WHAT DRIVES THE MARKET FOR PLUG-IN ELECTRIC VEHICLES?

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Agenda

1. Background & scope
2. Attributes for Comparison
3. Results
4. Conclusions
Vehicle sales of new technologies are hard to estimate but very important.

Idea: Compare market diffusion models and determine how they differ.
Scope

- **Focus on US and Europe** (esp. DE and FR)
- Paper should not be too detailed on mathematical description of approaches like *(Al-Alawi and Bradley 2013)*
- Better have a certain number of models with not too much detail than very detailed comparison of only a few models like *(Daziano and Chiew 2012)*
- Focus on models with a certain level of detail (simple top-down approaches that only model the vehicle stock with an equation for PEVs are not of interest)
- **No regional** or supranational **models**, but on country or state level
- **Only models for PEV**, no FCEV or NGV models

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Attributes for model (paper) comparison

A. Model design
- Research question
- Level of aggregation (highly aggregated to very disaggregated)
- Level of detail of data needed (Inputs)
- Main findings (Outputs)

B. Factors directly related to purchase decision
- Ownership costs (purchase price, operating cost (fuel and non-fuel), Resale price)
- Energy prices and taxes
- Decision alternatives (different drive trains / other transport options (e.g. car sharing))

C. Vehicle attributes
- Technological improvements (battery technology, energy consumption)
- Vehicle size and user group (private vs. commercial) segmentation and model diversification (make)
- Vehicle availability / supply constraints
- Other vehicle attributes (vehicle comfort (range, noise, …), vehicle power, emissions)

D. Consumer attributes
- User characteristics (e.g. income, vehicles per hh, people in hh, adopter groups, consumer preferences, mileage)
- Interaction between users

E. Special PEV factors
- Inclusion of charging infrastructure (Differentiation of private, work, public)
- Range anxiety / BEV driving range and recharging times
- Direct and indirect policy incentives and policy regulations

Focus of this presentation

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Agenda

1. Background & scope
2. Attributes for Comparison
3. Results
   1. Results on model design
   2. Results on model attributes
   3. Stated vs. incorporated important input factors
4. Conclusions
How do model types differ between countries and over time?

Main findings:
- Model types vary between countries
- Tendency to more disaggregation and detail in recent years (even into more detail in Germany)

**Aggregated:** only vehicle stock modeled  
**Sales modeled:** some differentiation of user groups possible  
**Disaggregated:** Individual users with their characteristics modeled
Research questions and their evolution

**Before 2014**
- 28 research questions
- 21 models

**After 2013**
- 25 research questions
- 14 models

**Main findings:**
- Policy measures and impacts of PEVs more often analyzed in newer papers
Outputs (1) - *In almost all papers PHEV have equal or higher sales shares than BEV in near future.*
Outputs (2) - PHEV have equal or higher sales shares than BEV, also in 2050, but only few models run until 2050.

But, are all limitations covered “correctly” in models until 2050? Uncertainty also because of uncertain input factors.
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   2. Results on model attributes
   3. Stated vs. incorporated important input factors

4. First Conclusions and further steps
How does the policy inclusion differ between countries?

<table>
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<tr>
<th>Research questions</th>
<th>ALL</th>
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<th>US</th>
<th>Other</th>
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TOTAL: 39 9 16 14

Main findings:
- Half of the models do not include any policy measures
- Only two models include indirect incentives (in three different papers)
- Only a few cover regulations, more of the US models

Direct incentives: directly given to customer on purchase
Indirect incentives: user might profit during use (e.g. car pool lanes)
Regulations: e.g. CAFE standard
Color indicates highest numbers in column.
Inclusion of technology improvement, charging infrastructure and vehicle attributes

Main findings:

- Charging infrastructure not included in 15/40 models, rarely endogenous (11/40)
- The limited range of BEVs is not considered in one third of the models (16/40)
- Explicit modeling of range anxiety or charging time is very rare (5/40 each)
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What were “important factors stated” by authors and do they differ in countries?

Main findings:

- A lot of factors are stated to be important after the analysis (16 different factors in 40 models)
- Factors with “n/a” were not investigated by us
- Some country-specific differences:
  - For the US vehicle cost seems to be most important
  - For Germany, energy prices and other factors tend to be more important
  - Very heterogeneous in other countries
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Discussion

- This kind of research is only qualitative and comparison should not be quantitatively interpreted.

- We tried to be as cautious as possible, but a misinterpretation of some facts in papers from our side is possible.

- Not detailed on mathematical description of model, but that was beyond the scope of our research.

- We may also have missed other attributes, but these seemed to be the most important ones to us (which was confirmed with the analysis on most important factors).
Apart from purchase price and operating cost, some important attributes should be covered in future models for PEV market diffusion.

- Several models lack the important features of PEVs:
  - Limited range of BEVs (not covered by 16/40 models)
  - Charging infrastructure and time (not covered by 15/40 models)*
  - Technological and cost improvement of batteries over time (not covered by 15/40 models)
- Some segmentation is helpful since not all vehicle buyers are equal, e.g. regarding:
  - Product segmentation (e.g. vehicle size)
  - Consumer segmentation (e.g. driving distance, adopter groups)
- PEV model and make availability should be considered in the early market

**Current (and future) policies should be considered in model development.**

- Future models should be capable of incorporating policy regulations (CAFE, CO₂ limits for vehicle sales).
- Incorporation of indirect incentives is difficult (since often on local level), but could largely influence PEV market diffusion. These should be considered for incorporation or discussion.

**Authors of future papers should mention important factors for PEV market diffusion especially if they have some quantitative evidence.**

* for detailed analysis with distinction of home/work/public
Important factors vary between countries but could indicate future evolutions.

- Current focus on purchase prices and vehicle attributes in the US.
- More weight on energy prices in Germany to date. Yet, this could become more important for US if energy prices rise.

Models should not be interpreted beyond the focus on their research question.

- Only some results can be compared, e.g. PHEV vs. BEV shares
- Research questions change over time and models are extended. More complexity in models in more recent years to cover more factors which makes interpretation more difficult.

Models can’t predict an exact market share (a crystal ball is a false expectation), but they help to understand what influences market diffusion (drivers and barriers).

- Large variety of results and heterogeneity of research questions found.
- Different changeable factors (e.g. vehicle attributes) and external input factors (e.g. energy prices) influence them and a large variety of these factors can be observed (16).
Thank you for your attention!

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