Modelling car purchasing behaviour: a disaggregated consumer segmentation approach

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International BE4 Workshop: Including Behaviour in Energy/Engineering/Economy/Environment models

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Transport behaviour change is not just about mode switch

- **Purchasing** - *which* cars are bought, and *by whom*
- **Driving** - *how* cars are driven
- **Use** - *how much* cars are driven

- Mode choice
- Car occupancy
- Timing
- Route choice
- Frequency
- Trip-chaining
- Destinations / distance
- Parking
- Residential location choice
- Work location choice
- Substitution (eg with ICT)
Focus for today: Purchasing which cars are bought, and by whom

Starting point:
Psychology, Behavioural Economics, Sociology – have revealed a coherent view of the importance non-economically rational aspects of human [choice] behaviour
Too many determinants to model...

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<th>INDIVIDUAL SUBJECTIVE</th>
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<td>• Affective motives (fun, comfort)</td>
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<td>• Instrumental motives</td>
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<td>• Values</td>
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<tr>
<th>COLLECTIVE SUBJECTIVE</th>
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<td>• Group cultures/ shared norms</td>
<td>• Physical surroundings</td>
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<td>• Trust in others and in government</td>
<td>• Infrastructure/ technology</td>
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<td>• Contextual/ situational factors</td>
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<td>• The media</td>
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Anable, J. et al. (2006) An Evidence Base Review of Attitudes to Climate Change and Transport. For the DfT (updated table)
...but there is some good empirical work out there on modelling private car purchasing behaviour

Energy Technology Institute: Plug-in Vehicle Programme - Consumer study (2009-2010)
1. Plug-in Pioneers (2% (N=48))

2. Zealous Optimists (13% (N=348))

3. Willing Pragmatists (11% (N=306))

4. Anxious Aspirers (16% (N=439))

5. Uninspired Followers (19% (N=516))

6. Conventional Sceptics (13% (N=361))

7. Image Conscious Rejecters (18% (N=495))

8. Company Car Drivers (8% (N=216))

It's about time! Why wouldn't you?

Yes please. It would save me how much fuel?

Yes please, but make it a plug-in hybrid for now, thanks.

Will they save the planet? Don’t think so.

Great, but not sure where I would charge it.

If everyone else is, then, maybe...

With my mileage? Convince me.

I’d never be seen in one of those!
The top **factors** that distinguish groups relate to barriers to/enablers of plug-in vehicle uptake:

- PIVs generally have **lower running costs**
- PIVs have a **high price premium** over non-PIVs
- **Supply of PIV models is limited**, in terms of vehicle segments (eg supermini, small family) and brands
- **Limited availability of charging infrastructure** (at home, public)
- Consumers are concerned by PIVs’ **shorter range** ...
- ... and **longer charging times**
- The majority of private vehicle buyers are not currently receptive to PIVs (**acceptance**)...
- ...or not aware of them or any incentives (**awareness**)...
- **NB:** mainstream attitudes to PHEVs are very positive, but most have strong reservations about pure BEV
Preferences for/against plug-in vehicles shows substantial variation across consumer segments.

- **Enthusiasts** are willing to pay a premium.
  - All show preference for PHEVs.
- **Mass market buyers** strongly reject BEVs but not PHEVs (as much).
  - Most segments have a strong bias against BEVs.
- **Enthusiasts** are willing to pay a premium.
  - Mass market buyers strongly reject BEVs but not PHEVs (as much).
Example: Perceived cost (disutility) for consumers with overnight charging but no access to day charging, medium (C/D) car, 2016

The previous section introduced choice modelling and described how the approach can be used to combine consumer purchase priorities with vehicle attributes to forecast the market share of EVs to 2030.

This subsection provides an overview of how the choice model, once constructed, can be used to develop a market pathway.

Identifying action targets to address barriers

In addition to analysing the main barriers (as per the example shown in Figure 28), the choice model can also be used to forecast how the market share would change under a set of action targets, defined as intervention(s) or measures designed to promote uptake.

Note on terminology

In this report, the term 'pathway target' is used to define a specific market share target for key years (in most cases as set by the Committee on Climate Change in commissioning this report, e.g. EV market share should reach 60% by 2030).

The term 'action target' is used to describe a type of policy measure or intervention which could be used to increase EV market share in order to achieve a required pathway target (e.g. implementation of a public promotion programme to increase level of awareness to 100% by 2021 as part of larger strategy to meet 60% pathway target for 2030).

To address the key barriers identified in the previous sections, action targets are defined for each of the following areas:

- Supply of EVs: a trajectory is developed based on announced model releases;
- Equivalent value support: to mitigate the cost premium of EVs and/or compensate for the loss of utility. In the model, this is effectively an intervention on the vehicle price seen by buyers in the showroom, in practice it can be delivered by non-financial measures, as discussed later in this report;
- Charging infrastructure: this encompasses the level of access to overnight charging, the proportion of drivers who have access to day infrastructure and the charging rate available. The infrastructure in place also influences the driving range compatibility for fleet vehicles;
- Environmental impact: this encompasses the level of environmental impact and the type of energy source used.

Element Energy (2013)
Benefits of consumer segmentation

Using multiple segments significantly increased the explanatory power of the model

- Highlights attitudinal/demographic factors influencing PIV purchase decisions
- Allows reactions to different attributes (e.g. willingness to pay for EV range) to be captured explicitly (rather than within the error term of the model)
Integrating segmentation and vehicle choice into systems models

UK Transport Carbon Model
UKTCM | outline

UKTCM modelling framework

scenario variables (e.g. GDP, demographics, income, pre-tax fuel prices)

policy variables (e.g. vehicle taxes, speed limits, driver behaviour)

transport demand (pkm, tkm)

vehicle stock (total, new, scrapped)

partial equilibrium

energy & emissions (direct from vehicle use)

energy & emissions (indirect, non-use)

lifecycle energy & emissions (direct and indirect)

environmental impacts and costs (e.g. GWP, acidification potential, external costs)

view & export results (Access, Excel)
UK TCM | new car choice model

VEHICLE ATTRIBUTES
Y1 costs, annual costs, range, supply...

CONSUMERS
Attribute preferences
Travel and charging patterns

INFRASTRUCTURE
Home and public charging points

ECONOMICS AND DEMOGRAPHICS
Energy prices, car ownership, total sales

CHOICE MODEL
gives market share probability of each powertrain for each consumer segment

POLICY
Ownership and use taxes, fiscal incentives, regulation, standards

VEHICLE STOCK MODULE
Current fleet – includes a scrappage model

OUTPUTS
New vehicle sales (by powertrain, segment, etc)

Powertrains included: ICE (petrol, diesel, HEV, gas, bio, H₂); Plug-in (PHEV, BEV); Fuel cell (H₂)
A car choice model for each consumer segment, now including a ‘fleet manager’ segment

**Vehicle attributes**
- Private/user-chooser
  - Year 1 costs
  - Annual O&M costs
  + for AFV:
    - Access to home/public charging
    - Charging/refuelling time
    - Driving range
    - Model/brand supply
    - Consumer receptiveness (ASC)
- Fleet manager
  - Total cost of ownership (4 years)
  - Model/brand supply
  - Certainty of access to charging
  - Driving range

**Consumer WTP for attributes**
- Consumer preferences (latent variable ASC)

**Multinomial logit model to calculate market share probability of each powertrain for each consumer segment**

**Share of consumer segments**
- Attitudinal survey (n=3000) – 8 segments into 5 ‘private’ groups and 1 ‘fleet’ group
- Demographic/attitudinal influences captured through separate consumer coefficients for each segment

**Sale volumes for each powertrain**
- Calculated from car ownership model (household car ownership, vehicle scrappage)
- Total sales

**Total sales**
Run model for each vehicle size and consumer segment

Company Fleet manager 33%

Company User chooser 20%

Private Mass 24%

Private Enthusiast 7%

Private Aspirer 7%

Private Resistor 9%

Company Fleet manager 33%

Private Mass 24%

Private Enthusiast 7%

Private Aspirer 7%

Private Resistor 9%

Company User chooser 20%

NB Same private consumer split applies across vehicle segment, but private / fleet sales split and mileage vary across vehicle segments
Example: scenario analysis exploring UK Committee on Climate Change EV pathway for 4th and 5th carbon budget
UK CCC’s high EV uptake pathway:

- 9% market share for PIVs by 2020
- 60% market share for PIVs by 2030
- Indicative 100% market share for PIVs by 2040, so that, taking the stock turnover into account, the vehicle stock is ‘virtually decarbonised’ by 2050

- NB: in 2013 only 0.1% of new car sales were PiV; in 2015 so far they are higher at 1.2%
Assumptions for BASE vs CCC for 2030

3.2m new cars predicted in 2030 (UK tcm)
So PiV target is 60% of this = 1.92m

- **Baseline / REF scenario**
  - Company car tax regime unchanged beyond 2020
  - No plug-in car grant (£5k) beyond 2017
  - No infrastructure intervention
  - Certainty of access to charging for fleet only 40%
  - UKERC assumptions on vehicle costs, car CO2 / fuel efficiency improvements, etc.

- **Adapted CCC EV scenario**
  - All potential consumers ‘aware’ by 2026
  - Preferences ‘equalise’ once 25% of new market share (except Resistors)
  - Increase in overnight access and rapid network
  - Reduced charging times
  - Increase in certainty of access to charging for fleet to 65%
Achieving these ambitious targets may require transformative change in supply, demand, infrastructure and policy

- **Vehicle supply**: PIVs to be available in all vehicle segments and by all major brands by 2030 – *driven by car CO₂ regulation?*
- **Awareness and acceptance**: all potential buyers aware of PIVs by 2020s – *promotional campaigns, field trials, car clubs, neighbour effect to achieve critical mass for acceptance*
- **Charging infrastructure**: investment in high levels of overnight (mainly off-street) charging complemented by a national network of ~2000 rapid charging points for day charging to increase market base for PIVs – *public & private investment*
- **Equivalent value support**: for private and company/fleet buyers – to mitigate purchase price premium – *capital incentives, graded purchase tax/VED, innovative business models*
Plug-in vehicle sales (share of total)

In baseline scenario market collapses then picks up again

In CCC EV much higher uptake and pace in 2020s – plateau from 2030s?

100% will be difficult to achieve even in long term

Continued value support (PIV grant, ECA) needed

 CCC EV target

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<thead>
<tr>
<th>Year</th>
<th>BASE</th>
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<tbody>
<tr>
<td>2015</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2020</td>
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<td>2040</td>
<td>50%</td>
<td>70%</td>
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<tr>
<td>2050</td>
<td>60%</td>
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Battery EV take up by consumer segment (CCC high EV scenario)

BEV market driven by fleet manager segment ...

...and user choosers

Resistors keep resisting
Direct CO₂ emissions decrease for cars but offset by indirect emissions from electricity generation and other upstream/downstream emissions.
Be realistic:

- There are too many behavioural features to include in transport models (particularly given multiple actors in the system)
- Data does not readily exist on these behavioural features in different choice / national contexts
- Evidence – concentrates on behavioural features of private end users (not fleets, other decision makers, investors etc)

Be Interdisciplinary and apply mixed methods
Think outside the box:

- **Attitudinal factors** may be as important as socio-demographic and economic attributes, especially for private travel.
- **Differentiation** across segments can improve model fit.
- **System thinking** - many influences on transport service demands do not come from the transport sector (built environment, ICT, retail patterns ...)
- **Policy diversity** - using insights to develop new policy strategies beyond fiscal instruments.
Get in touch

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