Abstract

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Ocean Carrier Network Design Problem and Port Sustainability: A Mathematical and Sustainable Maritime Balanced Scorecard Perspectives

In this PhD thesis, the ocean carrier network design problem and the triple bottom line concept of the port sustainability are addressed and two modeling approaches are proposed in this field. This thesis concerns design of liner shipping networks using operations research to optimize liner shipping networks. Liner shipping networks are often compared to public transit networks as they consist of a set of scheduled sailings connecting at main ports to consolidate freight on large vessels. The liner shipping network is constrained by the composition and size of the vessel fleet and the objective is to minimize the cost of shipping containers between origins and destinations by a high utilization of the capacity of the fleet. The research field of liner shipping network design is relatively young and many open research questions still exist. Among others, a unified and rich mathematical model formulating the main characteristics of the business domain has not been clearly described and exact methods for such mathematical models are still not able to solve significant instances of this complex optimization problem. In this thesis two research directions are explored within the field: The first research direction contributes to basic research on the liner shipping network design problem by describing the domain seen from the perspective of a global liner shipping carrier, and discuss alternative mathematical models of the problem. A domain description, literature survey and a base integer model of the problem are presented. This work is achieved by incorporating some of the port sustainability indicators related to the environment and the society. The second research direction is to identify and analyze a sustainable maritime balanced scorecard that integrates all the three aspects of the triple bottom line: economic, environmental and social indicators into just one sustainable maritime balanced scorecard. The first model proposed in this work is devoted to the optimization of the network design problem through a mathematical model. A second model was built through integrating environmental and social indicators from the triple bottom line concept. The problem, aiming at minimizing the shipping cost as well as reducing the gas emissions for each chosen route and increase the positive impacts on the surrounding community. This model is a sustainable ocean carrier network design problem which incorporates environmental and social indicators other than those of the economic perspective. On the other hand, the second model proposed in this work concerns the sustainable balanced scorecard. The traditional balanced scorecard is extended to integrate all the indicators of the triple bottom line concept: economic, environmental, and societal. This work was implemented through structured interviews and secondary data from the Egyptian Port of Alexandria. From the sustainable mathematical model and the balanced scorecard, we reached to build a "sustainable route" that optimizes the following indicators: minimizes economic costs, minimizes gas emissions, and maximizes societal satisfaction. This "sustainable route" is a starting point for future research work that targets to find the most optimal route that optimizes all economical, environmental and societal aspects. The thesis contributes to the understanding of the field of the Ocean Carrier Network Design Problem. Two different mathematical models for the problem are presented as well as a sustainable BSC.