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# Possible approaches to revise the demand module in TREMOVE

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## *The objective : revising the demand module in TREMOVE*

*The current version of the demand module is well established in the TREMOVE modelling practice and it is theoretically consistent*

*At the same time the demand module has some limitations*

*Overcoming such limitations would be helpful in order to improve the role of TREMOVE as a tool for transport policy analysis*

## The objective : revising the demand module in TREMOVE

*Alternative approaches for the revision of the demand module are proposed:*

A. *A relatively limited change using the nested logit model instead of the Constant Elasticity of Substitution (CES) functions*

B. *a deeper modification of the module structure, in order to transform TREMOVE into an autonomous forecasting model*

C. *to plug TREMOVE into TRANS-TOOLS where a sophisticated demand module already exists*



## Recalling the current demand module in TREMOVE

*In the current demand module of TREMOVE nested utility functions are used to represent demand in the form of a utility tree*

*The module starts from a demand baseline which has to be provided exogenously (a transport network based model is used: SCENES, TRANS-TOOLS)*

*Policies are simulated as changes relative to the baseline*

*It is assumed that the utility functions have a Constant Elasticity of Substitution (CES).*

*CES functions can be calibrated with a minimum of data and work properly for for moderate changes in demand levels relative to a baseline .*

## Limitations of the current demand module in TREMOVE

*The demand module is not autonomous, but depend on the availability of an external baseline*

*Constant Elasticity of Substitution (CES) functions are unusual in transport demand analysis and are not suitable for analysing situations where large deviations from baseline are expected*

*CES functions and the need for an external baseline make the structure quite rigid and makes hard to analyse the impact of changes in the values of parameters*

*A number of elasticity parameters, each summarising complex choices between alternatives, are needed. Realistically, many sources of possible uncertainty can rise within such a complex structure.*



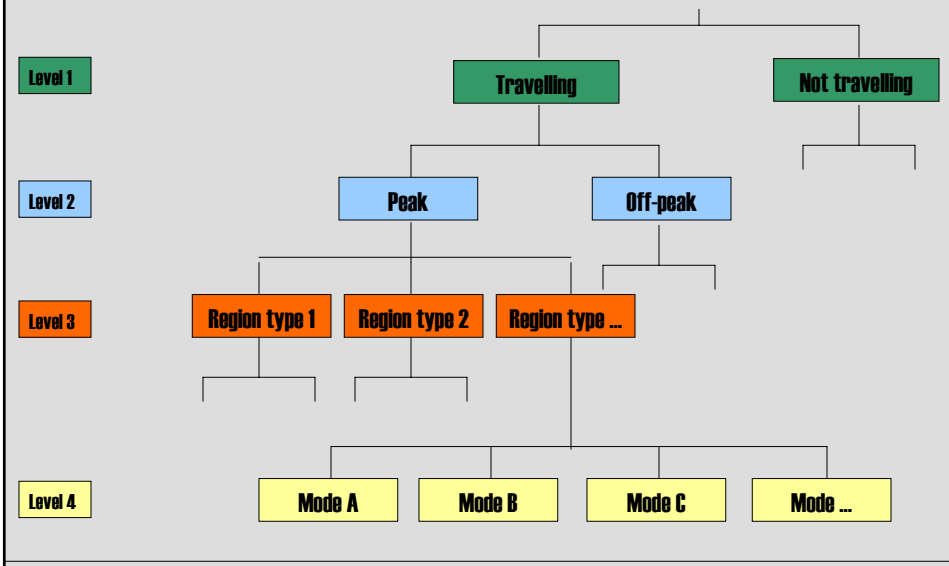
## Approach A: replacing CES with a nested logit

*The nested logit model is a flexible model building on the random utility approach well established in transport demand analysis*

*Nested logit is appropriate for dealing with the choice of alternatives sharing unobserved attributes*

*The nested logit model requires to identify a hierarchy in the choice set where each alternative is defined only once. Alternatives sharing unobserved attributes are then treated together as "composite alternatives"*

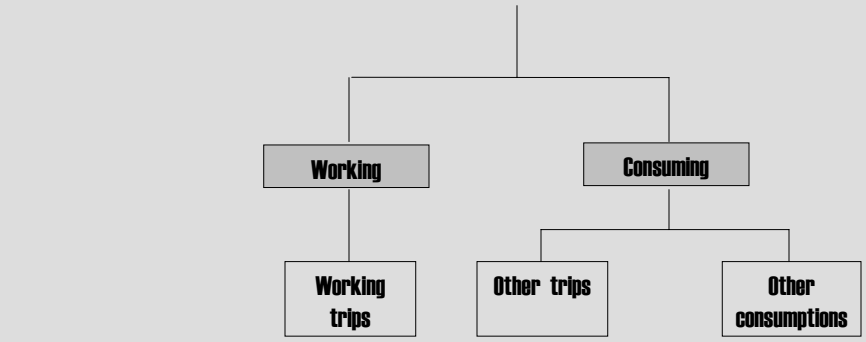
## Approach A: replacing CES with a nested logit






## Approach A: replacing CES with a nested logit

**1st level: choice of travelling**

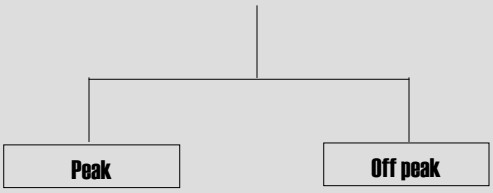



Composite Alternative

Elementary Alternative

## Approach A: replacing CES with a nested logit

**2nd level: choice of time (Total: 2 logit models)**



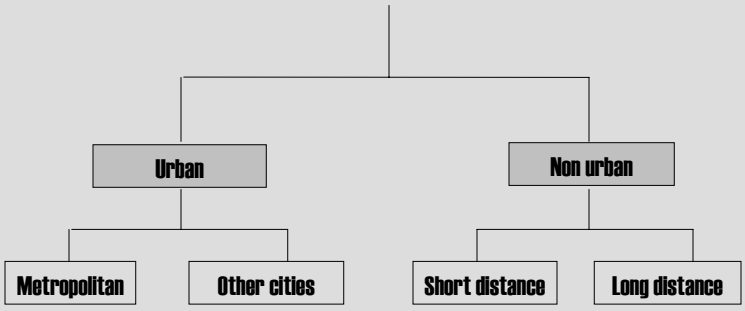

Composite Alternative

Elementary Alternative



## Approach A: replacing CES with a nested logit

**3rd level: choice of region type (Total: 4 Nested logit models)**

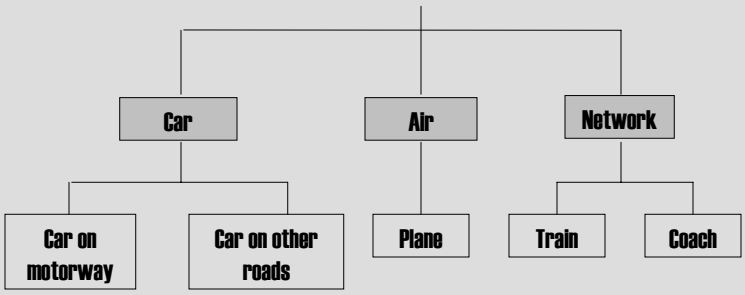



Composite Alternative

Elementary Alternative

## Approach A: replacing CES with a nested logit

**4th level: choice of mode**
**(Total: 16 Nested logit models, each with a specific set of alternatives)**




Composite Alternative

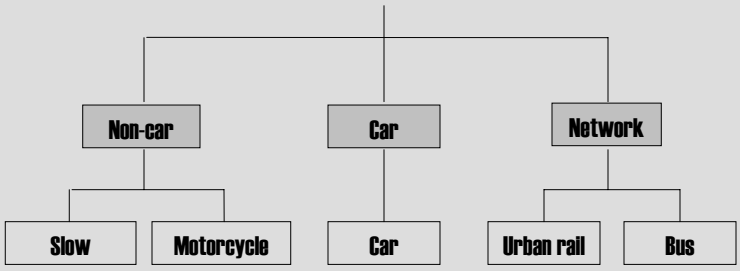
Elementary Alternative

**Nested Logit for Non-urban long**



## Approach A: replacing CES with a nested logit

**4th level: choice of mode**
**(Total: 16 Nested logit models, each with a specific set of alternatives)**




Composite Alternative

Elementary Alternative

**Nested Logit for Urban**

## Approach A: replacing CES with a nested logit

*At each level, the utility function of each alternative could include two terms:*

- *The generalised cost of alternatives*
- *An "Alternative Specific Constant" (ASC) for each alternative*

*At the lowest level, the generalised cost for each mode would be computed from monetary cost plus the value of travel time.*

*At upper levels, the generalised cost would be computed as weighted average of alternatives at the lower level (e.g. the generalised cost of the alternative "other cities" would be the weighted average of generalised costs for the modes available for this category of trips)*

*The ASC can be used for calibration purposes, e.g. replicating observed shares*



## Approach A: replacing CES with a nested logit

*Advantages of using a nested logit structure:*

*The nested logit model does not constrain elasticities to any fixed value, so elasticities can vary across different contexts (e.g. countries) and over time. In this way, the main drawback of the CES functions would be cope with.*

*The nested logit model is widely used to analyse transport demand, so the functioning of demand module would become much clearer for the transport researcher community and therefore more chances would rise to validate the procedure as well as the parameters of the model*

## Approach A: replacing CES with a nested logit

*Using the a nested logit structure:*

- *would not reduce the effort needed for calibrating the model: a large number of Alternative Specific Constants (ASC) should be calibrated plus the scale factors of the nested logit models. This should be repeated for each country*
- *the structure of the module in terms of segmentation of demand could be simplified. For instance, the separation between metropolitan and other urban areas or between peak and off-peak could be dropped at least in terms of endogenous choice.*
- *A baseline set of data would still be needed as reference to calibrate the model.*



## Approach B: endogenous demand model

*The substitution of CES functions with a nested logit structure would not avoid that the demand module is dependent on an external demand baseline*

*To upgrade TREMOVE from being a simulation model to be a forecasting model and get rid of external baselines some mechanisms to generate autonomously transport demand is required.*

*This would guarantee that the TREMOVE model is not only able to address marginal changes with respect to a given trend, but also to manage larger variations.*

## Approach B: endogenous demand model

*An endogenous generation model should be as simple as to fit in the current model structure, avoiding unnecessary details and keeping the number of parameters at the minimum (e.g. the generation module should not aim at producing O/D matrices).*

*Instead, the demand should be generated in broadly aggregated terms, segments should consist of the relevant groups currently used in TREMOVE (e.g trip purpose, transport mode, urban/non urban, etc.)*

*The segmentation of demand currently used can be revised and simplified, focussing on the most relevant aspects.*



## Approach B: endogenous demand model

*Passenger generation*

*The generation module should compute the number of trips given the size of the population*

*For instance, in the ASTRA model average trip rates by trip purpose are applied to the size of given population groups*

*Whatever methodology is chosen, a dedicated endogenous model to forecast population development would be needed*

## Approach B: endogenous demand model

*Freight generation*

*The generation module should compute the amount of tonnes transported given the size of the economic activity*

*For instance, in the ASTRA model, tonnes are generated by applying unitary values of goods to the monetary value of production or trade of different economic sectors*

*Whatever approach is chosen, an endogenous module to update the size of the economic activity would be needed.*



## Approach B: endogenous demand model

*Passenger and freight distribution*

*A simple distribution module would be required in order to compute the share of total mobility which take place in different places under different conditions (e.g. mode availability)*

*A small number of "region types" could be defined both for passenger and freight (e.g. urban – non urban short distance – non urban long distance – international)*

*Utility functions of alternative "region types" could include elements like generalised cost of transport and car ownership but also other parameters (e.g. to reproduce the sprawling effect due to land use impacts)*

## Approach B: endogenous demand model

*Advantages of an endogenous demand module:*

- *External baselines would not needed anymore: the model could be developed and used autonomously in a much more flexible way and alternative baseline scenarios could be defined more easily*
- *the analysis of modelling outcome would become easier and also sensitivity tests could be made more easily to carry out analysis of uncertainty*
- *Currently changes are computed independently for each year. With an endogenous demand module some interactions between demand development and policy measures could be modelled more realistically. For instance, if passenger demand generation depends on car ownership, a measure affecting the growth of the vehicle fleet size would affect also the trend of demand.*



## Approach B: endogenous demand model

*It should be considered that the steps from the theoretical structure of the model to a working tool can be demanding:*

- *Some kind of linkage with strategic network transport models at the European level will have to be maintained, even if in looser way than currently, for calibration purposes*
- *A good deal of data and information would be needed in order to calibrate the model parameters and estimate some variables (e.g. the size of population groups to be used for trip generation, unitary values of goods)*
- *Working with simple algorithms with a limited number of parameters, as proposed, is useful to avoid the need for calibrating a massive number of coefficients, but on the other hand reduces the degrees of freedom during the calibration phase as the number of leverages is low*

## Approach C: plugging TREMOVE into TRANS-TOOLS

*The TRANS-TOOLS model is a strategic transport network model recently developed for the European Commission to serve as reference model for the analysis of transport demand.*

*TRANS-TOOLS consists of different modules, developed as separate tools. In principle, there are no reasons to exclude that the modular structure can be expanded to include further modules and enlarge the capability of the model.*

*Given that both TRANS-TOOLS and TREMOVE operate at the EU scale and have been developed on behalf of the Commission, it might be sensible to think of a possible integration of the two models, using the capability of TRANS-TOOLS to model transport demand in detail and integrating in its structure modules from TREMOVE.*



## Approach C: plugging TREMOVE into TRANS-TOOLS

*Three modules from TREMOVE could be integrated within the TRANS-TOOLS model :*

- *the vehicle stock module*
- *the fuel consumption and emission module*
- *the welfare module*

*The existing TRANS-TOOLS modules would be used to simulate transport demand in detail (network level)*

*The specific features of the TREMOVE model would continue to live within TRANS-TOOLS improving its capabilities.*

*The development of the TREMOVE modules could continue, e.g. adding new pollutants, improving vehicle choice algorithm, making scrapping rates dependent on energy price, etc.*