Representation of heterogeneity and consumer behavior in the transport sector

Stylized or Explicit?
Non cost barriers in consumer choice

- Adoption of new vehicle technologies rely on consumer purchases
- Energy efficiency research shows that end-users do not purchase energy-efficient technologies based solely on a cost-effectiveness criterion (Mundaca et al. 2010)
- Referred to as “inherent characteristics of real world behaviour in decision-making” or as barriers to optimality (Wilson and Pettifor, 2014)
Key question

- Most IAMs represent investment decisions in technology as done by a **homogeneous** and ‘**unboundedly rational**’ end user.

- How can represent in our models influences on vehicle choices beyond costs and prices, in order to improve our evaluation of energy efficiency and climate policies?
  - Can we use a simple model to represent this complex issue? (given scope of IAMs, data quality)

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This is **not new**!

Decision Science, Marketing, Econometrics, Bio-statistics

- Surveys, experiments to support discrete choices, data enrichment and comparison of data
- Improve theory and modelling methods to describe individual and aggregate choice behavior.
- How to model and project choice response to changing opportunities
Outline

1. Model Comparison
   - Non monetary factors (disutility costs) disaggregated over different consumer groups implemented in MESSAGE and IMAGE
   - Different type of models, lead to different results
   - Compare results to identify robust insights

In both models:
- Transport activity is related to population, income, mode costs, speed
- Techno-economic parameter for each technology are exogenously assumed.
- Technologies compete with each other based cost per passenger km
- Technologies modelled are ICE, HEV, PHEV, Fuel Cell, EV
MA³T Model disutility costs

Lin, 2009. Oakland Ridge National Laboratory

- Limited EV Range “anxiety”
- Refueling Station Availability
- Model Availability
- New Technology Risk Premium

So, this data set only includes additional barriers for electric and fuel cell vehicles

- Early technology adopter
- Late technology adopter
27 Consumer groups

Light-Duty Vehicle Consumers/Drivers

Early Adopter
- Urban
- Suburban
- Rural

Early Majority
- Urban
- Suburban
- Rural

Late Majority
- Urban
- Suburban
- Rural

Frequent Driver
- ...

Average Driver
- ...

Modest Driver
- ...

Attitude toward technology/risk

Settlement Type

Driving Intensity
Scenario results US - baseline

**Without disutility cost**

**With disutility cost**

No electric vehicle adoption
Scenario results US - mitigation

- Slower phase out of oil
- More cars on biofuel
- More heterogeneity

Without disutility cost

With disutility cost
Vehicle choice model in IMAGE

\[ Share_{i,t} = \frac{\exp(\lambda \times \text{Cost}_{i,t})}{\sum_i \exp(\lambda \times \text{Cost}_{i,t})} [-] \]

- \( \lambda \) = large \( \rightarrow \) full optimisation
- \( \lambda \) = 0 \( \rightarrow \) indifferent
- \( \lambda \) = low \( \rightarrow \) heterogeneity
Influence of heterogeneity

27 groups

1 group

$\lambda = 100$
Influence of heterogeneity

27 groups

$\lambda = 50$

1 group
Influence of heterogeneity

27 groups

1 group
\( \lambda = 10 \)
Vehicle choice model in IMAGE

$$Share_{i,t} = \frac{\exp(\lambda_i \times Cost_{i,t})}{\sum_i \exp(\lambda_i \times Cost_{i,t})}$$
Differentiating in the 27 groups

Resembles 27 groups better than original
Conclusions and ways forward:

• Logit parameterization can reflect explicit representation of heterogeneity
  ➔ Explore other modelling methods of heterogeneity

• Consumers perceive high non cost related barriers to buy electric or fuel cell cars, therefore high dependence of cars driving on biofuel in a mitigation scenario
  ➔ Low biomass scenario
• Current disutility cost are static which is a barrier for vehicle transition
  ➔ Endogenise disutility cost assumptions on refuelling stations, model availability
    • Subsidies for early adopters

• Lower disutility cost for green technologies…
Thanks for your attention.
Questions?