Improving the representation of modal choice into TIMES energy system models – A case study for Denmark

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Background and motivation

- TIMES is an energy-economy-environment-engineering (4E) model generator
- Partial equilibrium **optimization model**
- Identifies least-cost pathways for technology deployment to meet future energy service demands while complying with some environmental targets
- Powerful tool for long-term policy and scenario analysis in the energy system
- Bottom-up, technology rich model: it describes in detail the technical, economical and environmental characteristics of the technologies
- **Weak in representing consumer behaviour**: only one average-representative decision maker is considered
- Behavioural parameters cannot be neglected, as they are a fundamental aspect of decision making in the transportation sector

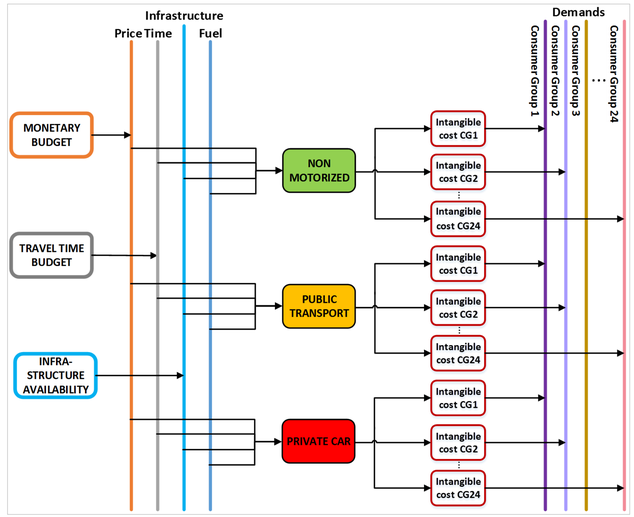
MoCho-TIMES model description

- **Mo**dal **Cho**ice in TIMES: It incorporates behaviourally realistic modal choice in TIMES
- The novel methodology is implemented in the standalone transportation sector of TIMES-DK, the intregrated energy system model of Denmark
- The methodology requires two steps:
  1. Divide transport users into heterogeneous groups with different modal preferences
  2. Incorporate intangible costs (disutilities) that assume different values across the diverse groups of transport users
- Each group of consumers chooses its optimal modes, thus resulting in a variety of modes each year
- Support model required to know how travel demand is distributed and to obtain the intangible costs. This model is the LTM (Landstrafikmodellen), the national inland 4-stage transport simulation model for Denmark, developed by Transport DTU

Modes and technologies in MoCho

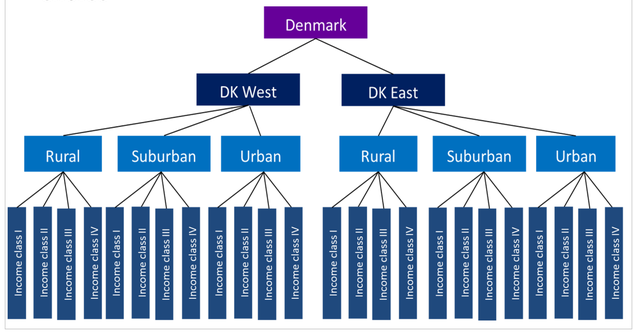
Category	Mode	Technology					
NON MOTORIZED	WALK	WALK					
	BIKE	NORMAL BIKE	ELECTRIC BIKE				
PUBLIC TRANSPORT	BUS	DIESEL-BIODIESEL BLEND BUS	NATURAL GAS BUS	FUEL CELL BUS	ELECTRIC BUS	HYBRID BUS	
	TRAIN	DIESEL-BIODIESEL BLEND TRAIN	ELECTRIC TRAIN				
	METRO	METRO ELECTRO					
	S-TRAIN	S-TRAIN ELECTRO					
PRIVATE CAR	PRIVATE CAR	DIESEL-BIODIESEL BLEND CAR	GASOLINE-ETHANOL BLEND CAR	NATURAL GAS CAR	ELECTRIC CAR	PLUG IN HYBRID CAR	FUEL CELL CAR

Scheme of MoCho-TIMES



Demand-side heterogeneity

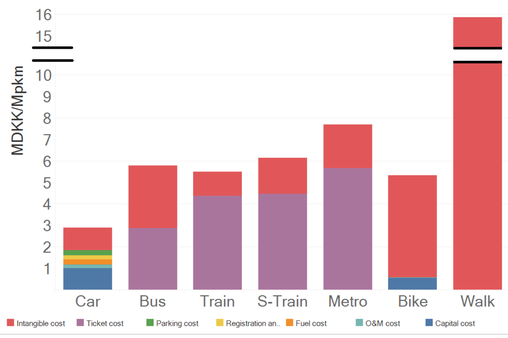
- The model represents 24 groups of transport users, characterised by homogeneous attitudes towards modal choice



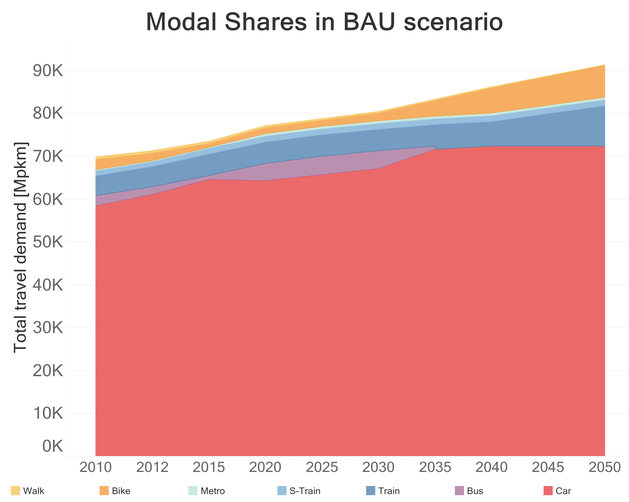
Intangible costs

- Different propensity towards mode adoption across heterogeneous transport users is captured through monetization, with intangible costs
- The same mode has associated different intangible costs depending on the demand segment it fulfills

$$Intangible\ Cost_{m,cg,y} = Level\ of\ Service_{m,cg,y} * Value\ of\ Time_{m,cg,y}$$

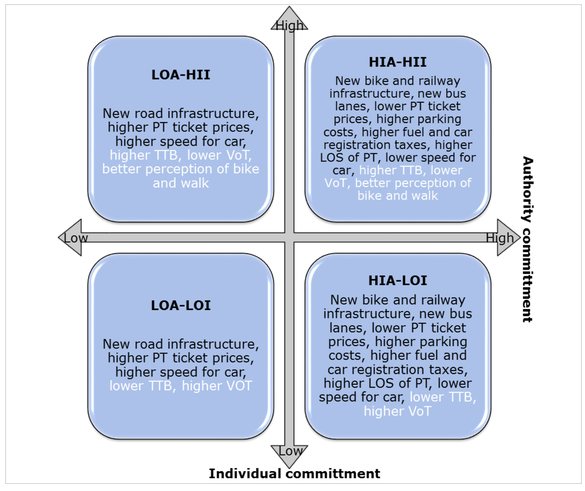


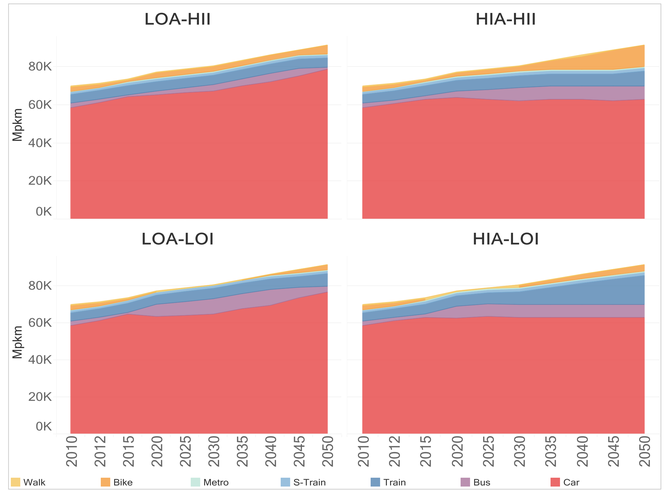
Results

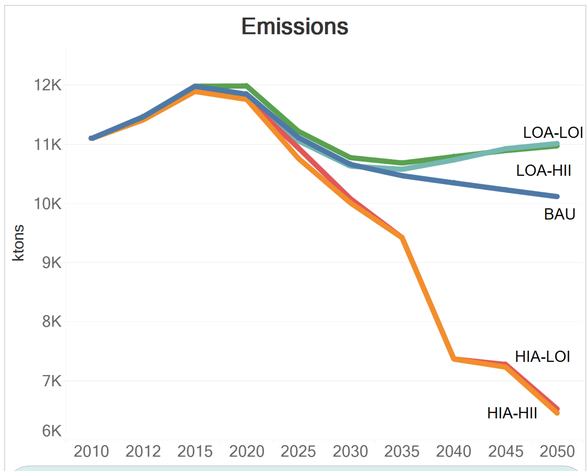


- The model endogenously determines the modal shares for each year until 2050
- In the BAU scenario the increase of travel demand is mainly covered by cars, with a significative contribution by trains and bikes
- MoCho-TIMES allows exploring how modal shift occurs in the different regions and in urban, suburban and rural areas
- The model provides an insight on the modes adopted by the different consumer groups in the future
- The robustness of MoCho-TIMES is tested in a scenario analysis involving alternative levels of service for the modes, consumer perceptions, taxation schemes, infrastructure deployments and incentives to public transport

Scenario Analysis







Note: Authority committment and in particular availability of infrastructure for transit and non motorized modes is fundamental to reduce CO_2 emissions

Conclusions and further work

- MoCho-TIMES incorporates modal choice within an integrated energy system framework
- The methodology presented can be easily replicated: it does not require editing TIMES code, but only changing the structure of the model
- A new set of variables is introduced in the model, regarding both the level of service of the modes and the consumer perception
- MoCho-TIMES improves the single "average decision maker" perspective and avoids the ”winner-takes-all” phenomenon
- Possible to understand barriers to adoption of more sustainable modes and to perform new policy analises
- Next steps:
  1. Incorporating the novel methodology within the rest of TIMES-DK
  2. Adding clones to improve the representation of variability of choice

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