

TRANS-TOOLS – an integrated support tool for European transport policy

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1 Background: policy and modelling needs

The use of modern computational models as support tools is common practice in many policy areas. A good model can quickly provide a policy-maker with key insights in those cases, where the only alternative source of information would be pure guesswork. This is particularly true when a policy measure applied in one economic sector causes important repercussions in other sectors, or when this measure affects many heterogeneous regions or countries. The necessity to account for such intersectoral and cross-border linkages is one of the main challenges faced by policy-makers aiming to shape the European transport system.

The study “Policy Support Tools for Transport Issues” (Eijkelenbergh et al. 2004), undertaken by the European Science and Technology Observatory (ESTO), can be regarded as the start of the European Commission’s search for an appropriate instrument for integrated transport policy analysis. Such integrated analysis would incorporate all elements in the mix: infrastructure, transport flows, logistics, cross-sectoral and cross-border effects. The inventory of models developed by various institutions was analysed in that study¹ with the conclusion that no model alone could do the job of integrated policy analyses on the European scale. An approach based on combining several models was suggested as the most appropriate solution. Draft blueprints of model combinations were put forward for five different policy issues: taxes, emission standards, intermodality, networks, and economic impacts. The implementation of these blueprints was, however, assessed as very difficult, because of substantial differences between the models and because of uncertain development perspectives for some of them.

The project “Tools for Transport Forecasting and Scenario Testing (TRANS-TOOLS)”, launched in 2004 as a part of the 6th Framework Programme and aiming to produce

an integrated European transport network model, which would overcome the shortcomings of the existing tools, therefore had to come up with the own blueprint. Besides closing the gaps in the methodology, the capabilities of the integrated model to be developed obviously had to correspond to urgent policy needs. The development of the Trans-European Transport Networks (TEN-T) had to be taken into account as well as the policy focus on sustainability, intermodality and decoupling. In particular, the European Commission’s guidelines (High Level Group 2003) highlighted the following operational needs connected to the implementation of the TEN-T strategy:

- to develop an impact assessment framework for the prioritization and evaluation of TEN-T projects, ex-ante and ex-post analyses, analysis of socio-economic impacts and externalities
- to monitor the quality of service of the TEN-T (congestion, accessibility, modal split, interoperability, costs, externalities)
- to identify measures to improve the TEN-T (missing links, new technologies, legislation).

After considering these and other policy requirements and comparing them to the capabilities of the models inventory, the TRANS-TOOLS project consortium agreed that the main gaps in the existing tools to be addressed in an integrated model were as follows (Burgess et al. 2008):

- coverage of all EU countries, including the new member states
- appropriate (fine-gridded) zoning system
- explicit link between transport and economic and external effects
- realistic representation of traffic mix (short/long distance and passenger/freight)
- freight intermodality and logistics
- consistent modelling of congestion
- use of recent and harmonized data.

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In retrospect it can be stated that all these technical aims were successfully achieved. Furthermore, the work done in the course of the TRANS-TOOLS development led to a substantial improvement of available data and to solid methodological contributions. The real challenge, however, turned out to be achieving consistent compliance with the original model concept (explained below) under the conditions of limited project time and changes in the modelling team.

The original TRANS-TOOLS project was running from 2004 to 2007. The produced model was substantially reshuffled during the TEN-CONNECT study (2007–2009). Currently, a third project directly concerned with the TRANS-TOOLS model development is running.²

2 Basic approach of TRANS-TOOLS

Two key considerations underlying the initial development of the TRANS-TOOLS framework can be summarized as follows. The first consideration is the concept of a system of models, as suggested by the ESTO study, where the state-of-the-art components stemming from different partners are combined using a common interface. The second consideration is the need to construct an instrument for policy analysis which is free of intellectual property rights (IPR) and is thus in the sole fief of the European Commission. If successfully implemented, this would allow a wide community of developers and experts to participate in the process and to discuss the model's approach and results.

In terms of model components, the TRANS-TOOLS project consortium agreed that they must cover:

- networks for all main transport modes (road, rail, air, sea, inland waterways)
- freight and passenger transport, including interrelations between them (road congestion, mode choice)
- modal split and logistics
- economic feedback processes related to changes in accessibility and pricing
- environmental impacts.

The exact way the components were supplied and combined in the two completed

rounds of the TRANS-TOOLS model development will be described in the next two sections. Overall, the model was aimed at addressing a multitude of detailed policy questions both at macro-level and at regional or even network link level. It had to become the main tool for transport forecasting, infrastructure planning, and analysis of a variety of policy instruments. This is the reason for the fast growing model complexity that was observed during the model development.

The technical strategy when building the TRANS-TOOLS system was not to link the models directly, but to build in intermediate data storage steps. This did not only allow for a quality control of intermediate output, but also made it potentially possible to replace and improve each submodel independently of other models, which is a clear advantage vis-à-vis many standard transport modelling software packages.³ It was also decided to store all data flow and parameters in a database common to all models.

The individual models provided by the consortium partners were originally implemented in different programming environments. In order to bring them together, the ArcGIS Model Builder (©Esri) was selected as the front end interface. The zonal database and the networks were also directly implemented in ArcGIS. The ArcGIS software being a fundamental innovation for transport modelling, this choice can be considered as an advantage of the approach taken by the TRANS-TOOLS developers. In particular, this significantly facilitated the merging of different network datasets and the quality control. Using the ArcGIS as a model interface also made it much easier to illustrate and analyse the results.

In terms of the IPR, the only restriction for using TRANS-TOOLS is thus the necessity to have ArcGIS installed.⁴ In fact, different offices and Directorates General (DGs) of the European Commission as well as national governments and other potential users apply ArcGIS to analyse transport data or for other purposes. For them, it is thus rather easy to learn how to use TRANS-TOOLS. For many others, however, the expensive ArcGIS license might hinder the adoption and use of the model.

(1) The seven big models analysed in the study were: ASTRA, EXPEDITE, GEM-E3, POLES, SCENES, TREMOVE, and TRENDS. For details see Eijkelbergh et al. (2004).

(2) The progress of the TRANS-TOOLS3 project can be followed at <http://transtools3.eu/home>.

(3) On the other hand, the “loose coupling” of models is much less efficient than using one integrated executable that optimally utilizes the computer memory resources.

(4) Some other software required is either free (*Matlab Compiler Runtime* by The Mathworks, Inc.) or free for the users authorized by the European Commission (*Traffic Analyst* by Ravidis A/S).

3 TRANS-TOOLS version 1

Table 1 gives an overview of the components in the first version of the TRANS-TOOLS modelling system. Technical details of the individual models are provided by the TRANS-TOOLS project reports (Burgess et al. 2006). Only a few general remarks will be added here.

The assignment model plays a central role in the TRANS-TOOLS architecture. It produces the main output of the model – traffic flows on each link of all networks. The corresponding link attributes, such as costs, speeds, capacities, lengths, are also provided in the output database. This allows the calculation of further aggregate indicators. As a first step, however, the assignment model provides the level-of-service data as input to passenger and freight models (see Figure 1). Passenger and freight blocks in their turn provide the unimodal origin-destination transport flow matrices at the respective level of detail to the assignment model, which is thus run twice for every scenario.

Congestion plays a role in the road network where passenger cars and trucks are simultaneously assigned through the included relationships between speed, number of

vehicles, and capacity. Maritime transports are not assigned to ship routes and are only provided as freight flows between port zones.

The economic model and the external impacts model produce indicators of regional welfare and transport-related external effects, respectively. There is no feedback mechanism from these models into the transport models. In particular the response of regional economic activity to accessibility changes is not further translated into the response of transport flows. This connection (as marked by the dotted lines in Figure 1) was planned in the course of the TRANS-TOOLS project, but was in fact not implemented due to the time constraint.

As can be seen from Table 1, different model components in version 1 worked at different levels of regional detail (in fact, this is still the case in version 2). In addition, the developers originally used different software. In order to make the data inputs compatible with the respective target model components, therefore, conversion routines were implemented at several model interaction nodes. Here, a certain loss of efficiency had to be accepted.

(5) NUTS stands for “Nomenclature of territorial units for statistics”, this is the official EU delineation of regions for statistical purposes.

Table 1
Components of TRANS-TOOLS version 1

| Module | Developers | Regional details | Short description |
|------------------|---|--------------------|---|
| Assignment | Danish Technical University (DK) | NUTS3 ⁵ | Based on the concept of stochastic user equilibrium. Includes separate assignment models for road trips (private, business-, holiday-, and freight-related), rail freight, rail passengers, inland waterways freight, and air passengers. |
| Passenger | Karlsruhe Institute of Technology (DE), based on <i>VACLAV</i> and <i>ASTRA</i> models | NUTS3 | Includes trip generation, trip distribution and modal split steps for passenger transport. Modes: rail, road, air. |
| Trade | NEA Transport research and training (NL), based on <i>NEAC</i> model | NUTS2 | An unconstrained gravity model predicting interregional freight flows by NST/R commodity group. |
| Mode choice | NEA (NL), based on <i>NEAC</i> model | NUTS2 | A multinomial logit model. Covers four modes: road, rail, inland waterways, and maritime transport. |
| Logistics | TNO Netherlands Organisation for Applied Scientific Research (NL), based on <i>SLAM</i> model | NUTS2 | For 5 NST/R commodity groups, the model allocates European and national distribution centres to regions by minimizing logistics costs. |
| Economic | Kiel University (DE), based on <i>CGEEurope</i> model | NUTS2 | A computable general equilibrium model covering the whole world, with rough sectoral structure, but many regional details for Europe. Calculates regional welfare and GDP impacts from transport cost changes. |
| External impacts | Institute of Studies for the Integration of Systems (IT) | Country-level | An environmental model calculates energy consumption as well as emissions and external costs thereof. A transport impacts model calculates safety impacts including fatalities. |

The TRANS-TOOLS model makes intense use of the ETIS (European Transport Policy Information System) database.⁶ Both freight and passenger model blocks draw upon this source to gain information on benchmark transport flows and transport costs. Presently, the updating and further development of the database⁷ seems to run parallel to the model improvements, which is of course a major efficiency prerequisite and therefore a very positive development.

As mentioned above, the analysis of the TEN-T policy has been one of the paramount objectives of the TRANS-TOOLS model development. However, the first version did not find many applications in this area, mainly because of the still raw character of the model. Here, we can only refer to the figures contained in the TRANS-TOOLS Final Report (Burgess et al. 2008) that depict the effects of priority rail and road projects with fine spatial resolution.

Detailed maps surely make one appreciate the fine spatial resolution of the model. This is achieved, however, at a cost of long computation times, which have been a burden of TRANS-TOOLS since the very beginning. Moreover, the validation exercises undertaken in the TRANS-TOOLS project revealed several important sources of implausible results. First, due to the omission of local and urban traffic, the model often could not reproduce official Eurostat data. Furthermore, the model was not flexible enough to incorporate sufficient reaction

to changes in some important parameters, such as the value of time, the speed on rail links, the mix of passenger trips (short vs. long trips), etc. In other situations, however, the model predicted too much response to scenarios, especially in the case of the assignment model, where a large part of this reaction could be attributed to stochastic noise. These and other remaining issues (such as lacking user-friendliness, intransparency of individual modules, need for database update, etc) motivated further model development that was undertaken during the follow-up projects.

4 TRANS-TOOLS version 2

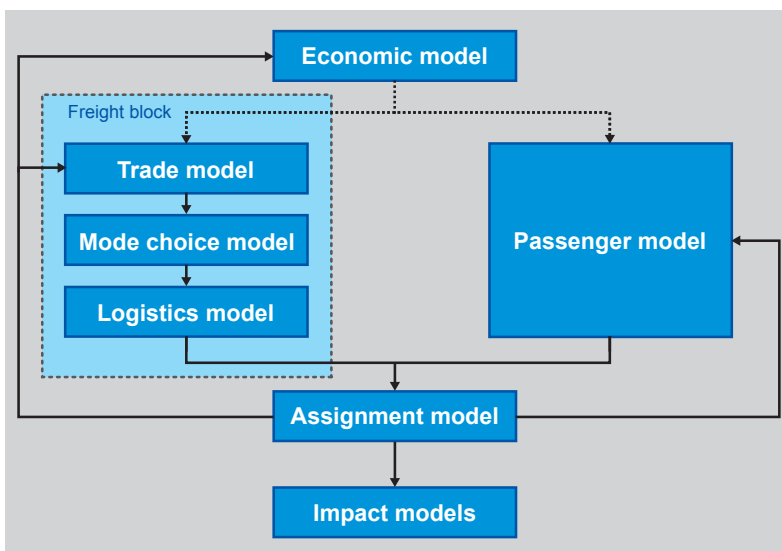
TRANS-TOOLS version 2 was finished in 2009 as the part of the TEN-CONNECT study (Petersen et al. 2009). Two components of the first model version were completely replaced. The new passenger model including the steps of trip generation, destination and mode choice was developed by the Danish Technical University. Major improvements in particular concerned the separation of short- and long-distance trips as well as the new air passenger assignment module. The new freight flows prediction model based on the modern gravity approach was developed by the University of Kiel. The networks and the zone system were extended and the benchmark database was upgraded to the state of 2005. Two freight modules, the logistics and the modal split, were not modified because their developers were not present in the consortium carrying out the study.

A lot of parameters of the model were made accessible and editable for the user. Thus, the user may specify the key drivers for freight and passenger transport such as regional GDP, population, employment, car ownership, and hotel capacity. Besides, the cost information is largely open to users, in particular, average driving costs for cars and trucks, rail and bus fares for passengers as well as costs per hour and per km for rail and inland waterways. Further key parameters that a user may edit include freight load factors and the value of time. As in the first model version, one of the most important features is the possibility for the user to add new links to the network or to amend the attributes of existing links.

(6) The database development was launched in the ETIS-BASE project (ETIS-BASE Consortium 2004).

(7) The main data work was done in the WORLDNET and ETIS-PLUS (<http://www.etisplus.eu>) projects.

Figure 1
Model interactions in TRANS-TOOLS version 1



Source: author's graph

The model output is a set of data files that may be accessed directly or through ArcGIS (for the purpose of visualization or analysis). The output files of the assignment module contain the most indicators. For example, for road network the following indicators are produced for each origin-destination pair and each time period: trip purpose, driving distance, driving time in free flow, extra driving time in congested driving conditions, waiting time at ferry crossings, ferry costs, toll costs, border resistance (number of delays at border crossings). It needs to be noted that the traffic volume is not present in this list. Traffic volume is produced by the freight and passenger models and serves as input for the final assignment model runs. The list of time periods considered in the road assignment is quite lengthy. The model distinguishes between summer and other time of the year, between workdays, weekends, and busy holidays, as well as between peak and off-peak time of the day.

Rail traffic assignment does not distinguish between time periods. In addition to in-vehicle time and distance, the output of rail assignment also includes time and distance indicators for commuting to and from the rail station (access and egress) for passengers. Air passenger assignment also reports the airport access and egress time and distance.

The output of the passenger model reports the number of trips between connected origins and destinations for each of three modes: road, rail, and air. In addition, the number of vehicles (drivers) on the road is also reported. Similarly, the freight block produces the number of freight tonnes transported per year between each origin and destination by road, rail, inland waterways or short sea shipping. For road transport, the number of trucks per year is also provided. Finally, the trade impact model produces the predicted regional GDP levels for the given scenario year.

Many of the improvements in the second round of model development were a direct response to the requests of the European Commission⁸ which envisioned the updated model to be involved in the analysis preceding the preparation of the new White Paper on transport (published in 2011). First of all, the zoning system was revised in order to provide a finer level of detail in the

new member states Bulgaria and Romania as well as in the neighbouring Balkan states, Turkey, Russia, and Ukraine. The new zoning system covered 1 441 European regions (NUTS3 level in the EU and comparable size in the neighbouring states, including the European part of Russia) and 19 external zones. This zoning system was applied in the passenger, assignment, and regional economic modules. The freight modules, however, remained at NUTS2 level, which was the finest level the ETIS freight data provided.

One of the major points of criticism about the first version of TRANS-TOOLS concerned the absence of the intra-zonal road traffic. This led to serious omissions in congestion calculations as the cases, when the local traffic uses main (inter-zonal) roads and thus contributes to congestion, were not taken into account by the model. Obviously, this biases the results mainly in urban areas. In TEN-CONNECT, an effort was made to include the intra-zonal traffic in the modelling. This was done by adding a short distance travel demand model for trips shorter than 100 km.

A further model improvement relates to the necessity to analyse infrastructure policy measures affecting the passenger choice between air and high-speed rail transport. In particular, all airports in the model are now properly connected to the rail and road networks. In the first model version, the changes of the land network did not influence the choice of airport and air routes. In addition, the former approach was likely to underestimate both, passenger volumes on the main rail networks leading to the airports and congestion on the roads near the airports. The improved air passenger assignment model resolved these issues.

The new version of TRANS-TOOLS went through a thorough peer review process by a team of external experts and the new developments mentioned above were positively evaluated (Monzón et al. 2010). The main criticism and corresponding recommendations of experts, however, concerned the fact that the model grew too much over the years of improvement efforts becoming very cumbersome, intransparent and slow, thus definitely missing a goal of becoming a convenient tool for a wide user community. Moreover, its growth was not always internally consistent and the latest devel-

(8) See also the article of Adelsberger in this edition

opments were also poorly documented. All this motivated another major revision of the framework that is currently underway in the TRANSTOOLS3 project. The results of that project, however, are not expected to be available before 2013.

As envisioned, the TRANS-TOOLS version 2 was applied in several studies preceding the publication of the new European transport strategy in October 2011. One of the main components of the new White Paper is the notion of the core network that must “ensure efficient multi-modal links between the EU capitals and other main cities, ports, airports and key land border crossing, as well as other main economic centres” (European Commission 2011a: 14). In the preliminary impact assessment, the new TRANS-TOOLS model was applied to simulate the effects of a variant of such a core network. Figure 2 shows the core network together with the set of TEN-T priority pro-

jects, which comprised one of the key elements of the previous strategic White Paper of 2001. The new core network is far more extensive.

Figure 3 shows the regional GDP impacts (in 2030) of the implementation of a scenario with a core network, labelled CORE, compared to the baseline case only assuming the completion of the priority projects, labelled PP. This scenario was analysed in the TEN-CONNECT2 study (Petersen et al. 2011) and the corresponding maps can also be found in the impact assessment report accompanying the new TEN-T guidelines (European Commission 2011b). The core network covers much more major axes than the set of priority projects. A maximum speed limit of 120 km/h is imposed within the whole core road network, while a minimum average speed of 80 km/h is imposed within the core rail network. The presented calculations only cover changes in the freight transport costs and business travel costs and do not include impacts on private passengers and therefore can only serve an illustrative purpose.

Figure 2
The TEN-T priority projects (hick lines) and the envisioned core network



Source: DG Move (http://ec.europa.eu/transport/infrastructure/connecting/revision-t_en.htm)

The GDP effects have been calculated using the regional economic module of TRANS-TOOLS version 2. It is based on the spatial computable general equilibrium model CGEurope developed at the University of Kiel. The model provides an analytical link between the transport network and regional economies in Europe. The model structure reflects the image of regional economies linked through endogenous trade flows. Traded commodities are final and intermediate goods. Trade is costly and depends on the availability and quality of transport infrastructure. Infrastructure improvements reduce e.g. travel times between particular pairs of regions and thus also reduce trade costs between them (transport cost changes are evaluated by the assignment module). Some regions then gain in competitiveness (e.g., prices for their imports from neighbouring regions are reduced), while other regions situated along unimproved routes lose competitiveness. This in turn changes interregional trade patterns, levels of regional production and income. The evaluated impacts then, for instance, include the following effects:

- lower goods prices through lower transport costs (substitution effect)

- higher factor income because of higher demand from other regions for local goods (income effect)
- higher utility from richer availability of goods from other regions (variety effect).

Figure 3 illustrates the predicted benefits of the CORE scenario for regions situated along the eastern and southern shores of the EU. Regions that are already well connected (or that should become well connected thanks to the completion of the current priority projects), however, do not gain much. These results appear quite sensible, and the magnitude of the effects is in line with the results from similar studies.

What still remains a problem of TRANS-TOOLS, however, is the inability to exactly reproduce the level of transport flows as reported in the official statistics. Many sources of errors (such as the local flows or the network attributes) have already been corrected, but the deviations are still not negligible (for road traffic around 20 %).

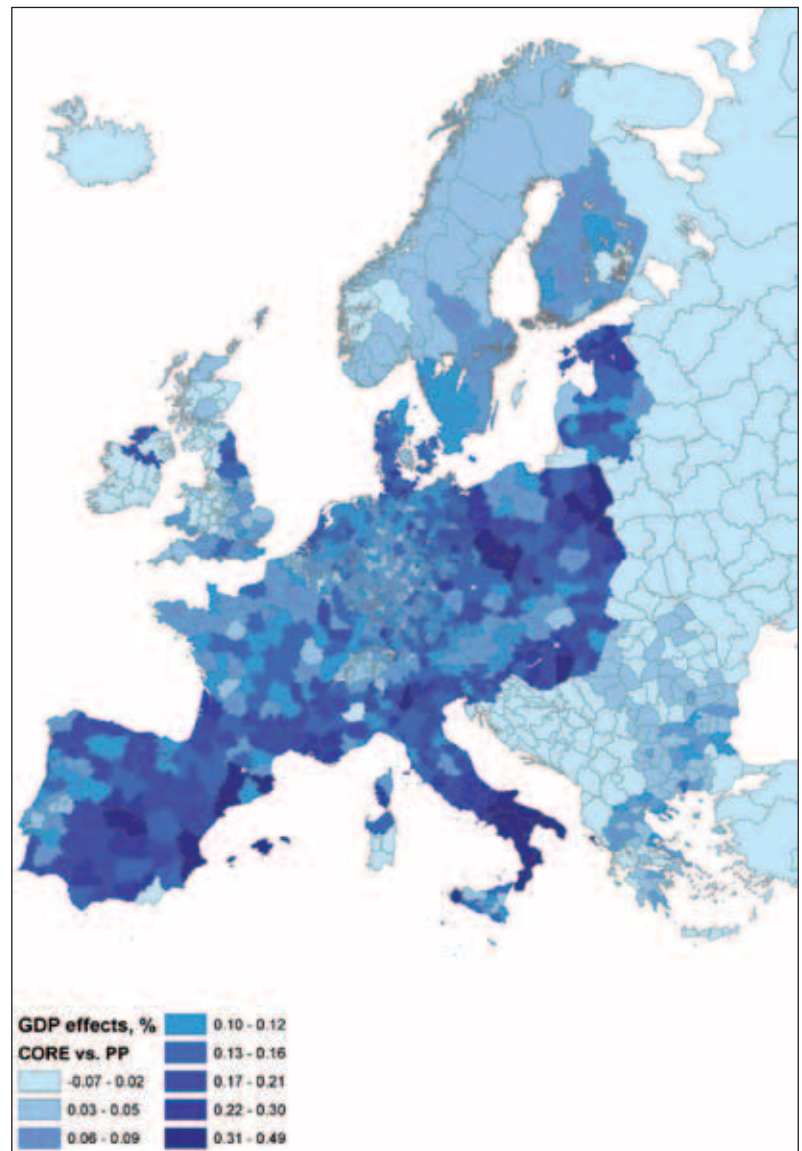
It must be mentioned that, in the impact assessment exercise, the model was only used to illustrate the general impacts of the selected set of projects and not to argue for or against their inclusion. For the latter, the usual attention was naturally paid to the specific proposals by the Member States that often have their own transport planning models. Apart from that, the remaining reliability problems obviously reduced the potential role of TRANS-TOOLS in shaping the new European transport strategy.

5 Concluding remarks

In the meantime, despite all the difficulties and rather unexpected turns in the development process, the TRANS-TOOLS model has obviously become the central collecting point for data and methodology improvements related to European integrated transport modelling. The model name has become a brand widely known among policy-makers and experts.

The TRANS-TOOLS development and use is currently coordinated by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) located in Seville. The latest model version as of December 2011 is v2.5. The IPTS webpage dedicated to the model con-

Figure 3
Regional real GDP effects of the core network scenario 2030



Source: Institute for Regional Research, University of Kiel

tains the reports of past projects and of the review process as well as the user support section. Training courses are regularly organized for researchers and consultants interested in using the model.

Despite this success, it is clear that the impact of the model on the policy-making process still remains limited. On the one hand, it seems to be rarely the case that some model delivers a decisive argument in the political debate. On the other hand, the review process clearly showed that reliability and thus also the impact potential of the model can be substantially increased.

The work currently carried out in the TRANS-TOOLS3 project must therefore lead

to reliability improvements. Several points have to be particularly stressed in this respect. First, the model results must undergo a thorough validation process. Dependence of the model output on the crucial parameter values must be fully understood and critically evaluated.

Second, the integration of the transport-economy linkage must be finally realized. Two different approaches had been implemented in the two earlier TRANS-TOOLS versions and none of them led to a sustainable structure. It might thus be reasonable to try to change the approach and to construct a transport-economy link in a less complex framework. This is related to the third point worth mentioning here. Recognizing that the TRANS-TOOLS model has become too

large for the purpose of fast back-of-envelope calculations that a policy-maker may very well wish to perform, Monzón et al. (2010) suggested to develop a simpler version of the model by relying on deterministic assignment and some other shortcuts allowing to save computational time. Such a tool would allow the user to quickly see the big picture without necessarily having the entire local detail right. Bearing in mind the original idea of the TRANS-TOOLS model applied by a wide community of users, this is an avenue definitely worth to be explored. The European Commission has allocated a research budget for such a “strategic high-level transport model” in the 7th Framework Program, with results expected to be delivered in 2015.

(9)
<http://energy.jrc.ec.europa.eu/transtools/index.html>

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