Improving the representation of modal choice into bottom-up optimization energy system models

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MOTIVATION AND OBJECTIVE

- Bottom-up energy system models (E4 models) describe in detail the technical, economic and environmental characteristics of the technologies
- They are **weak in representing consumer behaviour**: only one average-representative decision maker is considered [1], [2]
- The behavioural dimension cannot be neglected, as it is fundamental in decision making in the transportation sector [3]
- This study proposes and discusses a novel methodology to incorporate modal choice within E4 models

METHODOLOGY AND MODEL

- The new approach has been named **MoCho-TIMES** (**Mo**dal **Cho**ice in TIMES)
- MoCho-TIMES has been tested for the standalone transportation sector of TIMES-DK, the TIMES energy system model of Denmark
- The methodology requires a transport model, consistent with the scope of the analysis, as a **support model** (Figure 1). For Denmark this is the LTM [4]

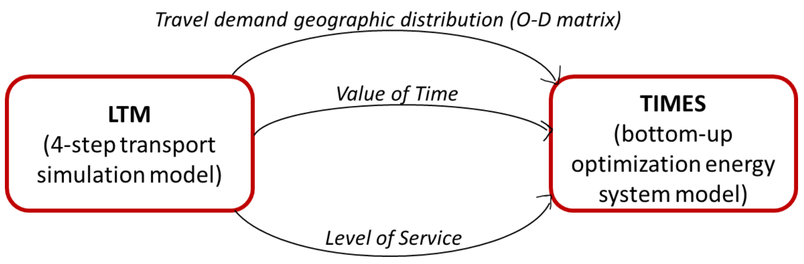

Figure 1: Data provided from the support model LTM to TIMES

- The methodology consists in two main steps:

1. DEMAND SIDE HETEROGENEITY

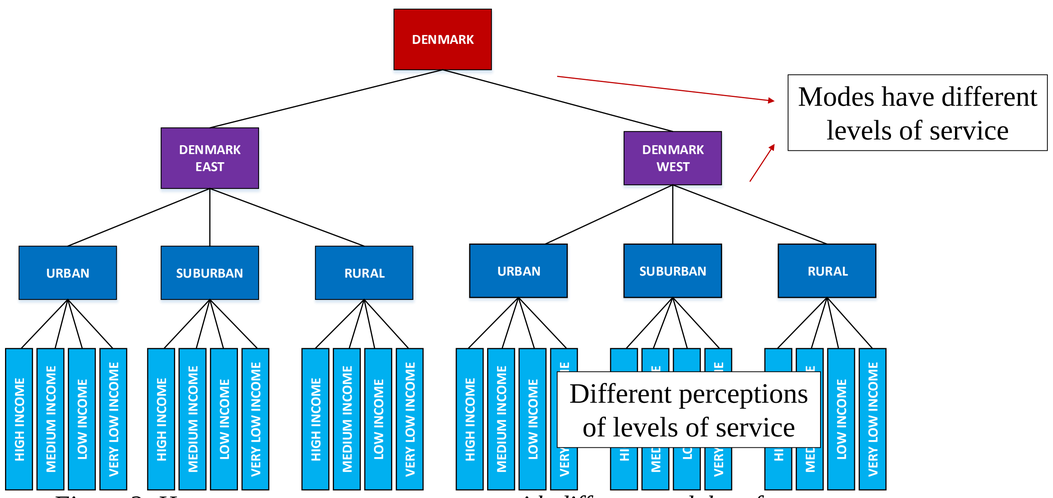

Figure 2: Heterogeneous consumer groups with different modal preferences

2. INTANGIBLE COSTS

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

$$Level\ of\ Service_{car} = f(Travel\ Time, Congestion\ Time, Ferry\ Time)$$

$$Level\ of\ Service_{public\ transport} = f(In\ Vehicle\ Time, Waiting\ Times, WalkingTime)$$

$$Level\ of\ Service_{non-motirized} = f(Travel\ Time)$$

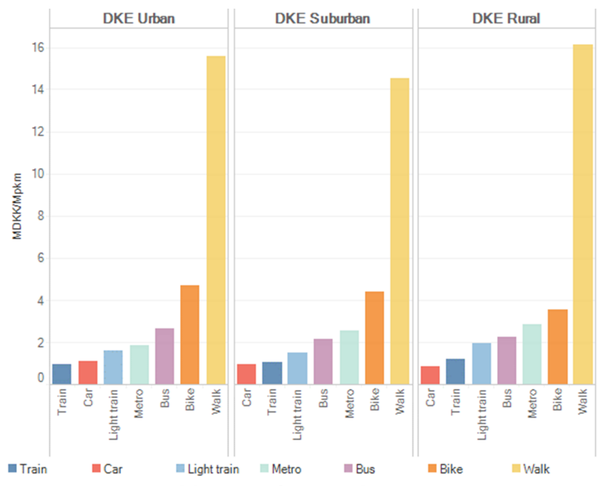

Figure 3: Intangible costs for very low income group in 2030

Income class	Personal income [100k DKK/year]	Weighted average VoT in 2010 [DKK/hour]
Very Low	0-200	50.8
Low	200-500	87.6
Medium	500-800	145.9
High	800-	240.5

Table 1: Value of time across income groups

MODEL STRUCTURE

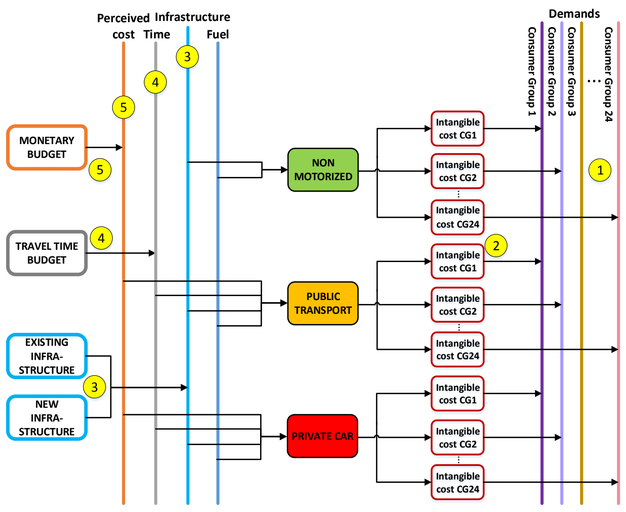

Figure 4: Scheme of MoCho-TIMES

1. Heterogeneity consists in a travel demand per each consumer group
2. Intangible costs are included as an additional cost for each mode and each consumer group
3. There must be enough infrastructure to accommodate the modal demand
4. Each mode has associated a time consumption (speed), subject to a travel time budget
5. The expenditure in car and transit is limited for each consumer group by a monetary budget, which accounts the perceived costs

RESULTS

1. Validation of MoCho-TIMES

MoCho-TIMES is reliable in determining modal shares because it is able to reproduce the results of its support model LTM satisfactorily (Figure 5).

2. Scenario Analysis

The model is tested under alternative assumptions regarding the variables in the scenario matrix (Figure 6). Results concerning CO_2 emissions and modal shares are presented in Figures 7-8.

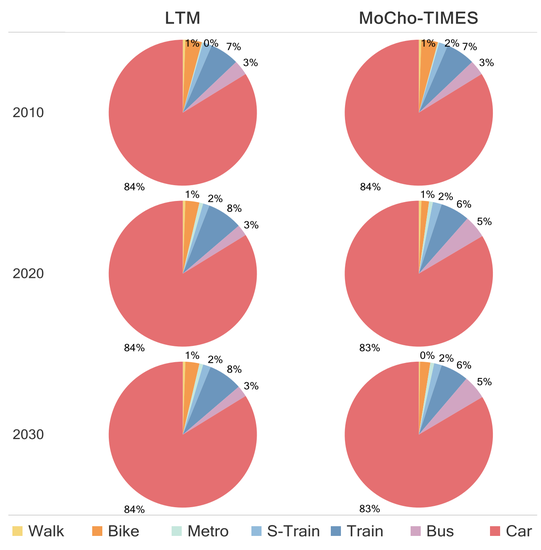

Figure 5: Comparison of modal shares between LTM and TIMES

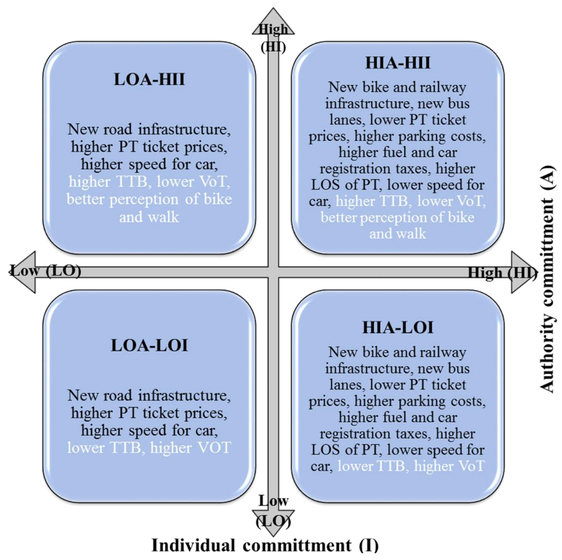

Figure 6: Scenario matrix

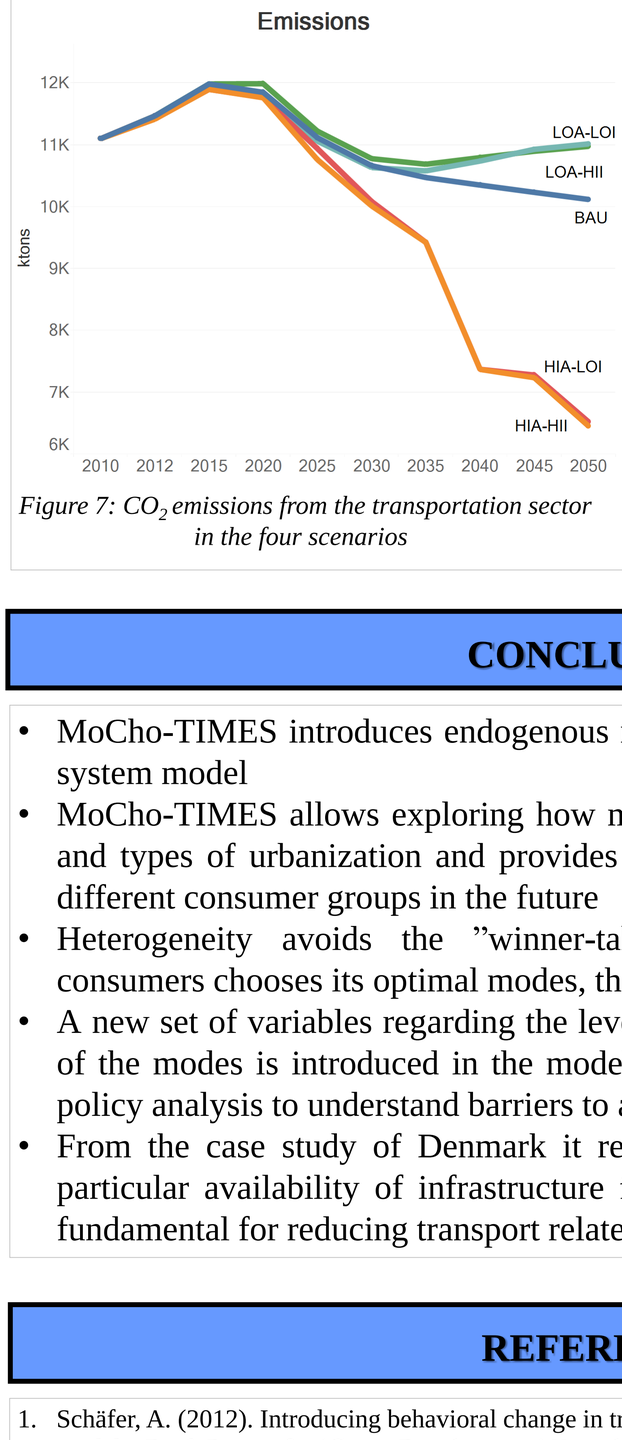

Figure 7: CO_2 emissions from the transportation sector in the four scenarios

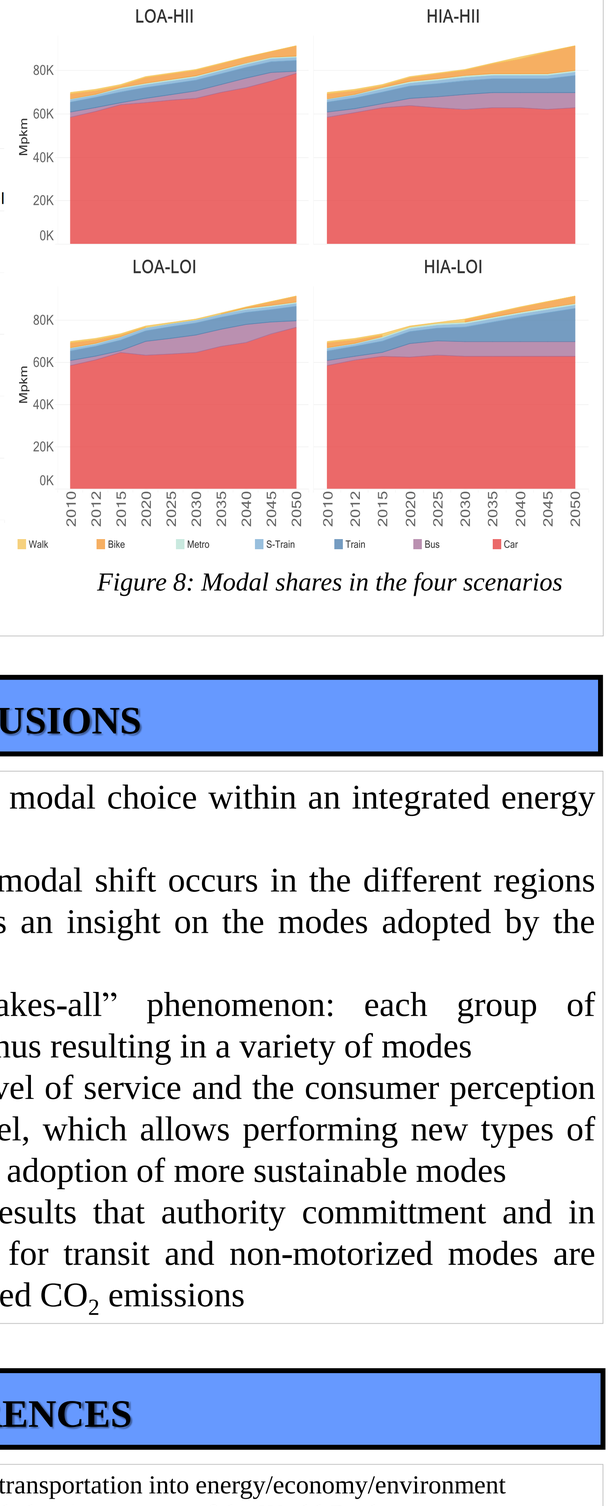

Figure 8: Modal shares in the four scenarios

CONCLUSIONS

- MoCho-TIMES introduces endogenous modal choice within an integrated energy system model
- MoCho-TIMES allows exploring how modal shift occurs in the different regions and types of urbanization and provides an insight on the modes adopted by the different consumer groups in the future
- Heterogeneity avoids the ”winner-takes-all” phenomenon: each group of consumers chooses its optimal modes, thus resulting in a variety of modes
- A new set of variables regarding the level of service and the consumer perception of the modes is introduced in the model, which allows performing new types of policy analysis to understand barriers to adoption of more sustainable modes
- From the case study of Denmark it results that authority committment and in particular availability of infrastructure for transit and non-motorized modes are fundamental for reducing transport related CO_2 emissions

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