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The market potential for plug-in hybrid and battery electric vehicles in Flanders: A choice-based conjoint analysis

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ABSTRACT

This paper considers the market potential for battery electric and plug-in hybrid electric vehicles in Flanders, Belgium. Making use of a large-scale survey conducted in 2011 and applying a choice-based conjoint experiment, it is predicted that by 2020, battery electric vehicles could have a market share of about 5% of new vehicles, and plug-in hybrid electric vehicles could have a share of around 7%. By 2030, these figures could increase to 15% and 29%. The speed of up-take of electric vehicles, however, is sensitive to purchase costs.

1. Introduction

The interest in electric vehicles (EVs) has waxed and waned over recent decades. In the mid-1960s, with concern over air quality, between 1974 and 1981 with concerns about imported petroleum security, and from 1985 with a renewed interest in reducing petroleum import and abatement of pollutants from automobiles.

The interests in modern EVs have arisen largely because of characteristics that differ from conventional petrol or diesel vehicles. Their ecological impact can be less when renewable energy such as wind or solar energy is used, the battery can be charged at home, the running costs are low and their acceleration, up to 50 km/h, is relatively very swift. Nevertheless, EVs still have some disadvantages: the purchase price is on average €10,000–€15,000 higher than conventionally fuelled vehicles, charging a fully drained battery can take up to 8 h, there is a lack of public charging infrastructure, and the driving range is limited to 100–200 km.

2. Methodology

2.1. Choice-based conjoint theory

There are numerous methodologies within the stated preference approach. Conjoint analysis is a multivariate technique that evaluates respondent trade-offs among multi-attribute alternatives to estimate consumers' utility functions (Green et al., 2001). Assuming that consumers choose the alternative that maximizes their utility, the conjoint methods map the preference structure of consumers based on their evaluation of the product's attributes (Lancaster, 1966). From the pool of conjoint techniques, the choice-based conjoint (CBC) methodology uses discrete choice models to collect consumer preferences. The respondents must select the product that fits them best among competing alternatives. This makes the choice experiment more realistic and it gives a better predicted accuracy, especially in market simulations (Chakraborty et al., 2002).

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In the CBC experiment, the respondent is confronted with a choice of alternatives. Each alternative is called a profile and their combination into a competing environment is called a choice-set. Table 1 illustrates a simple choice-set.

First, the respondent has to investigate the vehicle attributes – price, maximum speed and driving range – before evaluating which of the attributes is the most important. The respondent then looks at the attributes and their values. Finally, he/she must choose the vehicle for which the combination of attributes gives the highest utility. This process is called a task. Finally, a non-option is added to the task. This way, the respondent chooses the vehicle that gives him the highest utility, and subsequently indicates whether to purchase the vehicle.

2.2. CBC design

In a CBC experiment, the respondent evaluates the profiles based on the considered attributes and chooses the option that gives them the highest utility. It is assumed that the respondent processes its utility by summing up the utility brought by each attribute. As a result, our experiment needs to include every attribute that can influence the utility of the respondent to simulate as close as possible the real decision making process. The survey, however, needs to limit the number of attributes if the choice task is to be processed effectively by the respondent (Hair et al., 2010). Based on a selection of similar studies, eight vehicle attributes were identified as seen in Table 2.

A test survey was conducted at the yearly Brussels Motorshow (January 2011) to help select attributes using face-to-face interviews. The main outcome was that a factor reflecting the prestige and quality of the car was missing in the model the car purchase model and thus "brand-image-design-quality" was added. Further, to ensure respondents interpret vehicle attributes the same way, in the final survey, before starting the CBC experiment, they received an overview of all vehicle attributes setting out their measurement and definition (Table 3).

The attribute levels have to be communicable (Hair et al., 2010). The selected levels, as illustrated in Table 4, were therefore indicated by quantitative measures that can easily be understood by respondents.

Within refuel or charging time, the first level refers to inductive charging systems, where the battery of the electric vehicle is charged when driving or standing still on an installed coil, in which a magnetic field is created. Also, the vehicle attribute "brand/image/design/quality" is expressed on a one to five star scale to make the vehicle attribute actionable. The respondent has to make a trade-off between levels and thus has to be able to compare attribute levels.

After identifying the attribute levels, prohibited pairs are eliminated. This approach involves the elimination of any unbelievable profiles resulting from inter-attribute correlation. For example: when the randomized CBC design chooses the "never" level from the refuel or charging time vehicle attribute, two other attributes become obsolete: driving range and refuel or charging infrastructure alongside the road. At that moment, both attributes are set to "not applicable".

The respondents do not rate the alternatives; they choose the best option. Adding many profiles in the choice-set does not entail a rich added statistical value. However, studies have shown that respondents are efficient with processing choice-sets with up to four profiles (Orme, 2009). In this experiment, three profiles were given in each choice-set. Johnson and Orme (2002) suggest this is a good number of profiles, whilst not burdening the respondents.

To generate partial fractional designs, we used the shortcut method (Johnson, 1994) because it satisfies the most the additive rule assumption. This ensures that only main effects are considered in the model. Three hundred questionnaires were generated, each with ten choice tasks. In practice, one questionnaire version is sufficient to design. Multiple versions provide the shortcut method with more flexibility in respecting the orthogonality of the questionnaires as it can produce a wider range of unique choice tasks. The respondents thus answer a larger set of trade-offs, reducing potential biases of a unique questionnaire.

After the results of the conjoint analysis have been gathered, the information has to be processed using a utility estimation method. Multiple regression and multinomial logit models have been a standard during many years for estimating the conjoint model. However, the development of the Bayesian estimation method (Hierarchical Bayes, HB) has recently changed the landscape (Hair et al., 2010). It provides an accurate method to estimate individual level utilities, keeping the heterogeneity of the population intact (Gelman et al., 2009). In particular, HB has proved to be efficient and accurate with CBC experiments (Wellman and Vidican, 2008). It is therefore the selected method to estimate the utilities for this experiment.

3. Results

The target group for this survey was citizens of Flanders, older than 18 years. The data collection in May 2011 was in collaboration with a recognized market research company (iVOX) and involved 2037 people of which 1197 fully responded. The

Table 1
Choice-set.

	Vehicle A	Vehicle B	Vehicle C
Price	€12,500	€17,500	€15,000
Maximum speed	160 km/h	180 km/h	150 km/h
Driving range	400 km	600 km	500 km