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The impact of transport policies on railroad intermodal freight competitiveness – The case of Belgium

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ABSTRACT

This paper discusses the impact of three freight transport policies aiming to promote railroad intermodal transport in Europe, and examines the case of Belgium as a testing ground. These policies consist in subsidizing intermodal transport operations (such as in Belgium, to stimulate rail transport), internalizing external costs (as recommended by the European Union in order to foster cleaner modes), and adopting a system perspective when optimizing the location of inland intermodal terminals. The study proposes an innovative mixed integer intermodal freight location-allocation model based on hub-location theory and deals with non-linear transport costs in order to replicate economies of distance. Our analysis suggests that subsidizing has a significant impact on the volumes transported by intermodal transport, and, to a lesser extent, that optimizing terminal location increases the competitiveness of intermodal transport. On the other hand, according to our assumptions, internalizing external costs can negatively impact the promotion of intermodality. This finding indicates that innovative last-mile transports are needed in order to reduce the external impacts of drayage operations.

Introduction

Freight transport in Europe has grown by almost 40% over the last two decades while the number of truck movements has increased at an even higher rate. Ground freight is now the predominant option in Europe with market share in the EU27 growing from 73.7% in 2000 to 75.6% in 2011 (Eurostat). This comes from the greater flexibility and general economic competitiveness of the mode but partly also from the changes in production principles observed over the last decades. The freight context in Europe has shifted from heavy bulk cargo (e.g. steel and coal) to lighter cargo shipments involving smaller shipment size and more frequent freight services over longer distances. This shift has boosted road and air transport in Europe (Hesse and Rodrigue, 2004).

The present trend increases pressure on transport infrastructures and extends the negative impacts of transportation (e.g. emissions, noise, congestion, fuel consumption, economic losses). Consequently, in the current Transport White Paper, the European Union (EU) presents a roadmap for a more competitive and sustainable European transport system (COM, 2011). Concerning freight, one of the goals of the EU is to shift 30% of long-distance (over 300 km) road transport to more efficient modes, such as rail or water by 2030 and 50% by 2050.

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Containerizing cargo can be seen as an alternative option for the transport of lower volume flows, while offering the opportunity to consolidate goods and achieve economies of scale. In addition, as was pointed out by Notteboom and Rodrigue (2005), lack of space and congestion at seaport areas increases the relevance of inland intermodal terminals in the freight transport system in providing reliable connections and stimulating competition for distant hinterlands.

This situation has led to increasing interest in intermodal freight transport (i.e. the combination of at least two modes of transport without a change of loading unit, and where the long-haul mode is normally rail or inland waterways). This combination of modes is promoted by the EU as part of the solution to increase rail mode share and to foster more sustainable transport in Europe. Yet, despite the many advantages of this transport option and the various initiatives launched to increase intermodality, the share of intermodal transport in Europe remains limited – only about 5% of the total EU freight transport flows are made via intermodal routes (Savy and Aubriot, 2005). New transport policies are needed to change the European cargo paradigm and to increase this market share.

The potential markets for intermodal transport are large-flow routes over long distance. Small as they are, Belgium and the Netherlands still feature among the countries having the highest share of intermodal freight transport in Europe. According to Eurostat figures, road transport prevails in Belgium, with a market share of 66.3% (versus 77.4% in 2000) in terms of t·km. There are, however, increasing flows for rail (15.2% in 2011 versus 11.6% in 2000) and inland waterways (18.5% in 2011 versus 10.9% in 2000). Despite manifest improvement in Belgium, there remains ample spare capacity for these so-called alternative transport modes.

This paper, therefore, focuses on intermodal transport in Belgium and specifically on continental freight transport, considering road, rail and their combination. It analyzes the impact on freight transport of adopting three policies: subsidizing intermodal transport, internalizing external costs and adopting a system-wide perspective for strategically locating intermodal terminals. Subsidizing intermodal transport is a current practice in Belgium and internalizing external costs has been studied by the European Commission for several years. As to the third policy, we investigate the potential (in)efficiency of the fixed transport system with regard to the current location of the Belgian terminals. The hypothetical scenario tested here measures the gap between the current terminal locations and an optimal configuration.

For this analysis, a mixed integer-programming model is presented. The decisions to be made relate both to the location of railroad intermodal terminals in the network and to the allocation of freight flows between the modes with the view to minimize total transport costs. These can include direct operational costs, external costs and subsidies for intermodal operations. The model is based on the p-hub location problem. Most of mixed-integer linear programming formulations for the p-hub problem involve a large number of allocation decision variables representing the fraction of the total flow from and origin to destination node via two specific hubs. In network hub location problems with every origin and destination node as a candidate hub node, there are variables of size $O(n^4)$ where n is the number of potential hub nodes. According to the survey made by Farahani et al. (2013), the models proposed by Ernst and Krishnamoorthy (1996, 1998) are the only one to use variables of size $O(n^3)$. The variables in their models treat the inter-hub transfers as a multi-commodity flow problem. Each commodity represents the traffic flow originating from a particular node. Their formulation decreases the problem size in number of variables by a factor n. As in Ernst and Krishnamoorthy (1998), these variables are also used in our model but with a relaxation of some traditional constraints in order to better reflect the reality of intermodal freight transport. To the best of our knowledge, this work is the first to use this formulation to address a real intermodal freight problem. In addition, it makes use of non-linear transport cost functions capturing the effect of economies of distance and reflecting the concept of economies of scale.

In what follows, we review some of the most relevant literature on intermodal freight transport and our own contribution (Section 'Literature overview'); we present the case of Belgium (Section 'Problem definition'), the methodology, the model proposed (Section 'Methodology'), the results of our case study and the implication of the different policies tested (Section 'Results'); and draw conclusions (Section 'Conclusions').

Literature overview

As an emerging research area, intermodal freight transportation, has gained growing research interest over the last two decades (see Caris et al. 2008, 2013 for a review on this). As yet, several authors have addressed the strategic planning of these multimodal systems, mostly through developing operational research techniques (Macharis and Bontekoning, 2004). Rutten (1995) was one of the first to address this issue. His study aimed to define terminal locations likely to generate sufficient freight demand in order to operate daily trains to and from the terminal. van Duin and van Ham (2001) identified the optimal locations while incorporating the perspectives and objectives of different stakeholders, and developed a specific model for each decision level (strategic, tactical and operational).

More recently, a substantial number of analytical works addressing intermodal transport issues have appeared. Among these, Arnold et al. (2004) used an integer-programming model and heuristics to locate railroad terminals by minimizing the total transportation cost. Assuming the unit transport costs and transhipment costs to be constant and applying the proposed methodology to the Iberian Peninsula, they concluded that modal share is very sensitive to the relative costs notwithstanding the fact that these have little impact on the location of terminals. Limbourg and Jourquin (2009) discussed the location of terminals in a European road-rail network. Their main methodological contribution was the iterative procedure used in combining the results of both the location and the multi-model assignment problems. The concept of market area