

Service network design with empty container repositioning in intermodal barge transportation

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Abstract

A decision support model for service network design in intermodal barge transportation is presented. The model determines optimal shipping routes for roundtrip services between a major sea port and several hinterland ports. The model decides on the hinterland ports to be visited and which transport demand should be fulfilled in order to maximize profit. Empty container repositioning movements are taken into account. A case study on the hinterland network of the port of Antwerp in Belgium is discussed. Numerical experiments are presented to show how the model can be used to identify the appropriate vessel size and service frequency.

Keywords: Service network design, intermodal barge transport, empty container repositioning

A decision support model for service network design in intermodal barge transportation is presented. Service network design is concerned with the selection and characteristics of routes on which services are provided. An efficient service network design should take empty container repositioning movements into account. These empty container movements are highly interrelated with loaded container transports. Unfortunately, most existing models do not consider both types of movements together.

The mathematical model described in this paper can be used as a decision support model for a large logistic service provider or shipping company that wants to offer regular roundtrip barge services between a number of ports located alongside a single waterway. The model is formulated as an integer programming problem. Since the model takes the viewpoint of a single company, the objective is to maximize profit and unprofitable transport demand may be turned down. When considering a roundtrip service, both vessel capacity and frequency of service have to be defined. For each service type (capacity and frequency) the model determines the optimal shipping routes and the number of containers to be transported during each roundtrip in order to maximize profit. Empty

container repositioning movements are taken into account by imposing container balancing constraints at each port. These balancing constraints impose total container inflow to equal total container outflow for each port over the planning period. Other constraints are related to vessel capacity, maximum roundtrip time and maximum container storage space at hinterland ports. Revenues are generated by transporting loaded containers. Costs included in the model are: daily charter and crew costs, distance-related fuel and maintenance costs, port entry costs and container handling and container storage costs at the ports. No costs for turning demand down are assumed. A distinction is made between situations where demand is constant and situations where demand varies over the planning period. Both scenarios with a single vessel and scenarios with multiple vessels to offer barge services can be investigated.

A case study on the Albert Canal in the hinterland network of the port of Antwerp in Belgium is discussed. The Albert Canal connects four hinterland ports with two clusters of terminals in the port of Antwerp. Numerical experiments, using realistic data, are presented to show how the model can be used to identify the appropriate vessel size and service frequency. The model is implemented in AIMMS and solved using CPLEX 12.0. Results for three types of scenarios (single vessel with constant demand, single vessel with varying demand and multiple vessels with constant demand) are reported.

Finally, it is shown how the model can be used to support long term strategic decisions. This may not only be useful for logistic service providers and shipping companies but also for policy makers like port authorities. The model may be used to investigate the effect of changes in the network and service network configurations on the hinterland transport chain. For example, the effect of an empty container hub in the hinterland and the effect of changing maximum empty container storage space at the hinterland ports can be analyzed.

In the future, it will be analyzed up to which extend (in terms of number of clients, vessels and planning periods) the model can be solved optimally within reasonable computation time. Future research could also focus on taking uncertainty regarding transport demand into account.