Extended abstract:

"The impact of modelling sea transport loops"

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Short summary

We analyze the effect of removing restrictions in sea transportation modelling by allowing the ship operators to utilize loops. In the new model, the shippers' choice of sea transport routes is modelled as a mixed integer linear programming optimization problem.

Background

The Swedish national freight transport model system Samgods is a freight model that simulates logistics decision at a disaggregated firm-to-firm level. The model calculates total annual transport demand in Sweden for all transport modes based on a deterministic cost minimization approach.

In the core of the model system is a logistics model where commodities are assigned to different transport chains based on minimization of the total logistics cost where shipment size and transport chains are chosen simultaneously. The transport cost is calculated as a generalized cost composed of time costs, distance costs, other link costs (e.g. tolling) and costs for loading and unloading etc (Significance, 2016).

For sea transports, the transport chains only simulate vessels using direct routes between two ports. The model also cannot consolidate commodities of different commodity types in the same vessel. This implies that many of the features of sea transport such as utilizing larger vessels and building loops with fixed time tables to consolidate goods from different harbors is not possible in the current Samgods version.

A hypothesis is that these model restrictions could explain some of the difficulties of the model framework to model economies of scale in sea transportation and the overestimated share of smaller vessels compared to statistics .

Scope and purpose

The purpose of this paper is to analyze the effect of removing restrictions in sea transportation especially by allowing the ship operators to construct and utilize loops. In the model, the shippers' choice of sea transport routes is modelled as a mixed integer linear programming optimization problem.
The paper will also discuss how results from the study can be incorporated into the full Samgods model in order to better model sea transport. The paper will address the following research questions:

- What is the differences between simple routes with only two stops and more complex loops where a vessel can load and unload cargo at multiple stops along a predefined route?
- How does the response of the shippers from a cost increase change depending on how the model is formulated?

Literature

A large field of research in logistics and operations research concerns the development of models and calculation methods for analyzing and designing optimal loops and shipping schedules for sea transport. See for example Christiansen et al. (2004), Christiansen et al. (2013) and Meng et al. (2013) for some resent reviews.

A major challenge in this research is that the models often give rise to optimization problems with very high complexity. The problem of designing optimal loops can in many situations be described as a variant of the well-known traveling salesman problem (TSP). This problem is NP-hard, which means that in worst-case the resolution time increases very quickly with the problem size. This can make it difficult to solve exactly find a solution to the major problems with many nodes. A great deal of research in the field has focused on developing various forms of alternative heuristic methods to reduce computation times for large problems (see for example Korsvik et al., 2010).

Method

The model proposed in this paper, LIFREM, is in part based on models Fagerholt and Christiansen (2000) and Fagerholt (2004). In the new model, LIFREM (Loops Including FREight Model), the shippers' choice of sea transport routes is modelled as a mixed integer linear programming optimization problem. In doing so, we make use of a case study on sea transport of forest products from Northern Sweden to Western Europe, for one specific shipping company.

Preliminary results

The results show that allowing predefined loops decreases total transport cost by 5% and allowing the shipper to freely select loops decreases the cost by 12%. These result show that modelling of loops is important in order to realistically represent the attractivity of the sea transport mode.