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Challenges and future research needs towards international freight transport modelling

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ABSTRACT

The advanced internationalisation of markets and production processes continuously adds to the complexity of supply chains. At the same time improving the sustainability of the related international freight transport processes and optimising their efficiency is becoming a topic of central relevance. International freight transport models are an important tool to simulate impacts of measures taken to achieve such improvements of transport processes. Yet, the requirements towards international freight transport models are complex: they need to include various modes of transport, they need to cover different industries and their dynamics, they need to consider seasonality of supply and demand of goods, demographic parameters, economic developments, technological developments including their impact on production processes and structures, and many other aspects. Furthermore, international freight transport models need to include freight flows within countries as well as freight flows between the considered countries. This paper discusses the challenges which need to be confronted when developing international freight transport models which are able to correspond to the described complexity of international freight transport. Furthermore, it maps out the most important research gaps which need to be addressed by international freight transport modelling research in order to ensure that the challenges identified are captured within the models developed to improve international freight transport.

1. Motivation and objective of the paper

With the advanced internationalisation of markets and production processes, more and more supply chains are involving international freight transport processes. At the same time, concerns about the sustainability of transport have become an important topic, as environmental awareness is growing on a global scale. Next to international conferences which aim at developing global approaches to this issue, there are quantitative targets in place, such as the “20-20-20”-strategy, with which the EU has set as one of its key objectives for 2020 a 20% reduction in EU greenhouse gas emissions compared to 1990 levels, including transport related emissions (Europe, 2015). In order to achieve such a reduction of emissions and for the identification of the necessary and most effective measures to improve the efficiency of international freight transport, modelling international transport processes is an important tool. It is a prerequisite for being able to simulate impacts of rules and regulations, of international trade agreements, or major changes to infrastructure on transport and traffic. Several approaches toward modelling international freight transport have been developed. However, the task of modelling freight transport on an international level is still challenging due to its high complexity: these challenges are related to both the

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development of a model itself as to the data, which can be used for the modelling and simulation process. Based on the discussions and results of the "future issues and research needs towards international freight modelling" session at the International Freight Transport Modelling Workshop on March 22nd and 23rd 2014 in Berlin, it is the purpose of this paper to map out the challenges encountered when modelling international freight transport and to discuss requirements and possible approaches towards future freight transport modelling research. The paper gives an overview on traditional approaches to international freight modelling and remaining challenges as well as on the data availability and remaining data requirements and needs. This is complemented with an outlook on general requirements towards developments for further improved modelling of international freight.

2. International freight modelling—existing approaches and most pressing challenges

The requirements towards international freight transport models are complex: they need to include various modes of transport such as rail, road, air, inland waterways and sea. They also need to cover different industries with their different dynamics and structures, covering short lived fashion as well as slow moving bulk goods like iron ore, for example. International freight transport models need to consider seasonality of supply and demand of goods, demographic parameters, economic developments, technological developments and their impact on production processes and structures, resources needed and markets covered, geographical boundaries and trade agreements, just to mention some of the central aspects. Additional complexity in modelling international freight transport is the result of the involvement of freight flows within countries as well as freight flows between the considered countries and their related interfaces. Furthermore it needs to reflect the interrelation between various transports and transport chains. To cope with this complexity, two approaches for the development of international freight models can be distinguished: a micro approach and a macro approach. Whereas the micro approach links existing national freight models to generate an international "meta"-model, the macro approach builds a generic on international model based on international trade models.

Linking national freight models, the micro approach, seems to be straight-forward at first sight. It is not without problems though and some prerequisites are to be met for a successful integration of the different national freight models into one encompassing international model: models which are to be linked need to be based on comparable parameters, data formats, a similar logic and network structures. This also includes the use of the same granularity of data. In other words: these models need to focus on the same central purpose, they need to endeavour to answer the same core questions and they need to include the same choices and transport modes. Furthermore, they need to apply compatible structures and work with similar data structure for in—and output.

An alternative approach to linking national models is the development of a communication structure between the individual national models based on data exchange interfaces. This approach links the output and input parameters of the individual national models provided to each other. Also this approach requires compatibility of input and output data, same transport modes included, same period of analysis. Furthermore, even if not a prerequisite for a technical solution, these models linked by interfaces need to answer the same core question and need to be based on compatible logical structures in order for any outcome of the modelling to be meaningful. A fully identical structure is not necessary though.

Both approaches are likely to require a reduction regarding their level of detail when combining national models into one international model for two main reasons. International freight models follow a different purpose by definition. They aim for reflecting structures of international goods movements. Although local developments may have an impact on such international goods movements, the detailed structures within one region are of minor importance for the larger scale analysis of goods flows. Furthermore, the level of detail of the international freight model is defined by the common denominator of data, structure and parameters of the combined national models. Here also lies the central risk of linking national models into one international model: the most important influencing parameters of international freight transport development are not necessarily identical with those parameters available and relevant within the individual national models. As a consequence there is a risk of missing out on structures and influencing aspects for achieving more efficient international freight flows by merely linking national models without incorporating the specific drivers of international freight. Another challenge for the micro approach to international freight transport modelling are the interfaces to areas outside the analysed transport system and their interrelations with the individual national freight transport systems as well as their impact on the intra-relations of the individual national freight transport systems.

Alternative to the micro approach of linking existing models, generic international freight transport models can be developed based on international trade models. Such macro models can be broken down into national fragments and models if needed. This approach ensures the application of a uniform set of parameters and structures over the included national structures, enabling full comparability and compatibility of the data of in- and output. In practice, global freight transport models often lack a sufficient degree of detail to allow them to be used for very specific problems though. The Swiss experiences with the European model "TRANS-TOOLS" when modelling the route choice in the alpine crossing transports (Gotthard vs. Lötschberg axis), illustrates this issue: The structures of the international freight transport model were not able to support the analysis of the specific situation in Switzerland on a more disaggregated level (Ickert et al., 2014).

Beyond these challenges regarding the choice of a micro or macro approach to the development of an international freight transport model, the question on how and to which extent logistics aspects can be included into an international freight transport model is a continuing issue. These logistics aspects include questions such as: which regional classifications and commodity classifications are to be considered in the model? What shipment sizes should be used? Which year should be used as year of reference when analysing trends and developments? How can the different transport needs of goods (high value per volume and perishable goods vs. low value per volume goods, e.g.) be reflected when modelling international transportation? How can values of traded and transported goods be translated into volumes and weights and is it necessary and possible to establish a standardized way for collecting data of volume internationally? How can the role of operators be included in such models? How can strategic decisions taken regarding the choice of transport mode and route be reflected in international freight transport models? How can external costs be included on a global scale? How can business- or location-related preferences for specific transport modes be captured and included? How can the route choice for intermodal transport chains be integrated in a freight model, especially for intercontinental transport flows?

Despite the described challenges, several models have been developed successfully to cover international freight transport, e.g. TRANS-TOOLS, Worldnet or NODUS (de Jong et al., 2013). The