HYBRID CHOICE MODELLING ALLOWING FOR REFERENCE-DEPENDENT PREFERENCES: THE CASE OF ALTERNATIVE-FUEL VEHICLES IN DENMARK

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1 Background

The literature on discrete choices has seen an increasing focus on how attitudes and perceptions affect choice processes. This has generally been captured in hybrid choice or latent variable models and many researches applied to various fields (see e.g. [1] for a review) showed that attitudes and personality are major factors in determining motivation and the structuring of cognitive task. Hybrid choice models have also been used to study the demand for alternative-fuel vehicles (AFV). For example [2,3] found that a positive attitude toward environment and new technologies increase the probability to choose electric vehicles versus conventional cars.

All these works use Stated Preference data to elicit preferences accounting for the latent attitudes that affect individual choices, because, with the exception of very few cases

(few alternative-fuel vehicles are already in the market), AFVs are not yet an available alternative in the private vehicle sector.

Stated choice experiments are often pivoted around an actual recent choice. The framing gives credibility to the choice experiment as respondents have recently faced a similar choice situation. This raises the question whether the attributes describing the recent choice set a frame for the stated choice experiment (see, e.g. [4]). Following the framework introduced by [5], several recent papers have investigated loss aversion in various context (see for example, [6,7,8,9]). The framework is based on an assumption about loss aversion, i.e. that individuals value losses higher than gains. This is in contrast with conventional utility theory where a change is valued independently of any reference point. An operational model allowing for reference-dependent preferences is presented by [10] who develop a model for the estimation of the value of travel time. [4] applied the approach of [10] allowing the marginal utility of price to depend on whether the price of an alternative is above or below the price of the reference vehicle. They applied the model to investigate the potential futures for AFVs and found that the inclusion of reference-dependent preferences in the model was important as individuals on average value a loss (paying more) compared to their reference price 52 % higher than an equivalent gain (paying less).

Both latent variables and reference points are ways to account for the fact that behaviour indeed deviate from perfect rationality. Research so far have only concentrated on one of the two effects at a time, while there is no evidence of models accounting for both effects. In this paper, we estimate hybrid discrete choice models to test the extent to which preferences are affected by attitudes, e.g. toward the environment, new technology, and perceptions, e.g. the perception of the car as a status symbol, when we allow the preferences to be reference dependent. In particular we test to which extent both attitudes and reference points affect individual preferences, and the relation between attitude and framing. In fact, attitudes are formed over time and are affected by experience [11] so the reference point, which measures the experience gathered in the past, might affect individual attitudes.

2 Data

The sample used to estimate our models consists of 2107 individuals. A random sample of Danish new-car buyers in 2007 were contacted and 28 % of these completed a survey. Within the survey, the individuals answered 25,280 stated choice experiments. Each choice was a binary choice between two vehicles labelled by any two of the five fuel types: conventional,

hydrogen, hybrid, bio-diesel, and electricity. For each alternative, information was given concerning the pollution related to the fuel type. The alternatives were described by the attributes: price, annual cost, range, acceleration time, and a service dummy. Furthermore the survey included questions on attitudes and perceptions regarding vehicles as well as the environment. These questions where grouped into six categories:

1. Attitudes towards vehicle characteristics, e.g. comfort, safety, reliability, resale price.
2. Attitudes related to the environment and car driving, e.g. "I prefer a car that pollutes less".
3. Attitudes towards car driving in general, e.g. "I don't care which car I drive".
4. Perceptions of whether different fuel types are clean, unrealistic, reliable, etc.
5. Perceptions related to specific statements about fuel types, e.g. "Electric cars are more comfortable than conventional cars".
6. Questions concerning how ecological products and low-energy devices are part of the respondents' everyday lives.

In the stated choice design, the recent purchase made by the respondent was used as a reference for the included attributes. In all remaining aspect the respondents were told that both alternatives were equal to their reference vehicles. The experiments were generated by pivoting around the attribute reference values according to a random design. This design is less efficient than a corresponding efficient design. On the other hand the design is useful when efficiency is not a concern because of a large sample size since the design does not assume any a priori restrictions on interactions among attributes.

3 Results

Our model describes vehicle choice in the presence of AFV alternatives conditional on vehicle-class choice. We estimate a mixed logit model. The model is specified as a random-effects model to take the panel nature of the stated choice data into account. Our results show that it is important to account for both reference-dependent preferences and latent variables in modelling of choices as they complement each other as tools to explain behaviour in the data. Furthermore in some cases the inclusion of reference-dependent preferences allows us to better capture the effects of the latent variables.

References

[1] Cherchi, E. (2009) Modelling individual preferences, State of the art, recent advances and future directions. *Resource paper prepared for the 12th International Conference on Travel Behaviour Research*. Jaipur, India, (on CD)

[2] Bolduc, D., Boucher, N., and Alvarez-Daziano, R. (2007) *Hybrid Choice Modeling of New Technologies for Car Use in Canada*, Département d'Économique Université Laval.

[3] Alvarez-Daziano, R. and Bolduc, D. (2009) *Canadian consumers' perceptual and attitudinal responses toward green automobile technologies: an application of Hybrid Choice Models*, Département d'économique Université Laval.

[4] Mabit, S.L. and Fosgerau, M. (2011) Demand for alternative-fuel vehicles when registration taxes are high, *Transportation Research* D 16(3), 225-231.

[5] Tversky, A. and Kahneman, D. (1991) Loss aversion in riskless choice: a reference-dependent model, *Quarterly Journal of Economics* 106, 1039-1061.

[6] Bateman, I., Day, B., Jones, A., and Jude, S. (2009) Reducing gain-loss asymmetry: A virtual reality choice experiment valuing land use change, *Journal of Environmental Economics and Management* 58, 106-118.

[7] Habib, M.A. and Miller, E.J. (2009) Reference-dependent residential location choice model within a relocation context, *Transportation Research Record* 2133, 92-99.

[8] Hjort, K. and Fosgerau, M. (2011) Loss aversion and individual characteristics, *Environmental Resource Economics* 49, 573-596.

[9] Masiero, L. and Hensher, D. (2011) Shift of reference point and implications on behavioral reaction to gains and losses, *Transportation* 38, 249-271.

[10] De Borger, B. and Fosgerau, M. (2008) The trade-off between money and travel time: a test of the theory of reference-dependent preferences, *Journal of Urban Economics* 64, 101-115.

[11] Walker, J.L. (2001) *Extended Discrete Choice Models: Integrated Framework, Flexible Error Structures and Latent Variables*. PhD Dissertation, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology.