A System Dynamics Model for Long Term Travel Demand Forecasting and Policy Analysis

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1. Introduction

Long term explorations (15 to 40 years ahead) of future developments in travel demand are fraugt with uncertainties. In particular, in long term policy development it is essential to use comprehensive and consistent scenarios and to incorporate the essential factors, constraints and feedback mechanisms in the analysis. It is on the long term that complexity arises because many of the usual assumptions on steady conditions on the short term are not valid. Moreover, long term developments in society which determine travel demand are hard to predict. It is no surprise that there is little consensus among professionals on an adequate concept for the passenger transport system which is valid on the long term.

2. Scenario approach and consequences for modelling technique

The scenario method is in itself a well-known forecasting technique (see for a general discussion for instance [Sviden (1989) and Masser et all (1990)]. From discussions in the literature we can derive three essential components which should be part of any scenario.

1. An integrated description of the future, which pays attention to developments in all factors affecting travel demand
2. A plausible sequence of events leading to this future situation, without the necessity of including statements on the probablity of those events.
3. An analysis of the present situation and a connection between future developments and the present situation.

Because of this characteristics we think that scenario models should by definition be incremental, with mutations of the existing travel demand being calculagted as a result of changes of explanatory factors. After all, future outlines and developments are only explicitly related to the existing initial situation in the case of an incremental approach.

One modelling approach that meets this demand is System Dynamics, which is by definition based on an incremental step by step forecasting approach, starting from a certain state of a system. Again we refer to some general literature for the backgrounds of this technique [Wolstenholme (1990), Morecroft (1984)]. System Dynamics models are highly flexible and aggregated, and therefore very suitable for scenario analyzing, where we have to deal with a variety of interrelated long term developments. System dynamics are also very promising for analyzing the passenger transport system, because this is pre-eminently a system with a lot of saturation levels (car ownership), dynamics (demand vs supply) and external contraints (in terms of money, space, raw materials, etc.). An optimal representation of know-how is at issue here. The first consideration is to recognize directions, causalities, sensitivities, feedback mechanisms and external constraints, not to indicate exact relations.

3. The Scenario Explorer

3.1 Objectives

An example of a SD model for long term scenarios about transport is the Scednario Explorer developed by TNO-INRO for the Ministery of Transport and Housing and Planning in the Netherlands. The ScenarioExplorer is meant to be a 'front end' model on a supra regional or national level. The model should enable policy makers to explore future developments in the transport system, to experiment with this future (what if?) and to evaluate possible effects of policy interventions by the government or other actors. Tutoring and communication about assumptions are key elements in this

process. This 'modelling as learning' philosophy [de Geus (1988), Morecroft (1984, 1992)] calls for special models which:

- support the building of integrated and consistent scenario's;
- are based on a comprehensive and flexible model structure, which adequatly represents the main long term (15-40 years) mechanisms in the transport system;
- are easy to operate and interpret by different type of users
- are able to incorporate insights form users into relevant factors and causal relationships within the system;
- are methodological hybrid and give room to both empirically validated model relationships and more intuitive relationships based in expert judgement and intuition [Forrester (1992)]

3.2 General design of the ScenarioExplorer

The ScenarioExplorer is an interactive PC simulationmodel for long term nationwide travel demand and supply forecasting. The model input is based on a whole range of scenario variables. The output describes the development in personal mobility, using four basic indicators:

- travel demand (kilometers driven by mode, purpose, etc.)
- travel suppkly (developments in infrastructure, levels of service)
- supply and demand equilibrium (travel times) and
- car ownership

On the basis of these indicators various impact variables are calculated for the purpose of evaluation of the scenarios in the light of numerous policy goals.

To support this process of scenario building and analyzing the ScenarioExplorer distinguishes three phases. In the ScenarioExplorer they are worked out into separate modules:

1. *The Scenario building module*: for the building of a integral and consistent scenario, describing the developments in the traffic and transport system as well as in the system environment.
2. *The Travel demand model:* for the assesment of the effects of the various developments on the demand for personal transport.
3. *The evaluation module:* for the evaluation of these effects in terms of their impacts upon society in the light of various targets set by the government policy.

The scenariobuilding module will be descibed in more detail in the next paragraph.

4. The Scenariobuilding module

When researchers and policy makers want to say something sensible on long term developments in travel demand, they are faced with an impressive range of interrelated factors which might be of importance [Chambers and Taylor (1991)]. Building a dynamic and consistent scenario that takes into account all the relvenat factors and interactions is therefore a very complicated task. The scenario building module within the ScenarioExplorer is meant to support users on this point. The scenario variables are classified into 7 so called *themes,* divided in two categories:

<u>The environment of the transport system</u>

- Demographic developments
- Economical developments
- Social and cultural developments
  Spatial Developments

<u>The Transport system</u>

- Technological developments
- Developments in infrastructure supply

- Pricing and regulation

The ScenarioExplorer distinguishes three different kind of variables:

1. Steering variables, describing general trends in non-correlated variables (for instance volume of immigration).
2. Scenario variables, describing the actual consistent scenario (for instance population by age and sex).
3. Model variables, decribing the input for the travel demand model (for instance population by zone and category).

Scenario building takes place in two steps:

1. Transfering assumptions in steering variables into values for the scenario variables. This takes place through thematic procedures. In an interactive and graphical way he can specify the development of each steeringvariable over the planning period (see figure 1). These procedures are in fact one integrated System Dynamics model, which take into account the interrelations between the variables in different themes. Both dependencies between variables and in time (constraints, delayed feedbacks) are taken into account. An example of the interrelations of the different theme's is illustrated in figure 2.
2. Translating scenario variables into values for model variables with translating models, based on deductive calculation rules for quantifying model variables out of scenario variables. Most of these rules are logical and straight forward.

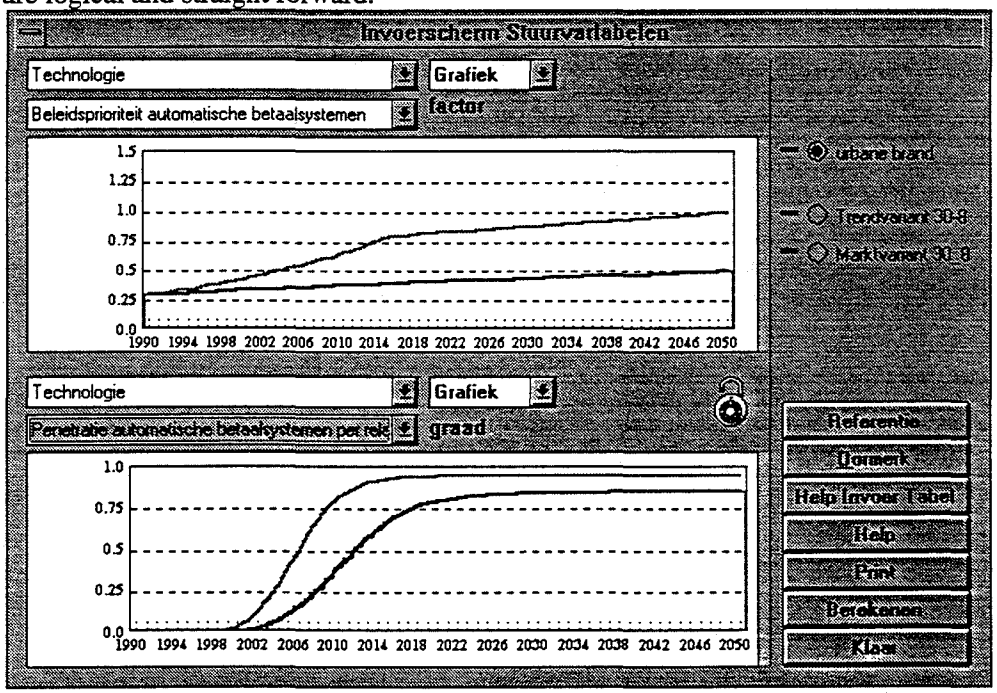

Figure 1 ScenarioBuilding screen

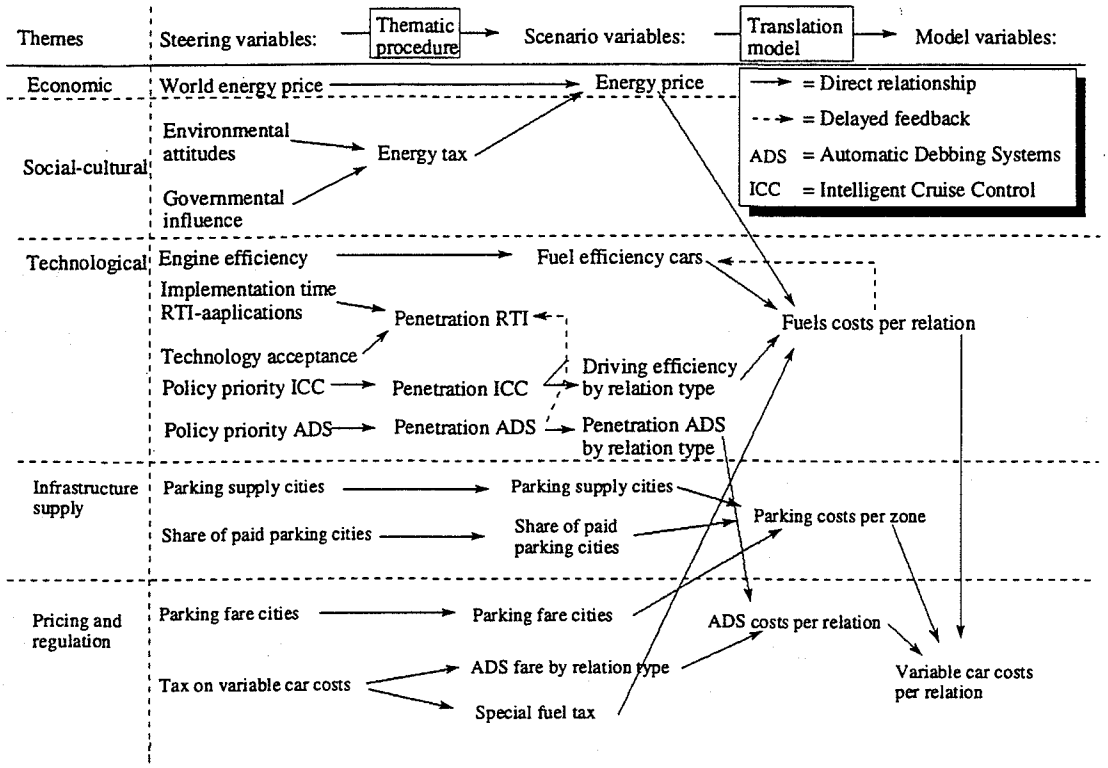

Figure 2 Variable carcost

5. Conclusions

The use of System Dynamics in the Scenarioexplorer is very suitable for different reasons: It offers the possibility of exploring the long term dynamics of the transport system: the dentification of saturation levels, equilibriums and growth mechanisms within the system. furthermore System dynamics has an 'open structure' and is therefore flexible in the input
and parameters of the model. Finally System Dynamics can deal with both quantitative and qualitative relationships. Quantifying qualitative relationships is very important in long term analysis of the transport system. The first experiences with the instrument are very promising and the approach seem to be valid. Further developments are focused on creating an instrument which is suitable as a gaming tool for group discussions.

Further information about the ScenarioExplorer:

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