Measuring freight transport elasticities with a multimodal network model

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Abstract

The paper presents a full set of freight demand elasticities for the three modes of rail, road, and waterways navigation with respect to transport cost changes. They are derived from a trans-European transport model developed for analyzing traffics that could possibly use waterways transport on the river Rhine, and for assessing the impacts of climate change on inland navigation (EU's ECCONET program). The transport model is based on the NODUS software applied with a multi-flows assignment technique which minimizes transport costs. Elasticities are presented as aggregate elasticities over a set of 11 commodities, and separately for each commodity; direct and cross-elasticities are also given as well as elasticities per distance category. Previous studies' results and methodologies are assessed and compared to those presented in this paper.

Longer abstract

There are not many analyses of freight transport elasticities to be found in the literature, and available estimates cover a wide range of values according to modes and cases. Such a diversity of results could be expected as similar results can be observed in the numerous studies on passenger transport demand elasticities. Indeed, the type of modeling, the differences between transport markets, data set and spatial scope may substantially affect the estimates, which may also correspond to short or long run elasticities (Oum, Waters and Yong, 1992). These differences must be taken into account for the interpretation of the results and their use in formulating transport policies.

Our work within the European ECCONET project on climate impacts on inland navigation led us to set up a full multimodal freight transport model over the Rhine area market (Beuthe et al., EWGT 2012, Procedia 2012), from which it is possible to extract transport demand elasticities. Earlier, we applied a rather similar approach using the multimodal freight model NODUS calibrated on Belgian transport data (Beuthe, Jourquin, Geerts, Koul à Ndjang'Ha, TR-E, 2001). This model is based on a GIS virtual network approach that identifies all the required transport operations for each mode and means between every origin and destination, and assigns traffic by minimization of the generalized transport cost. Given the high density of the Belgian network and its fine zoning mesh, a rather simple 'all-or-nothing' algorithm was applied, which assigned each origin-destination traffic to the least costly solution chosen among all available modes, means and routes solutions. The aggregate direct cost elasticities in respect of tonnage were of the same order of magnitude as those available in the literature at that time: -0.59 for road, -1.77 for rail and -2.13 for waterways, but there was a wide dispersion of results among commodities. In respect of tons-km, rail and waterways demands were still elastic, though at a smaller level, and so were road elasticities at -1.21.

In the present research, the zoning over the relevant continental Europe's regions is at the much larger NUTS 2 level, and a 'multi-flows' assignment technique, available in more recent versions of NODUS, was applied which spreads traffic between each origin and destination over several possible solutions. In short, a first step assigns traffic between modes in inverse function of their generalized costs; in the same way, a second step spreads the traffic within each mode between the available means (vehicles). The outcomes of this modeling generally show inelastic demand reactions to cost variations. In the aggregate we obtain: -0.16 for road, -0.76 for rail and -0.19 for waterway, as shown in the Table below. Note also that both rail and waterways modes are more sensitive to road's cost change than the reverse. This may largely be explained by the much higher market share (77%) of road transport in that market. Considering the range of their values between commodities, they appear somewhat stronger than the recent estimates by Rich, Kveiborg and Hansen (J. of Transport Geography, 2011), who derived their estimates from a Scandinavian freight demand model on a network with sparser multimodal connections. We obtain -0.01 to -0.82 for road as against -0.01 to -0.29, and -0.58 to -1.0 for rail as against -0.1 to -0.4. Two factors at least explain the difference with our previous results. Firstly, the larger zoning implies that substitutions of transport are made more difficult, as pointed out by Rich, Kveiborg and Hansen. Secondly, the multi-flows approach imposes the use of several vehicles and, possibly, different routes, with the effect of moderating the responses to price/cost changes. In other words, these lower elasticities express the shippers' adjustments within a shorter term horizon than the previous ones.

The paper first reviews the state of knowledge in the field, the various available results, their modeling and data differences. Next, it outlines the multimodal NODUS model specificities as applied on the Rhine area market. Then, it presents a full set of direct and cross-elasticities for the three modes (rail, road and waterways), both in terms of tonnage and tons-km, for 11 categories of commodities, including the containers. The results by distance categories also are presented. These results are commented and their coherences discussed. The final section attempts to draw some synthetic conclusions and recommendations on the good use of the alternative results in different circumstances.

Aggregate elasticities on traffic in the Rhine area

(all traffics that could possibly navigate on the Rhine)

		Total cost reduction			**Travel costs reduction**		
		Road	**Rail**	**Water**	**Road**	**Rail**	**Water**
Tonnes	**Road**	-0.16	0.11	0.06	-0.11	0.04	0.04
	Rail	0.62	-0.76	0.15	0.43	-0.34	0.12
	Water	0.42	0.19	-0.59	0.29	0.1	-0.47
T-km	**Road**	-0.16	0.11	0.06	-0.12	0.05	0.05
	Rail	0.59	-0.74	0.16	0.45	-0.38	0.14
	Water	0.4	0.24	-0.61	0.31	0.15	-0.53