Accommodating supply chain structure in models of freight mode choice

John William Polak and Kriangkrai Arunotayanun, Imperial College London

Abstract
Modern logistics systems involves complicated interactions amongst many different decision agents within a complex supply chain structures. Accordingly, in contrast to passenger transport, choice decisions in freight transport are typically not concentrated in a single agent, but are co-operatively and sometimes competitively made with different degrees of relationships by multiple individuals and firms in logistical chains, each element of which is endowed with particular policies and specialists from different backgrounds. Existing approaches to the empirical analysis of freight demand have, almost without exception, ignored the influence of supply chain and logistics concepts and have instead relied to conceptual and methodological approaches developed in the passenger sector.

Against this background, the aim of this study is to present an approach to exploring the influence of supply chain structure on the mode choice decisions of freight shippers. The paper is divided into a number of sections. The first section provides a brief overview of the existing freight demand modelling literature, focusing in particular on mode choice decisions. The second section presents a number of alternative theoretical approaches to accommodating supply chain structure within discrete choice models of freight demand. These approaches are drawn from passenger transport studies whose interest is in the interdependency among memberships in the household and freight transport studies whose strategic frameworks accounting for joint choice decision across agents and for supply chain networks were suggested but not yet empirically been revealed. The advantages and disadvantages of each approach are discussed. The third section discusses issues related to data and provides a brief overview of the data source used in this work. These data come from the 2004 French shipper survey (ECHO). A unique feature of the ECHO dataset compared to other national freight transport data sources is that the shipments were individually monitored from their origins to final destinations, of which all related agents were interviewed. That means it includes the information of physical and flow characteristics of individual shipments, characteristics of shippers and transport operators related and especially organisational supply chain structures. These data provide a unique opportunity for some of the theoretical models of supply chain influence to be implemented and tested. The fourth section of the paper presents the main analysis. This analysis focuses on shippers choice of mode amongst four alternative (own account road, for-hired road, rail and combined road-rail) using multinomial logit (MNL), nested logit (NL) and cross-nested logit (CNL) models, where the last two were used to account for possible patterns of correlation in the unobserved utilities among alternatives.

To investigate the influence of supply chain structures, two separate NL model structures were developed; one is to account the heightened correlation between alternative transport modes sharing the same supply chain structure and another is to account the correlation between different supply chain structures sharing the same transport mode. The CNL model was also used to account jointly for the correlation along the two choice-dimensions. With an intention to reduce the impact of the correlations across different transport modes, these models were developed using the detailed utility specification developed previously. The results indicate that some gains in model performance can be obtained either in the nesting by supply chain structure or in the nesting by mode, where the former shows a better performance. The use of the CNL model also leads to some further gains in model fit. The analysis again shows the impact of the models accounting for supply chain structures through the change in the cost-time trade-off.