

Behavioural insights into the Modelling of Freight Transportation and Distribution Systems

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Improvements in technology and logistics practices have radically altered distribution chains. More efficient and less expensive transport, communication, and information systems have fuelled the extension of supply chains and the globalization of the world economy. At the micro-level, companies have become increasingly customer-order-driven. Production systems such as JIT, Lean Production, or Time Based Manufacturing are now ubiquitous. More customer-order-driven production and distribution systems have led to a higher demand for short delivery times, increased demand uncertainty, an increasing preference for fast modes of transportation, and smaller consignments.

Freight models and related public policy tools have lagged behind logistics and technological advances. The structure of supply chains and freight systems have rapidly evolved in the last few decades and their complexity cannot be accurately captured by existing freight transport models at the international, national or regional level that use the conventional four step approach, originally developed for passengers. Freight models simply based on the four-step modelling paradigm cannot provide adequate answers in the twenty-first century global customer-driven economy.

This special issue is dedicated to innovative modelling efforts that provide new insights into the behaviour of freight transport and distribution systems at urban and national levels. Innovative freight models are needed to deal with increased congestion in urban areas and freight hubs and to maintain the reliability and efficiency of freight transport systems. Although efficient movement of freight is crucial to the overall economic vitality of a metropolitan area as well as nationally, it is increasingly difficult to expand or even upgrade freight facilities and capacity. High costs, lack of land, and in some cases, increasing public opposition to freight transport-related environmental, amenity, and health externalities has stalled freight infrastructure expansion and upgrades. In this challenging environment, advances in modelling that take into account supply chain relationships and logistics constraints are needed to significantly increase our understanding of freight systems and the usefulness of freight planning tools.

Research in recent years in the modeling of urban freight distribution has begun to rethink the basis of how choices and decisions are made across the distribution chain. The exporting of modelling ideas from passenger transportation has been called into serious question and as a result we are seeing innovative new research perspectives that seek to understand the complexities of interaction between the key stakeholders in freight distribution (i.e., the seller of goods, the transporter and the receiver of good), and the way in which the activity-based methods might aid in understanding urban truck flows. In developing this Special Issue of Transportation Research B, the co-editors were

interested in (but not exclusively) sourcing contributions that focused on commercial vehicle trip chains, modeling choices in distribution chains (especially the role of transporters and shippers in transport-decisions), methods to model group decision making, and modeling congestion charging impacts in the freight sector. A guiding rule was that the generic focus of the papers should predominantly be behavioral (including willingness to pay) and micro-analytic with a strong element of integrating behavioral structures with econometric/operation research methods and, where possible, empirical examples.

There is growing evidence, notably in real markets, that the study of supply chain relationships and the impact of agent interaction on freight system performance are likely to become key areas of future research. In particular, the modelling of trust, power, and business relationships in supply chains seems a promising field of study. Hensher, Puckett, and Rose present a new framework to parameterise the preferences of agents in a distribution chain for retail goods. They suggest that distribution chains are fundamentally crafted through negotiation and preference revelation and the formation of preferences of two or more agents in the chain, and that each agent brings different objectives to the table that should be reflected in the role that each attribute associated with alternative distribution chains plays in satisfying the requirements of each agent. The need to identify the preferences of each agent, and then to establish how their preferences are used in negotiation (with feedback, review and revision) is important in establishing an equilibrium set of group preferences which are the basis for predictive work. Hensher *et al.* introduce a new method to establish the bounds of group preferences and willingness to pay for key transport service attributes such as travel time and reliability, when the ability to collect data interactively between interacting agents is not feasible. This method known as *Minimum Information Group Inference* (MIGI) is appealing when the analyst needs to establish the concession that each agent is willing to make that would be most likely if they were subject to direct pairwise negotiation. *MIGI* analysis centres on the *sequential* sampling of group members, with group behaviour *inferred* through the coordination of each group member's stated preference rankings for a series of choice sets that are common across the group. MIGI provides a parsimonious and behaviourally plausible alternative to a full interactive agency choice context when budgets and the logistics of mapping agents are not feasible.

The transition from conventional four-step models to supply-chain based models will require proper representation of the movement of products and commodities to and from production centres, storage points, retailers, and consumers. Using Norwegian and Swedish data, de Jong and Ben-Akiva have jointly modelled shipment size, mode choice, and the use of consolidation/distribution centres. The model is based on a behavioural framework that minimizes firm logistics costs and can be estimated on disaggregate data and then applied using micro-simulation.

In time-based logistics systems the flow of materials and products in the supply chain require predictability in time and cost. The understanding of time and reliability in freight transport is a key element to predicting mode-choice decision. Fowkes studies how to estimate shippers' valuations of the benefits originated by reducing both

scheduled journey times and the variability of actual journey times. A theoretical discussion and results from a case study using Adaptive Stated Preference method are presented. Fowkes takes special care to analyze and minimize estimation and model biases.

The efficient movement of groceries, consumer products, industrial supplies, and other staples of modern life is critical to the economy and quality of life of urban economies. Unlike regional or international freight, urban freight is predominantly dependent on trucking and characterized by shorter trips and multi-stop tours. Traditional urban four-step freight models have neglected the importance tour-based and activity-based modeling. The transition to urban freight tour-based and activity-based has already begun and Calgary is the first city to attempt a large-scale tour-based freight model. Hunt and Stefan develop an agent-based microsimulation approach to model tour generation, duration, number of stops, and destinations. Their work details the development of this large-scale model effort and its results.

An analytical framework to study the efficiency of commercial vehicle tours and the relative influence of the number of stops per tour, tour duration, and time window on vehicle-kilometer traveled (VKT) is presented by Figliozzi. Using a continuous modelling approach and a tour classification based on route characteristics and constraint, Figliozzi analyzes the impacts of network/logistics changes and policy implications on VKT. Data collection needs are also discussed. Congestion is a pervasive problem in large urban areas and it severely affects distribution logistics. Sankaran and Wood model the impact of road traffic congestion and Just-In-Time distribution on distribution costs. Using data from shippers and carriers in Auckland, Sankaran and Wood have found that the marginal impact of congestion on distribution costs is shown to increase with the average number of rounds per day achieved by a vehicle and to decrease as the workday lengthens. It is also shown to vary as the square-root of the number of consignments, duly normalized by the number of vehicles.

Changes in information and communication technologies have not only affected consumer purchasing patterns, e.g., home-deliveries, but also allowed the adoption of new real-time mechanism to increase the efficiency of delivery and freight transport systems. A hybrid system of contracting freight services is studied by van Duin, Tavasszy and Taniguchi. This hybrid system allows long-term contracting as well as a real-time auction system to accommodate demand peaks. Using simulation, they show that a hybrid mechanism can provide substantial increases in the distribution system efficiency. Garrido analysis a freight transport market where the availability of real-time information is used to reduce the number of empty trips and transport costs. Garrido shows that a significant reduction in the transport tariff may trigger an adjustment in the replenishment pattern of shippers and a reduction of empty trips in the network.

To cope with the changes in the logistics and freight industry, the study of freight transportation and distribution systems has gained a new momentum among researchers. The papers presented in this special issue are just a sample of the new approaches and modelling techniques being used to tackle the ever increasing complexity of freight

transport systems. The goal of this special issue is to disseminate existing research efforts and to spur new contributions to the field. The papers finally accepted after a two round peer review process are, we believe "fresh" and significant contributions to the field of behavioural research in freight distribution chains.