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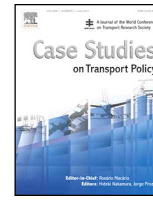

Challenges and future research needs towards international freight transport modelling

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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 different approaches and structures of these models reflect the relevance and impact of their central focus and purpose: TRANS-TOOLS is a suite of macro models combined to one meta-model, also including a passenger transport model, freight transport model, a logistics model and a spatial computable general equilibrium model. TRANS-TOOLS was a project part-financed by the EU within the 6th RTD framework programme with the objective to build a "basis of the development of an integrated policy support tool for transport at EU level" (TRANS-TOOLS, 2006). As a consequence the TRANS-TOOLS includes passenger as well as freight transport and its first version covered the at that time 25 European member states. WORLDNET's objectives were to "attain a more precise representation of the freight flows between European countries and the rest of the world" as well as to "facilitate the use and uptake of the model within other countries and regions" whilst building on TRANS-TOOLS (Worldnet, 2009). Given these objectives, WORLDNET's developments focused on long distance freight transport and put a stronger emphasis on intermodal transport outside the EU. Subsequently they also include air transport as additional transport mode. Furthermore, WORLDNET covers the EU27. Some aspects of transport and transport chains still remain uncovered by international freight transport modelling though: despite their relevance for the flow of goods and transport, transhipment centres and logistics hubs are not integrated in current international freight models. They are implemented in some national models, e.g. into the modelling approach of SMILE, the Dutch model which was the first to include endogenous transport (Tavasszy et al., 2012). SMILE offers an important and valuable approach towards the modelling of international freight transport. A global freight transport model covering also transhipment centres and logistics hubs does not exist yet though.

Closely related to the consideration of a models core objective is the question of who will be using the model and who is funding its development, as this has a direct impact on the models central focus. Developing an international freight model is, due to the complexity of the topic and as outlined earlier, challenging and therefore costly. Such an investment is therefore primarily of interest for legislative bodies within their areas of steering power. As mentioned for example, TRANS-TOOLS and WORLDNET were developed with the European Union being the awarding party. The EU is able to set guidelines and regulations for its members. Analysing transport flows and simulating the impact of measures within its area for targeted steering is therefore a meaningful development and purpose. Many transport chains are international transport chains nowadays. Global transport models therefore would be necessary as a basis for understanding, analysing, and improving international freight transport chains. Motivation and financing for the development of such global freight transport models are difficult to find although they could support international negotiations and policy measures. Global transport steering measures are relying on international agreements which are the result of complex negotiation processes where national interests are often in conflict with global targets. The Kyoto-protocol and its following discussions and meetings have shown how difficult it is, to reach such an agreement on a global scale for measures that can contribute to improve global efficiency of transportation.

Next to the development of an international freight transport model itself, the sourcing of data for the model and for the development of scenarios and simulations is the other central issue that needs to be faced when modelling international freight transport. In the following chapter challenges and important gaps in regards to data sourcing for international freight transport modelling will therefore be analysed.

3. International freight transport data—availability and challenges

In the age of Big Data, data seems to be available in abundance but the challenge to get the "right" data remains. We have a richness and huge variety of data but it is often collected for different reasons and in different formats; sometimes it is electronically stored, sometimes still noted on paper, sometimes it is confidential and for various reasons, including data protection, not accessible to third parties at all. In addition, with more and more data being available through information technology, there is the issue of big data. From a lack of data we have moved to an offering of data which is so vast, that handling it and identifying and selecting the relevant and necessary data, which allows the best handling and use, is the new challenge. Therefore, more efficient ways for data collection and management are needed, on a national as well as on a transnational scale. At the same time it is important to keep in mind that any decision on which data to include c in a model, also comprises the decision on which data to exclude. Therefore it is necessary to have a good and well-founded idea of the variables and parameters to be included in a modelling or simulation process and which are relevant for certain analyses and developments. Hence, the selection of data holds an inherent understanding of interrelations of parameters responsible for developments in relation to international freight transport developments.

Apart from the aspect of selection of data, availability of comparable data continues to be a challenge for international freight modelling. With the development of the ETIS database an important step was taken to shared standards for transport data. In fact ETIS' objectives were to develop a shared understanding within the EU on requirements towards a pan European transport modelling data set, to develop a frame for a database and a first data set to fill this database format (ETIS, 2005). Such a database requires at a minimum that all data is supplied for in the agreed format by all involved countries. For being able to do so, the involved countries have to ensure that their transport and trade statistics and the underlying and statistics-feeding administrative processes and procedures generate this specific data in the required format and quality. Ensuring such a uniformity of administration and procedures is a complex and complicated process. Also, the data basis for within a defined area such as the EU still leaves the challenge open on how to ensure data interfaces with areas outside this defined area, where completely different data in different format might be available. For the encompassing modelling of international freight transport it is necessary to link into global freight transport movements. Considering the need to get comparable and compatible data on an international scale, the previously mentioned aspect of selective data use within a model gets an additional dimension. Model developers might easily be tempted and obliged to a certain extent to base the design of models on data availability, thus pre-selecting, and hence limiting and interpreting interrelations in order to obtain in the end a usable model instead of a model reflecting better real-life interdependencies.

Another important aspect in the context of data is data quality. Official statistics, national as well as international, are considered a reliable source for high quality data. Still, it has to be kept in mind that the context of the data collection can be very different from country to country and that using official statistics not necessarily implies instant compatibility of data. Additional data on transport costs, infrastructure characteristics etc. are needed in addition to the official statistics and standards for these sorts of parameters is rare.

International freight data on an aggregate level is often registered in value, rather than in volume and/or weight. This is due to the fact that a lot of official data is the basis for taxation or other fiscal matters, where value is often the most important aspect of the goods. For modelling freight transport weight and volume are often the relevant factors in order to estimate the related transport demand and the organisation of the logistics chains. Finding a generally accepted way to "translate" value into volume and weight would be required, especially in container transport. Using a comparable commodity classification on a global scale would contribute to such a "translation". With classifications changing again and again over time and varying between countries, a globally accepted value/volume ratio per class of goods is not in sight.

Next to these variations in classifications, national differences in consumption of goods have to be taken into consideration when modelling international freight transport. Collecting data for specific goods and markets (e.g. food or pharmaceuticals) in one country is not necessarily transferable as structure or data basis for other countries. These patterns of consumption have a strong impact on international transport as they impact distribution structures and related transport demand.

International transport structures are not only affected by consumption trends, they are also subject to distribution trends: e-commerce as a new distribution channel has a dramatic impact on consumption patterns as well as distribution structures. This complexity is further raised by the effect that not all trade relations are directly linked to transport relations. Transport relations often are not direct origin-destination relations. As a consequence transport relations are often even further complex than the trade relations they are originating from. Choices on how, when and by which modes, routes, ports and airports are shipped, can only be understood if the competitiveness of global logistics chains is taken into consideration.

4. Other challenges related to international freight modelling and possible directions of future international freight modelling research

Beyond the challenges related to the development and structure of an international freight transport model and to the sourcing of data for it, there are several aspects that need to be taken into consideration in the context of freight modelling which are related to a more general perspective on international freight transport and its modelling.

One of these issues is the inclusion of reliability of modes of transport and their impact on decision-making by those who have to decide on transportation choices. Although reliability of railways is an important policy aim for example, there is no data available that allows including it into freight transport models. Attempts are made by using a 95% reliability interval for instance instead of an average travel time but this is not sufficient to capture the actual user perception and the impact the perceived and experienced punctuality has on their transport mode decision. Most models do not take reliability explicitly into account.

Another important challenge when modelling freight transport and when interpreting the modelling results is that the main transport data reflects or reveals the actual choices made; it nearly never shows the reasons why specific choices were not made. Capturing information of avoided choices is very difficult. Sometimes it is possible to gain access to this kind of information by questionnaires and stated preference techniques for a sample of the population. Obtaining quantitative information on a larger and global scale is usually impossible though, as those, who avoided a specific choice, are difficult to identify. Although most transport models assume that elasticities are fixed in time, in reality this is not the case. There are a multitude of reasons why transport demand may become more or less sensitive to impacting factors. Globalisation of production processes, growing international trade, new and more important supply-chain management strategies, time-based competition, and the growth of EDI and global e-commerce, are some of the factors shaping international logistics developments resulting in a changing relationship between freight transport and economic activity (Meersman and Van de Voorde, 2013). Furthermore, implementations of innovations tend to follow an S-curve and not a linear pathway. For example the impact of the introduction of containers was initially under-estimated and then overestimated once the rapid growth phase was reached. Also the modal shift to rail has followed a similar development, where first, in the seventies, a shift was established but this development slowly was reduced until all commodities for which railways is a realistic alternative already have made the right choice. Even the introduction of internet shopping shows this pattern. This variance in elasticity is not taken into consideration within the majority of freight transport models, as it is difficult to capture and therefore difficult to include. Still though, elasticities reflect choices and these choices are the basis for transport demand developments. An inclusion of changing or dynamic elasticities is therefore highly desirable in the context of international freight transport modelling.

This dynamic of elasticities becomes especially apparent when analysing investments into sustainability of improvements of transport. Not all of these investments currently seem to be justifiable from an economic perspective; the problem though is the existence of externalities which are not priced and as such are not considered as a cost in the choice process. Furthermore, if we look at intergenerational optimisation, we can explain some of the choices which are made with respect to environmental-friendly modes and alternatives and which do not seem relevant or 'rational' when a temporal approach is used. Concerning asymmetric behaviour, this again is an economic decision, sometimes with asymmetric information. It depends upon the fact that road transport has a number of advantages often related to the value of time and the value of flexibility, which decision makers are not willing to give up easily. A resulting challenge of transport demand modelling is therefore, that it is difficult or even impossible to obtain a sufficiently solid data base to incorporate these factors and elements into global freight models.

From a timeline perspective an important challenge to freight transport modelling is that both data as well as the understanding of the interrelation of parameters, variables and of structures available is in general rooted in analyses of the past. Future data only exists in the form of extrapolations, estimations, guesses and scenarios and our understanding of structures of future freight transport flows is mostly based on information available at this very point in time. The impact of these limitations of the perspective of the moment becomes obvious when comparing the current status of transport with scenarios which were developed in the past to analyse and forecast the current situation. The impact of the development of information technology in the format of online shopping, e-freight, 3D-printing and internet of things, as examples, was not foreseeable when Bill Gates supposedly made the remark that 640KB should be enough RAM for PCs in the early 1980s. For modelling possible future developments this implies major challenges as the impact of new technologies is difficult to estimate and integrate. Not only does it imply that data itself is not available for simulating the impact of innovations and changes. With their given, mostly static structures, freight transport models currently don't include the impact of innovations on structures and interrelations with other parameters of the system. A striking example is the rapid innovation of the road sector: we will soon see communicating truck driving in platoons next to traditional trucks. These new truck platoons should be regarded as a new mode in terms of cost structure and should be integrated in freight transport modelling as such. Longer Heavier

Vehicles (LHV) have seen a similar development. Also their cost structure is different to traditional trucks and so is their usage within the transport system. Models currently do not capture this. They just reflect the different load capacity of these vehicles. Currently, freight transport models do not include new modes as they are based on historical data; Future freight transport models should be able to integrate interrelations of data and structure, and they should enable the inclusion of new modes.

Another challenge to freight transport modelling, and in particular to international freight transport modelling, is the inclusion of an increasing scarcity of various resources and the internalisation of external effects. This is an issue which will become more and more influential for the whole economy, human behaviour and choices, including migration and location of production, and subsequently transport demand. Strategic decisions aiming at and taken in the transport sector have an impact on other sectors as do choices of other sectors have an impact of the transport sector. Increasing or decreasing fuel prices affect not only the freight transport sector but all oil dependent sectors. They also have an impact on households' budgets that influence other expenditures. Sizes of budgets, distribution of resources within societies and allocation of budgets to expenditures will change and as a consequence demand for transportation of goods will change, by origin and destination, by mode and by volume.

Many policies are aimed at behavioural change in the sustainability context by internalising the external effects and/or encouraging positive behaviour by means of financial benefits. Such measures can be included in freight transport modelling scenarios. Including the full impact of these measures is often impossible though: next to direct impacts such policies often result in indirect impacts and rebounds in other sectors. The fact that elasticities are usually fixed as mentioned above, combined with the difficulty to reflect complex interrelations of parameters within international freight transport models renders it almost impossible to fully simulate impacts of steering policies on transport demand.

So there is a limitation to capture the complexity of interdependencies of international freight transport structures and of its actors' motivations and behaviour. The impact of this is further increased by the fact, that, given this complexity, the system taken into consideration when analysing international freight transport needs to be limited in order to keep it manageable. Therefore, adjacent fields, impacting transport demand, often are not considered sufficiently in current international freight transport models. This is for example applicable for social aspects and developments: recent studies have shown that in the US about 40–50% of all jobs are replaceable within 15 years (Frey and Osborne, 2015). Within the freight transport sector platooning can be seen as a first step towards self-driving trucks, which, ultimately, is likely to result in a replacement of jobs in the transport sector. Whether the production of the related information systems and infrastructure will result in the creation of an equal number of jobs and where these jobs are going to be created is yet to be seen. In combination with demographical changes it is to be expected that in the future major societal change will impact demand and production and subsequently transport demand. These changes are not integrated in international freight modelling yet, as freight transport models are not integrated with social development models.

5. Future requirements towards international freight transport modelling

From the previous bullet points it can be concluded that an international freight transport model with fixed elasticities, interdependencies and structures, including a (historical) set choice of modes, is not sufficient to reliably and realistically simulate scenarios with a time horizon further than five years from now. Any mid- to long-term forecast will be difficult, given the changes induced by other societal areas on the international freight transport demand. A completely innovative view on freight transport modelling is therefore required. The time horizon and the level of detail may vary greatly thereby. That means that different types of models are needed, in order to meet these diverse needs.

As mentioned, it is important to better understand the complexity of international freight transport in order to further improve its efficiency, effectiveness and thus its sustainability. All these aspects together show the need for a broader approach than modelling transport alone, let alone international freight transport separately. It is generally agreed that freight transport demand and supply should be regarded as part of the economic system and that it therefore should be interrelated with a macro economic model or embedded in more general economic models. Such an approach to freight transport would also allow a more systemic approach to transport policy developments. Beyond the inclusion of economics it is important to ensure an interrelation of international freight transport modelling with societal and social developments on an international scale. International production chains and related supply and transport chains are an accepted, basic element of logistics. The relevance of logistics for freight transport demand also does not need to be justified further. The link between the impact of global social and societal developments on transport demand is not included in international freight transport models yet though. This gap should be addressed in future freight transport modelling developments.

Similarly upcoming and future technological developments only find entrance into freight transport modelling via scenarios nowadays. Also here a gap needs to be closed and a way for the inclusion of such developments into structures of freight transport models needs to be developed, a way to add dynamics to the structure of international freight transport models.

As far as the development of a database for international freight transport modelling is concerned, a further standardization of international trade data would be a valuable support. Efforts like the IATA initiative Cargo 2000, which aims at the development of a standard for freight document data, is a step into that direction. Not only does this kind of data need to be structured and to be included in databases, these databases need to be accessible, too. Still too often data is currently or too expensive or not available at all and valuable information remains inaccessible. Furthermore, coping with Big Data will be a challenge that needs to be tackled in the future for developing good databases for international freight transport modelling. Tools, devices and structures for handling huge amounts of data will be an important aspect of freight transport modelling therefore.

Another important aspect is the continuous exchange of experiences and best practice between researchers, transport and logistics managers, and politicians in order to establish a better understanding of trade, transport and policy relationships on national levels as well as on an international scale. Only then it is possible to understand what the central drivers of current as well as future transport demand are, how they interact and how the interactions is changing over time. It is also important to keep in mind that drivers of demand may vary from country to country, from industry to industry, from consumer to consumer and from company to company.

6. Summary and outlook

Based on the above described challenges and perspectives, four major fields of research for international freight modelling can be identified:

- Improvement of the link between national and international freight modelling and the related data bases;
- New requirements towards international freight transport models, in particular the impact of new technologies, societal and social changes, the impact of transport costs on international trade and transport structures, the impact of international environmental policies as well as the impact of structural changes of transport routings;
- A better understanding of organizational structures and their impact on dynamics and interrelations of freight transport systems, in particular the interrelation of trade structures and transport structures of international logistics chains, the role of transit and transhipment processes, the impact of the internationalization of transport services and the impact of pressure towards a raised efficiency of transport and logistics chains;
- Improved data bases for international freight modelling, in particular better overview and accessibility of existing data, development of an internationally applicable approach for translating transport values into transport volume, standardized commodity classifications, research into the challenges related to big data, standardization of data quality and improved data consistency.

There have already been a number of efforts to model international freight transport but, often due to limited data sets, they were either very targeted towards specific issues or very general and aggregated. The problems we are facing today and in the future will require consistent international freight models with a high degree of detail. These models should be able to evaluate the consequences of international transport policies, of relocation strategies of companies and multinationals, of shifts in foreign direct investments, of international trade policies, of changing competitive positions of ports and airports, etc., at a very detailed disaggregate level as well as on society as a whole.

Challenges not only include aspects related to the availability of data, but also issues related to the degree of detail that is to be analysed: should an international freight model focus on goods movements only, are decision relevant aspects included, do these focus on economic parameters of industries and countries or also of businesses and branches.

Despite those difficulties, international freight models become – due to globalization and increased international production processes – more and more important, especially in the context of optimization of efficiency of transport chains and of their sustainability, and in order to understand and simulate impacts of possible future development and steering measures. Besides data availability it is important for the development of such international models, that all users and developers share a joint understanding of the basic purpose of the project in order to ensure that the central objective and scope of the model is clear and concise. It is difficult though to identify such a joint understanding and motivation for the development and financing of a global freight transport model. With their modelling tool for CO_2 Emissions of international freight transport Martinez, Kauppila and Castaing have moved discussions on the topic an important step forward (Martinze et al., 2014). Still though, there is no international standard for the calculation of emissions. Furthermore, as seen, standardized data and data formats are not available. Any emission calculation of global transport is therefore based on assumptions and estimated average values. Subsequently, the policies developed to increase efficiency of freight transport are only attempts with consequences that are difficult to predict. With further developments on both aspects, modelling and data sourcing, transparency on actual transport flows and related emissions will improve and identifying the most effective measures for improving transport chains efficiency and, subsequently, sustainability on an international scale will become easier.

It is clear that traditional international freight models are becoming less suitable to make the transition from aggregate to disaggregate freight flows which are carried from their origin to their destination by a combination of modes through different distribution centres and with the intervention of different global and local actors. Moreover, they do not allow to study the interaction between the economy and freight transport demand in an informed manner. However, this interaction is crucial because it is at the heart of the dual character of the sustainability problem of freight transport on a national and international scale. It will thus be necessary to investigate how these complicated processes can be modelled to the best. The combination of an aggregate with a disaggregated approach will be required which is explicitly based on the behaviour of all actors in the global supply chain, their negotiation strategies and their market position and market power. This makes it possible to examine how certain measures and innovation initiatives can affect the relationship and the duality between economic growth, international trade and sustainable freight transport.

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