Supply chain elements in freight transport modelling

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Editorial

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ABSTRACT

This editorial introduces the papers of a special issue of the journal on freight transport modelling. Together, 9 papers present recent advances in 3 key areas of descriptive and predictive freight modelling: activity chaining, joint modelling of choices and segmentation of users. Next to a methodological contribution in one of these 3 areas, several papers also present empirical findings that are of broader relevance for different choice problems, industries and countries.

1. Introduction

Methods and techniques for descriptive and predictive freight transport modelling have developed strongly during the past decades. Whereas in the past the use of these models was limited to the context of public policy making, nowadays more and more use is made of such models by private service providers for purposes of strategic (investments, marketing, service package design), tactical (planning and pricing) or even operational (asset deployment) decision making. A dominant direction of innovation in these models, during the past decades, has been the framing of freight decision making in a supply chain context (Tavasszy and De Jong, 2014). Specific innovations in freight transport modelling research included:

- Modelling frameworks that reconcile micro (firm level), meso (segmented) and macro (zonal aggregates) scales of the system (Tavasszy et al., 1998; Roorda et al., 2010; Liedtke and Friedrich, 2012; Ben-Akiva and De Jong, 2013).
- Interpretation and use of micro level optimization models to develop a better descriptive understanding of freight transport choices (De Jong and Ben-Akiva, 2007; Combes, 2012; Halim et al., 2016; Holguín-Veras, 2015; Anand et al., 2016; You et al., 2016).
- New models of choices in the broader logistics context that impacts transport flows, like supplier selection (Pourabdollahi et al., 2017), distribution structures (Friedrich, 2010; Davydenko and Tavasszy, 2013) and shipment size choice (Johnson and de Jong, 2011).
- New empirical models that address specific modelling challenges of the global, national or urban scale (Tavasszy et al., 2011; De Jong et al., 2016; Marcucci et al., 2017).

Together, the papers presented in this special issue span the whole range of the above innovations, while most papers emphasize one. We introduce them below.

2. The papers

A first group of papers addresses the explicit modelling of the chaining of activities that lead to freight transport. Chains occur at different levels. Chains of production activities drive the trade of goods and hence are the basis for commodity-based freight models. Chains of transport modes occur around transshipment terminals and allow efficient crossing of long distances or natural barriers like oceans and mountains. Chains of truck trips occur in delivery processes, where round trips or tours are designed in a way that vehicles can serve multiple clients and return to their home base. Also passenger activity chains are important, as they can relieve parcel delivery processes by adjusting to freight origins and destinations, and taking over transport. Despite the abundance of normative models for optimizing freight operations, descriptive models of most of these chains are scarce and still very much in the early stages of development. Altogether, five papers study new ways to describe the typical chaining structures in freight transport, at different levels.

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Balster and Friedrich develop a dynamic, spatial supply chain model at national level. Its approach is inspired by multi-regional input-output models (MRIO), but it elaborates the approach into a dynamic model at multiple scales (D-MSMRIO). It explains the impact on logistically relevant variables such as stocks or transport demand on an aggregate level and demonstrates the use of the model for the case of shocks in the food supply chain.

A second paper on supply chains is from **Ottemöller and Friedrich**. Its focus is on structural changes in supply chain architectures – for example, vertical disintegration or spatial centralization. A modelling framework is presented which translates these architectures into a scenario based freight flow modelling system, by introducing location optimization models in addition to firm synthesis and trade modelling. An empirical case is developed to demonstrate the working of the model through the effects on freight flows of centralization in the poultry supply chain.

The paper by **Jensen, Thorhauge, de Jong, Rich, Dekker, Johnson, Cabral, Bates and Nielsen** marks a significant step forward in applied, large scale, disaggregate freight modelling. It tests various choice models for multimodal transport chains using data from the French and Swedish shipper surveys. The research constitutes the first attempt at the estimation of a large scale international freight model using disaggregate data. The authors find that it is important to recognize heterogeneity as well as non-linearity in transport costs, values of time and rates of substitution.

At the level of single-mode routing problems for pick-up and delivery, **Gonzalez-Calderon and Holguín-Veras** develop a method to estimate tour flows in a multi-zone system. This generalized variant on the freight O/D matrix estimation approaches of the 90s presents various challenges, like the prediction of plausible tours and the interpretation and re-design of the inference mechanism to estimate the most likely trips given the traffic observations. Empirical testing of the approach is done on the Sioux-Falls network instance.

Liu, Wang and Susilo address the question of last-mile movements of goods by consumers. This study focuses on the choice of consumers, whether and how – i.e. by which mode – to pick up goods from a central collection-delivery point (CDP), as an alternative to regular delivery by a logistics service provider. The authors develop a discrete choice model for the choice to add pick-up activities to work and leisure centered activity chains and consider different modes of transport. The results will help to shed light on the traffic reduction potential and the optimal location choice of CDP's.

A second series of papers focuses on the problem of joint modelling of interdependent choices. Some problems have been addressed before in the literature as joint choices, such as sectors and regions in spatial CGE models, modes and routes in supernetwork models, or vehicle type and mode choice in discrete choice models. These have led to interesting new approaches and considerations, amongst others about causality and (dis)equilibrium. This series of 2 papers looks at two original joint choice problems: firstly, modes and ports and, secondly, port terminal and dwell time. Both have a strong industry focus but, due to their descriptive nature, are also of interest for practitioners preparing transport policies.

The paper by **Tapia, de Santos Senna, Larranaga and Bettella Cybis** studies the joint choice of modes and ports of soy producers and traders in Argentina. Road and rail are the main modes competing to move soy export shipments towards ports. A combined SP/RP nested logit model is estimated. An important finding is the relevance of the business terms of the transport contract, in particular the specific international price agreement between shipper and receiver. The authors study opportunities for increasing the share of the rail mode and find that, besides freight price, train service frequencies are critical service parameters.

Next, **Irannezhad, Prato and Hickman** present a model in which the maritime carriers' choice is modelled as a combination of calling at a container terminal and the dwell time of containers at a terminal. As the causal relationship between these choices can be in both directions, a joint model is developed. An understanding of the expected use of terminal facilities is important as the growth of maritime freight requires large investments in port land and infrastructures. The authors propose a copula formulation for the joint probability function, develop an approach to overcome the problem of data scarcity using latent variables, and apply the model to the port of Brisbane, Australia.

Finally, a third group of papers appears in the special issue, which present advances in the treatment of heterogeneity of the population of users of the freight transport system. Heterogeneity is dealt with either applying continuous distributions to display variation around a population mean, or by formulating discrete classes of users, that together describe the population but are not bound by a statistical distribution. This group of papers focuses on the second approach of segmentation. Specifically, two papers discuss segmentation from within different modelling contexts: freight trip generation modelling and shipment size choice.

In their study on freight trip generation modelling, **Gonzalez-Feliu and Sánchez-Díaz** develop a framework to study the categorization of firms, in the search for a proper aggregation level and functional form. As has been shown in earlier publications, the relation between trip volumes and land-use attributes is very strongly sector dependent and one could expect that disaggregate data may result in more accurate models. A key finding is that model accuracy does not necessarily benefit from a detailed sectoral segmentation. For demand generation modelling, research efforts may be better spent on finding the appropriate functional form of a model than on data acquisition for further disaggregation.

The final paper of this issue is by **Piendl, Matteis and Liedtke**. A disaggregate, latent class choice model is proposed for the choice of shipment size and estimated on a sample of German firms using road transport. An optimal number of 4 distinct user classes are identified which, interestingly, can be clearly related to the type of commodities moved. For the purpose of an application in a national transport modelling context, an association between these classes and aggregate commodity flow categories is made using a machine learning approach with a Bayesian classifier. A test case for medium-distance transports is presented.

3. Concluding remarks

Together, the papers present significant advances in 3 key areas of descriptive and predictive freight modelling: activity chaining,

joint modelling of choices and segmentation of users. Next to a methodological contribution in one of these 3 areas, several papers also present empirical findings that are of broader relevance for different choice problems, industries and countries.

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