Intermodal network design for freight transportation in Belgium - location of rail/road and road/inland waterway terminals

M. Mostert
HEC-ULg, QuantOM
martine.mostert@ulg.ac.be

S. Limbourg
HEC-ULg, QuantOM
sabine.limbourg@ulg.ac.be

In the recent years, growing concerns about environmental, societal and economic issues have led the European Commission to promote a clear vision for competitive and sustainable transport development (2011). This can be done by the improvement and the expansion of the multimodal network. An intermediate objective of this vision is therefore the shift of 30% of the road freight transport over 300 km to other more environmentally-friendly modes of transport such as rail and waterborne by 2030.

In this context, the problem which consists in finding the optimal location of intermodal freight terminals is of strategic importance (Macharis and Bontekoning, 2004). Intermodal transport is defined as the "Movement of goods, in one and the same loading unit or vehicle, by successive modes of transport without handling of the goods themselves when changing modes" (European Conference of Ministers of Transport, 2001).

The intermodal freight terminal location problem has already been studied by several authors in the literature. Arnold et al. (2004) develop a mixed integer linear program in order to determine the optimal location of rail/road terminals and they apply it to a case-study in the Iberian Peninsula. Their formulation relies on a multicommodity fixed-charge network design problem. Sörensen et al. (2009) develop two different metaheuristics procedures for solving those types of problems. Comparisons of developed metaheuristics are done with an MIP solver. The results found using the metaheuristics are close to optimal solutions in short computing times. Ishfak and Sox (2010) focus on the network design problem, based on the development of a mathematical model using the multiple-allocation p-hub median approach. Again, the authors consider both rail and road networks in their model.

However, none of those papers treats the problem of having more than just two modes of transport (i.e. either intermodal transport using rail for the long-haul journey and road for pre-and post-haulage or only road transportation). Moreover, they generally consider constant marginal transportation costs, which do not reflect clearly the different components constituting the cost (operational costs, external costs), which makes it more difficult to assess the impact of several policies on the solution. The objective of this work is therefore the integration of a third mode of transport into the linear modeling of intermodal terminal location problems, based on transportation costs functions which are nonlinear with the distance traveled. The model should also take into account the capacity constraints linked to the different modes of transport. The goal is to be able to identify the impacts on the rate of use of intermodal transport and on the terminal locations of several policy measures, such as the granting of subsidies or the internalization of the external costs caused by transportation.

Our work should extend the model developed by Santos et al. (2012) in order to integrate a road/inland waterway terminal into the formulation. The model is based on a hub-location theory and the decision variables are of two types : the location of terminals and the repartition of freight flows over the different modes of transport (i.e. : intermodal using rail, intermodal using inland waterway or only road). The objective function consists in the minimization of the total costs which include costs of using only road, pre-and post-haulage costs when intermodal transport is chosen, as well as handling costs at the different terminals and rail and inland waterway costs for the long-haul journey when the intermodal solution is preferred. Beyond considering costs functions which are nonlinear with the distance traveled, the formulation developed by Santos et al. has the advantage to decrease the problem size compared to the most formulations "flows" in the literature, which facilitates the resolution of the problem by reducing the computing time for obtaining the optimal solution.

The added value of this study is the integration of a second type of intermodal terminal into the intermodal terminal location problem with costs functions that are nonlinear with the distance traveled. This problem has, at our best knowledge, not been addressed in the literature until now. The comparison of the optimal solution of the model with the current location of rail/road and road/inland waterway terminals in Belgium can be a good tool for validating the model.

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