifically, HEV had the highest marginal willingness to pay (MWTP), and CDV had negative MWTP. The coefficients of purchase price, and fuel/electricity cost were negatively significant. Conversely, maximum driving distance were positively significant. The coefficients of the reduction of CO_2 emissions and FCV were not statistically significant. By identifying consumers' preference for the least attractive goods, the results of economic valuation using choice modelling approaches could possibly be improved.

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 (Louviere, Flynn, and Marley, 2015). 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 and autonomous driving technology. 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 HEVs—is still limited. As for FCVs, the construction of hydrogen stations is a key to promote their sales but the number of the public hydrogen stations is still 108 in Japan. FCVs may be less attractive for ordinary consumers and the sales volume of FCVs is still low though the Japanese government provides subsidy programs. 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 32 choice sets, each comprising of four profile types with six attributes and four levels. Respondents were each presented with eight different choice sets. Attributes of the profile are engine/motor type, autonomous driving levels (level 1, 2 and 3), 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/motor types were gasoline, HEV, CDV, PHEV, EV, and FCV. 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 2 million yen.

The multi-profile BWS model is analyzed with a mixed 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 $4 \times 3 = 12$ combinations of the best and worst profiles in this BWS analysis. Respondents with a valid driver's license were pre-selected and 1,048 samples were collected through this survey. The gender ratio and age groups with intervals of 10 years were normalized. Of the respondents, 80.3% had at least one vehicle in their household. AFVs (HEV, CDV, PHEV, and EV) accounted for 17.4% of the vehicles that was owned by respondents.

Results

The data obtained from the multi-profile BWS was analyzed with a mixed logit model. The coefficients of all attributes were statistically significant. The alternative-specific constant (ASC) for FCV was 0.00269 but not statistically significant. The ASC for HEV was 0.593, for CDV it was -0.180, for PHEV it was 0.226, and for EV it was 0.304. MWTP for HEV was 905,344 yen, and EV was 464,763 yen, and CDV was -275,023 yen, PHEV was 350,061 yen. This indicated that HEV, PHEV and EV among 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 and its standard deviation parameter was statistically significant. Preference heterogeneity, i.e., taste difference among respondents was confirmed only for HEV, the most popular AFV in Japan.

The coefficients of purchase price, and fuel/electricity cost were negatively significant for both mean and standard deviation parameters. Conversely, maximum driving distance were positively significant. The reduction of CO_2 emissions was not statistically significant. The coefficients of mean parameters of autonomous driving were all significant. Level 1 (driver assistance) was the highest and the Level 3 (conditional automation) was the lowest. Only a coefficient of standard deviation parameter of Level 2 (partial automation) was statistically significant. MWTP of Level 1 was 235,237 yen, Level 2 was 149,130 yen, and Level 3 was 123,817 yen.

Interaction terms were also estimated to determine the factors affecting the attributes. The results demonstrated that higher household income increased the probability to choose FCV, and the preference for the reduction of CO_2 emissions. Respondents who owned HEV were likely to choose EV. As for autonomous driving, elder respondent with higher interest and expectation for autonomous vehicles were likely to value the autonomous vehicles.

Conclusions

This experimental study applied a multi-profile BWS to analyze Japanese consumers' preferences concerning AFVs and autonomous driving technology. 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 HEV. The coefficients of purchase price, fuel/electricity cost, reduction of CO_2 emissions and maximum driving distance were significant. By identifying consumers' preference for the least attractive goods, it can be said that the results of economic valuation could be changeable. The detailed knowledge of the powertrain of AFVs affected the probability to choose AFVs.

The results showed that Japanese consumers valued driving assistant technologies and HEV. However, the diffusion of AFVs other than HEV 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

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