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Freight transportation demand elasticities: a geographic multimodal transportation network analysis

Michel Beuthe [a,*], Bart Jourquin [a,b,1], Jean-François Geerts [c], Christian Koul à Ndjang' Ha [a]

[a] *Group Transport & Mobility (GTM), Facultés Universitaires Catholiques de Mons, 151 Chaussee de Binche, 7000 Mons, Belgium*

[b] *Limburgs Universitair Centrum (LUC), Universitaire Campus, gebouw D, B-3590 Diepenbeek, Belgium*

[c] *STRATEC S.A., Avenue A. Lacomblé 69-71, 1030 Brussels, Belgium*

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Abstract

This paper presents direct and cross-elasticity estimates of the demands for three freight transportation modes: rail, road and inland waterways. They are computed for 10 different categories of goods with a detailed multimodal network model of Belgian freight transports. The model, which minimises the generalised cost of transportation tasks defined by O-D matrices, assigns traffic flows to the different modes, transport means and routes. Successive simulations with different relative costs permit the computation of specific arc-elasticities. In contrast with the usual methodologies, the present methodology is not based on a statistical analysis of disaggregate data on actual modal choices and transport tariffs. This is a particularly useful feature since such data are mostly not available for freight transports in Europe. Furthermore, it fully takes into account the detailed characteristics of the network, all available routes and combinations of modes, as well as the specific localisation of activities within the network. Its estimates are compared with previously published estimates, and, in particular, with Abdelwahab's results published (1998) in this journal.

Keywords: Elasticity; Freight transport; GIS; Network

1. Introduction

Few estimates of freight transportation direct and cross-elasticities are available in the literature. Exceptions include earlier papers by Oum (1979a,b) on inter-modal competition

* Corresponding author. Tel.: +32-65-32-32-11; fax: +32-65-31-56-91.
E-mail address: gt&m@fucam.ac.be (M. Beuthe).
[1] Tel.: +311-11-268600; fax: +32-11-268700.

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between rail, road and inland waterway in Canada. Moreover, freight transportation price elasticities are rarely estimated separately for different market segments, i.e., different categories of goods, and, they do not explicitly take into account the spatial characteristics of the geographic network, such as a convenient accessibility to a waterway or a rail track at some locations. A notable exception is the recent paper by Abdelwahab (1998) which analyses the rail and road transport demands for different categories of goods and in different United States' regions.

In this paper, we present estimates of direct and cross-elasticities for rail, road and waterway transports which are obtained with an entirely different methodology based on a detailed multimodal geographic information system (GIS) network model of freight transportation in Belgium. The model of the Belgian railway, waterway and road network, embedded within the European networks, was developed with the NODUS software [2], which is based on a detailed analysis and comparison of the costs involved in each transport solution, mode, transport means (heavy and light trucks, type of boats, etc.) and route. Given the matrices of origins and destinations for ten different categories of goods, it minimises the generalised cost of the corresponding transportation tasks by an optimal assignment of the flows between modes, type of vehicles, or their combination, and routes. Simulations with different cost parameters allow then a thorough analysis of modal substitution and the generation of direct and cross arc-elasticities with respect to cost variations. Specific estimates are obtained for each category of goods. They fully take into account the detailed spatial characteristics of the network and the different localisations of activities for each group of commodity.

In contrast with the usual statistical methodologies, the computation of these network elasticities is not based on a data analysis of actual modal choices and tariffs. In effect, such disaggregate data are mostly not available for every freight transport mode in Europe. The methodology rather assumes that shippers minimise their generalised cost of transportation, a commonly accepted hypothesis, and requires (only) aggregate matrices of origins and destinations plus detailed cost information on transport operations. Strictly speaking, they are generalised cost elasticities rather than price elasticities. Hence, they are somewhat unusual, and their assessment requires a good understanding of their particular character in comparison with the statistically derived behavioural elasticities. However, it will be shown that they share some characteristics with those estimated by Abdelwahab (1998).

Thus, in Section 2, the paper starts with some methodological considerations. First, Section 2.1 compares network elasticities with the other more usual elasticities; then, Section 2.2 gives some basic elements of the multimodal transport mode and its cost functions. Section 3 explains how it was built up and calibrated over the Belgian network and gives some measures of its performance. Section 4 presents the elasticities obtained from a set of simulations and compares them mainly with the estimates obtained by Abdelwahab (1998). A global assessment of the results concludes the paper.

[2] Presented in Jourquin (1995), Jourquin and Beuthe (1996), and further developed in Deliverable D5 (1998) of the Terminet (1998) research programme funded by the European Commission.