Mayland University
16 January 2015

Formation of preferences and attitudes in the choice of Electric Vehicles

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Motivation

It is more than 20 years that researchers have been interested in EV and in understanding what drives individuals choice for this type of vehicles.

There has been an ample discussion around EVs, among researchers but also in the medias. Several people do have some knowledge about them, though very few have directly experienced an electric vehicles.

The risk with these new products (i.e. a product that individuals do not know well and have not experience with) is that there might be a misconception about the impact they can have on the individual's daily life.

Lack of knowledge and experience affect individual choices (preferences and attitudes) and our estimates of them. Consequently also the prediction of the possible market penetration.

Content

In this workshop I will present the results of a research carried out to investigate to which extent:

- preferences and attitudes for EV change as individuals acquire **direct experience** with the new technology and how it affects their live
- preferences for EV are affected by **indirect experience**, i.e. information on experience acquired by others and by the expansion of the EV market
- the direct and indirect experience affects our **predictions** of the market penetration.

Effect of direct experience

Methodology:

- long panel survey where individuals were interviewed before and after they had experienced (i.e. used in real life) an EV for 3 months.
- hybrid choice models jointly on the two waves to assess the change in preferences and attitudes.

Effect of direct experience

Long Panel survey:

The long panel survey was structured in two waves with a 3-month period in-between:

First wave Participants were asked to complete an internet survey, consisting of:

- background information
- a customised SC experiment
- a set of attitudinal questions

In-between Following the first survey, respondents received an EV, which they could use for three months as if it was their own.

Second wave After the 3-month period, respondents were asked to complete, again, exactly the same survey that they had completed in the first wave.

Effect of direct experience

SC experiment:

It consists of a binary choice between a conventional car (gasoline or diesel) and an electric vehicle.

The SC experiment was customised based on:

- the (most likely next) family purchase.
  Respondents could choose among seven car classes
- the km driven on average during a week.

The attributes included were:

- purchase price, driving costs, driving range, top speed, carbon emissions
- charging possibilities (*in the city, at the road network, at work*) and battery lifetime

The attitudes measured were:

- environmental concern, technology interest, safety concern and scepticism.

Effect of direct experience

Sample recruitment:

Recruitment process:

Individuals were randomly selected among more than 10,000 households that applied voluntarily in response to an advertisement sent out in the local press.

Target sample:

- electric installations characteristics at home.
- access to a private parking space, which was needed to install a designated charging device.
- had bought a car within the last 5 years or intended to buy a car within the next five-years.

Sample gathered:

After a check of the data, to ensure that the same respondent answered in both waves, the dataset with complete answers included 369 individuals and 5904 SC observations .

Choice of Electric Vehicles

Hybrid joint choice model

Latent attitude

(*w* =1,2)

$$LV_q^w = k^w + \boldsymbol{\lambda}^w \mathbf{SE}_q + \omega_q^w$$ $$\omega_q \approx N(0, \sigma_\omega^2)$$ Structural model

$$I_{kq}^w = \gamma_k^w + \delta_k^w LV_q^w + \nu_{kq}^w$$ $$\nu_{kq} \approx N(0, \sigma_{\nu_k}^2)$$ Measurement model

Discrete choice

$$\begin{cases} U_{qjt}^w = V_{qjt}^w + \alpha_j^w LV_q^w(\omega_q^w) + \eta_{qj}^w + \varepsilon_{qjt}^w \\ \tilde{U}_{qjt}^{w=2} = \phi U_{qjt}^{w=2} \end{cases}$$

$$\varepsilon_{qjt}^w \approx EV1(0, \sigma_{\varepsilon^w}^2)$$
$$\eta_{qj}^w \approx N(0, \sigma_{\eta^w}^2)$$
$$\phi\sigma_{\varepsilon^{w=1}}^2 = \sigma_{\varepsilon^{w=2}}^2$$

Structural model

$$y_{qjt}^w = \begin{cases} 1, & if\ U_{qjt}^w = \max_i \{U_{qi}^w\} \\ 0, & otherwise \end{cases}$$

Measurement model

Choice of Electric Vehicles

Modelling results

The final model estimated includes 79 coefficients:

- 45 in the discrete choice model (DCM)
- 33 in the latent variable model (LVM)
- 1 scale factor

Overall results:

- For half of the attributes in the DCM, individual preferences were significantly different before and after the direct experience with an EV.
- The scale between waves was not significant (as expected)

Choice of Electric Vehicles

Modelling results

	Before		After		Before-After	
Attributes	**Estimates**	**t-test**	**Estimates**	**t-test**	**Estimates**	**t-test**
Driving range (EV) [100km]	0.78	4.28	1.62	6.61		
Top speed (0-120km/h) [100km/h]	2.81	2.24	5.24	3.90		
Top speed (120-160km/h) [100km/h]	1.17	3.59	0.06	0.15		
Purchase price [100.000DKK]					-0.59	-7.24
Purchase price * Car class Mini	-1.81	-3.19	-3.16	-3.39		
....						
Latent environmental attitude (EV)					1.86	5.12

- individuals' concern about driving range doubled after the direct experience
- the effect of top speed is not linear and double after the direct experience.
- preference for EVs is higher for smaller car classes than for larger car classes.
- people with higher environmental concern have a greater preference for Evs. But, the effect is not affected by the EV experience.

Choice of Electric Vehicles

Modelling results

Attitudes towards the environment did not change before and after people have a direct experience with EV, nor its effect in the preference for EV. This was expected.

However, after respondents gained experience, they expressed:

- less scepticism about having to remember to charge the EV
- less scepticism about the power of EV to make a safe take over

- more scepticism about being able to maintain current mobility (they had to cancel some activities).

Interestingly, there is a large difference among respondents depending on how many days (during the three months) they actually used the EV. The more people used the cars the more marked were the above effects.

Effect of indirect experience

With **indirect** experience we refer to the information that individuals can get from the direct experience of other people and by getting used to the market (observing the market growing)

Methodology:

Participants were asked to complete an internet survey, consisting of:

- background information
- a customised SC experiment
- a set of attitudinal questions

Effect of indirect experience

The SC experiment consisted of a binary choice between a conventional car (gasoline or diesel) and an EV (plus opt-out option).

The SC experiment was customised based on:

- the (most likely next) family purchase.
- the km driven on average during a week.
- the duration and frequency of the parking in public spaces

The attributes included were:

- purchase price, driving costs, driving range,
- # of parking spaces reserved for EV, parking cost
- # of EV bought in Denmark
- information from a good friend on his/her experience with an EV regarding:
  - driving range
  - using the reserved parking spaces
  - need to modify activity schedules when using an EV

Effect of indirect experience

Sample recruitment:

Recruitment process:

All individuals who had applied voluntarily in response to the advertisement to try an EV, were contacted again (so far 11,200).

Target sample:

- Individuals belonging to families owning at least one car
- Individuals who have recently used the car to a destination where it is difficult to find parking spaces.

Sample gathered:

After excluding those who have changed email or nation, and those who do not have a car or never had problems in finding a parking space (approx. 20%), we got:

- approx. 1,600 respondents (and 9,600 observations)
- approx. 30% are the same as the previous survey on direct experience

Effect of indirect experience

Preliminary results

After the SC experiment, we asked individuals whether they had considered all the attributes when choosing the scenarios presented.

45% considered all attributes
55% did not considered all the attributes

Attributes not considered:

5%	Purchase price
4%	Driving cost
4%	Operation range
15%	Cost of parking
14%	Number of parking space
19%	Number of EV recently bought in Denmark
15%	Comments of your friend about parking space
11%	Comment of your friend about the range
12%	Comment of your friend about changing activities

Effect of indirect experience

Preliminary results

Attributes	Estimates	t-test
Driving range (EV) [100km]	0.14	11.10
Purchase price [100.000DKK]	-0.12	-11.71
Parking Cost [100.000DKK]	-0.01	-8.16
Monthly Fuel Cost [100DKK]	-0.08	-7.23
# of Parking spaces reserved [100]	0.27	3.83
Positive information on Range	0.41	2.44
Positive information on Parking	0.07	0.40
Positive information on Activities	0.33	1.98
N. of EV bought [100]	-0.006	-0.40

Indirect positive experience seems to be relevant, especially for range and the possibility to realised the activities planned (flexibility).

Effect on prediction of EV penetration

Using choice models to simulate the EV market share is problematic, because the current market share used to recalibrate the model in the base year is very low.

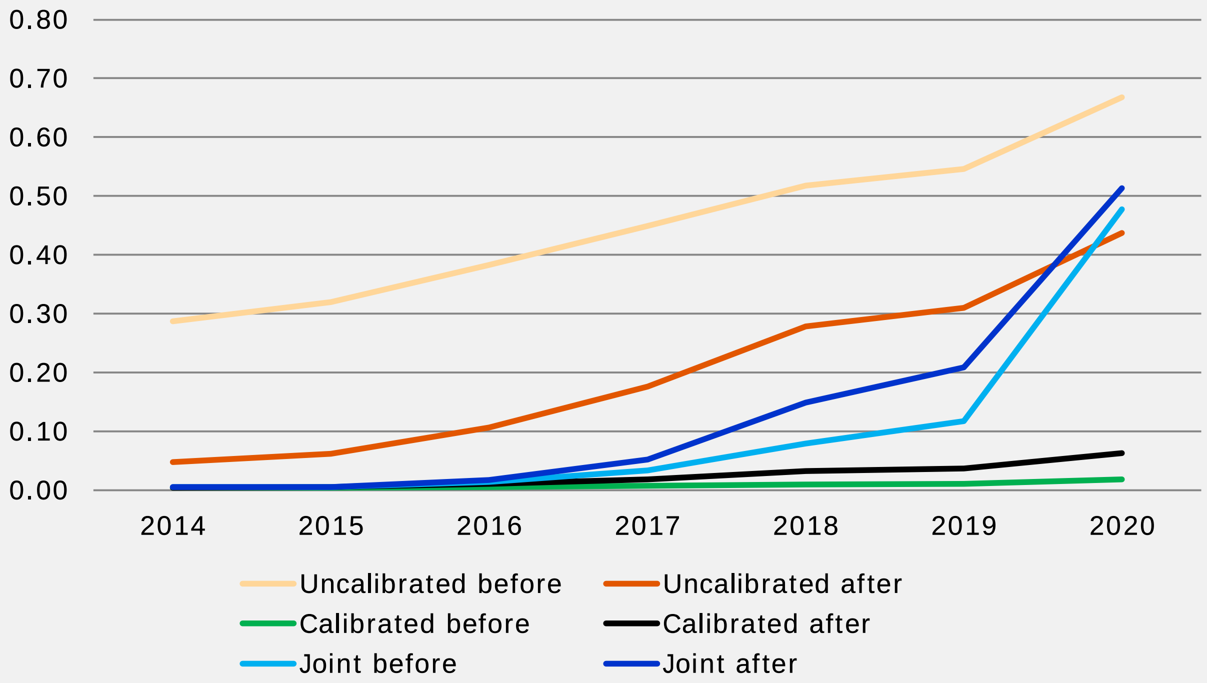
This means that even with major improvements of the EV attributes, a low market share is obtained in prediction.

Moreover, when predicting the market for new products it is crucial to account for the role played by innovation and how it penetrates the new market over time through a diffusion process.

"The diffusion process has been defined as the process by which an innovation is communicated through certain channels over time among the members of a social system"

(Rogers, 2010)

Effect on prediction of EV penetration



Results show that a model estimated after individuals had real-life experience with electric vehicles produces what appears to be more reasonable aggregate market shares, especially for the base year.

Effect of experience in the choice of EV

Conclusions and some policy indications

Results indicate that:

- Preferences and some attitudes differed after having tried an EV (results depended also on the type of EV used in the experiment)
- The environment plays a role in the choice of EV. Being pro-environment is highly significant BUT it is not enough to boost demand.
- Technical improvements are needed to face the problem of "flexibility".

- People need to be informed about how EV work. The right information can prevent some misconceptions and unjustified negative preferences.

  (e.g. *that charging at home is easy to do and to remember)*
- Campaigns can be targeted for the right category of people:

  (e.g. young people without a family yet , people who mainly travel in the city, people with more than one car)

- Policy forecast cannot be based on individual preferences estimated from a sample of people without experience and without a market of reference.

Many thanks

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Additional info: direct experience

In our sample : 51% have only one car; 49% have two or more,

In Denmark in 2012, 60% of Danish households owned a car; 76% of these have one car, 24% had two or more

The SP were generated by pivoting around the attribute reference values according to an orthogonal main-effects design. All attributes were treated as alternative specific and varied among 4 levels, except for the possibility of charging at work where it was only either “possible” or “not possible”.

The final design matrix consisted of 64 scenarios, divided in 6 blocks of 8 tasks each.

Information about attitudes was collected by means of 27 attitudinal statements covering topics assumed relevant for the choice of an EV.

In Denmark, the maximum range was set to 200km

On average the EV was chosen in **31%** of the cases before trying the EV and only in **17%** of them after. The **largest decrease** in EV share between before and after occurred in the **Mini** and **Intermediate** car classes (the car used in the trial was a small car).

Additional info: direct experience

we tested several non-linear specifications, including logarithm and power functions. We found that the marginal utility of one extra kilometre is clearly much higher for the EV than for the ICV. Since the driving range is much smaller for the EV than for the ICV, this difference might indicate presence of non-linear effects in the marginal utility.

Top speed is another attribute that varies significantly before and after individuals have tried an EV. We tried several non-linear specifications for top speed and we found that the piecewise linear utility function gave the best results.

Clearly, top speeds below 120km/h are not acceptable and have a significant impact on the demand for EV.

The other variables where the effect also changes after experience are **fuel cost, battery life and charging in city centres and train stations**. Regarding fuel cost we found a factor of 2.5 between the EV and ICV coefficients (similar to Glerum et al., 2011). The EV coefficient is stable between waves, whereas the ICV fuel cost coefficient is more negative after the experience and closer to the preference for the EV electricity.

Citroen C1 rebuilt

Choice of Electric Vehicles

Several papers have studied the characteristics of green vehicles

Relevant characteristics widely studied are:

Against EV

- Selling price / change of battery
- Driving range
- Duration of the recharge
- Availability of recharging points
- Acceleration/ top speed
- Space for luggage

Flexibility.

Fit daily needs, long trips (holidays) or unexpected events

Pro EV

- Fuel/electricity price
- Pollution
- Noise of the engine

Let M_{EV} be the market potential of the EV alternative and Y_{t-1}^{EV} be the cumulative number of V sales before time period *t*. The number of EV sales in period *t* is then calculated as:

$$S_t^{EV} = (M^{EV} - Y_{t-1}^{EV}) \cdot \Pr(EV_t),$$

Or more specifically as:

$$S_t^{EV} = (M^{EV} - Y_{t-1}^{EV}) \cdot \frac{\exp\left[ASC^{EV} + q^{EV} \cdot (t - \tau^{EV} + 1) + \lambda\left(\beta^{EV} \cdot x_t^{EV}\right)\right]}{\exp[ASC^{ICV} + \lambda(\hat{\beta}^{ICV} \cdot x_t^{ICV})] + \exp[ASC^{EV} + q^{EV}(t - \tau^{EV} + 1) + \lambda\left(\hat{\beta}^{EV} \cdot x_t^{EV}\right)]}$$