

Optimal subsidies for rail containers: a bi-level programming solution

Abstract

High demand for containerized cargo and the low share of rail containers in China is causing heavy container truck traffic and pollution. Due to its social benefits, many provinces/municipalities provide subsidies for rail containers. These subsidies, aimed at reducing road traffic and emissions, may, however, have unexpected results if they are uncoordinated. Our objective is to illustrate the problem with uncoordinated subsidies and propose an optimal subsidy scheme. This study applies the minimum cost flow model to analyze three scenarios: no subsidy, the internalization of external costs, and uncoordinated subsidies. A bi-level programming model is developed to study the scenario of coordinated subsidies, where a hypothetical network planner minimizes the total subsidies for a given externality reduction target in the upper level and the cargo owners minimize total transportation cost in the lower level. A novel method is designed to transform the model into a simple four-step linear programming process. The model and solution method are then applied to containerized trade of Northeast Asia with Europe and that with northern Chinese inland cities. The coordinated subsidy scheme is found to use less in total subsidies, achieve better results than the uncoordinated one, and better total social welfare.