Applying Best-Worst Scaling to Assess Consumer Preferences for Electric Vehicles in Japan

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Outline

- Japanese consumers' preferences for electric vehicles (EV)
- Best-Worst Scaling (BWS)
  - Choice modeling with Best & Worst choices
  - Object case (case 1)
    - Relative importance of specific features of EV
    - Price, charging, or the environment?
  - Multi-profile case (case 3)
    - Marginal WTP estimates under two scenarios

Data Collection and Survey Design

- Online questionnaire survey in Japan
- Samples: 448 monitors
- Survey in January 2018
- Male and female 50%
- Automakers of respondents' main car
  - Toyota (32.8%), Honda (15.0%), Nissan (12.7%), Daihatsu (11.8%), Suzuki (10.9%)
- Types of engine
  - Gasoline (85.0%), HEV (12.5%), EV (1.1%), PHEV (0.4%), Diesel (0.9%)
- Average annual driving distance
  - 7,890km

Object Case Best-Worst Scaling

ID	Items (attributes)	Level
1	Purchase price	LGM + ___ yen, subsidy, eco-car exemption
2	Operation cost	-5,000 yen/1000km
3	Driving range	400 (240) km
4	Charging availability	Quick charging station (7,100 spots)
5	Charging time	Quick 40 min.
6	Reduction of CO_2	50 - 100%
7	Reduction of air pollutants	100%
8	Driving performance	Acceleration, horsepower
9	Battery life & warranty	8 years or 160,000 km, roadside assistance

"Check the most important item and the least important item when you purchase an EV"

	Purchase price	Driving range	Charging time
I think that this feature is the most important	✓		
I think that this feature is the least important			✓

Example of a choice set designed by BIBDs

Object Case: Best and Worst Choice counts

ID	Items (attributes)	Best	Worst	B-W	B/W	Rank
1	Purchase price	1381	181	1200	7.62	1
2	Operation cost	804	409	395	1.97	2
3	Driving range	811	424	387	1.91	3
4	Charging availability	673	421	252	1.60	4
5	Charging time	556	561	-5	0.99	6
6	Reduction of CO_2	115	1236	-1121	0.093	9
7	Reduction of air pollutants	111	1147	-1036	0.097	8
8	Driving performance	432	584	-152	0.734	7
9	Battery life & warranty	493	413	80	1.20	5

Multi-Profile Case BWS

- "Please imagine yourself thinking about purchasing an electric car. Purchase price, charging electricity fee (operation cost), maximum driving distance, availability of quick charge facility, time required for quick charging are different."
- Brand availability. Two scenarios (A & B) for operation cost

Example of a choice set

	Car A	Car B	Car C	Car D
Purchase price (thousand yen) (compared with conventional gasoline vehicles)	+500	+750	+1000	+1250
A. Operation cost (price/100km)	250	200	150	100
B. Operation cost (annual saving)	40 thousand	60 thousand	80 thousand	100 thousand
Driving range	200 km	300 km	400 km	500 km
Charging availability (quick) (% of existing gas stations)	25%	50%	75%	100%
Charging time	40 min.	20 min.	10 min.	5 min.
I'm most likely to choose				✓
I'm least likely to choose	✓			

Multi-Profile Case BWS: Question

- (1) “Purchase price” is the actual purchase price (thousands yen higher than gasoline-powered car of the same type) that subtracted government/local government subsidy and eco-car tax exemption from manufacturer selling price.
- (2A) “Operation cost” is a standard electricity cost that it takes to drive 100 km.
- (2B) “Operation cost” shows how much electricity cost when driving 10,000 km per year, which is the average mileage, can save thousands of yen compared to gasoline-powered vehicles.
- (3) “Driving range” is not the numerical value on the catalog, but is the average driving distance after full charge in a situation close to actual driving such as air conditioning use.
- (4) “Charging availability” means how many quick charging facilities are installed compared with the number of gas stations. If it is 100%, it means that it is the same number as the gas station and 50% means the number of facilities is half.
- (5) “Charging time” indicates the time required to quickly charge from the empty state to 80% of full charge in the quick charging facility on the go.

Multi-Profile Case BWS: Question (cont'd)

- (Features common to all vehicles)
- Driving performance (acceleration, power, etc.) is equivalent to gasoline cars.
- The battery comes with a guarantee system that repairs free of charge if it is broken or malfunctioning up to 160,000 km or in 8 years.
- The warranty system that the contractor himself can select the service contents corresponding to the payment amount is prepared for the road service at the time of electricity shortage at annual fixed amount.
- Also, the reduction of greenhouse gas emissions and zero emissions of air pollutants during driving are the same level for all vehicles.

Estimation Results of Multi-Profile BWS

Variables	Operation Cost A	Operation Cost B
Purchase price	-0.0230***	-0.0230***
Operation cost	-0.0065***	0.1121***
Driving range	0.0039***	0.0043***
Charging availability	0.0144***	0.0174***
Charging time	-0.0367***	-0.0298***
Standard deviation parameter		
sd_Purchase price	0.0206***	0.0242***
sd_Operation cost	0.0079***	0.2073***
sd_Driving range	0.0039***	0.0046***
sd_Charging availability	0.0179***	0.0185***
sd_Charging time	0.0513***	0.0450***
Pseudo R^2	0.150	0.140

Note: N=1792. *** denotes significance at the 1% level, respectively.

Estimation Results of Multi-Profile BWS

Variables	Operation Cost A	Operation Cost B
Purchase price (PP)	-0.0120***	-0.0170***
Operation cost (OC)	-0.0041***	0.0724***
Driving range (DR)	0.0026***	0.0026***
Charging availability (CA)	0.0107***	0.0136***
Charging time (CT)	-0.0223***	-0.0176***
Interaction term		
PP × AGE	-0.0002***	-0.0001***
PP × price of his/her car	0.384×10^{-4}***	0.418×10^{-4}***
DR × annual driving distance	0.458×10^{-7}**	0.358×10^{-7}*
DR × Non-long-distance-driver	-0.0015***	-0.0015***
DR × Hybrid car owner	0.0007	0.0013***
CA × House with parking space	-0.0020	-0.0036***
Pseudo R^2	0.146	0.135

Note: N=1792. ***, **, * denotes significance at the 1%, 5%, 10% level, respectively.

Discussion and Conclusions

- Object case BWS
  - Purchase price was the highest, operation cost, driving range, charging availability was the second most important features of EV
    - More government supports and automakers' efforts to cut down costs (price), charging stations. 66% of respondents were unwilling to buy EVs
  - On the other hand, reduction of CO_2 and air pollutants were likely to be overlooked. They were the least important features
    - Raising awareness, and detecting factors of higher preferences for EV
- Multi-profile case BWS
  - Respondents considered properly for two different operation cost scenarios, but they led to a different MWTP estimates
  - The RPL estimation results demonstrated taste differences in all of the attributes
- BWS will be applicable for FCV and EV comparison or simulation of the future market share of FCV