Vessel Network Optimization in the Great Lakes Region

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MIT GLOBAL SCALE NETWORK

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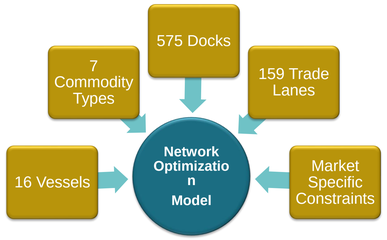
Motivation / Background

- The sponsor company for this capstone project, ASC RAND, is a provider of dry bulk shipping services throughout the Great Lakes region in North America.
- RAND Logistics acquired ASC in May 2020 that resulted with an increase in their capacity (increased fleet size) and opportunity to serve Canadian market.
- The company is looking for a novel quantitative approach to minimize the costs and the ballast time.

Drivers of Complexity



Key Question / Hypothesis

If the company intends to serve the whole market;

- What is the optimal allocation of vessels to each trade lane that will give lowest operational cost?
- What is the optimal routing of vessels that will minimize the ballast time?

Relevant Literature

- Higginson, J. K., & Dumitrascu, T. (2007). Great Lakes short sea shipping and the domestic cargo-carrying fleet. Transportation journal, 38-50.
- Tsiakis, P., Papageorgiou, L. G., & Georgiadis, M. C. (2008). Optimal design of supply chain networks using mathematical programming. Process Systems Engineering.

Methodology

Phase 1 – Vessel Allocation

In the first phase, we solve a Transportation Problem to find the optimal allocation of vessels for that minimizes the cost.

$$Min\ z = \sum_{i=0}^{I}\sum_{j=0}^{J}\sum_{k=0}^{K}\sum_{l=0}^{L}(x_{ijkl} \times c_{ijkl} + M * u_{ijkl})$$

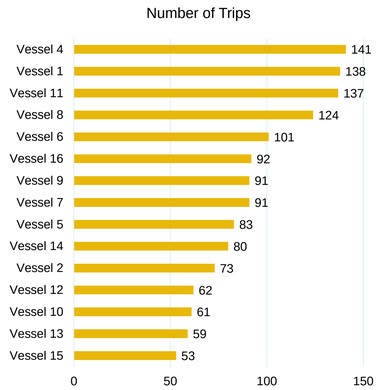
Phase 2 – Trip Sequencing

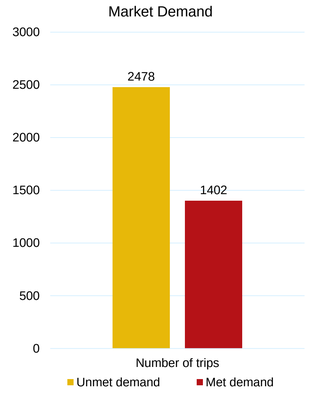
In the second phase, we solve a Pick-up and Delivery Problem by distributing the demand into months to find the optimal sequence of trips for each vessel, while minimizing the ballast time.

$$Min\ z = \sum_{t=0}^{T}\sum_{i=0}^{I}(sd_{it} * \sum_{q=0}^{Q} v_{q0} + \sum_{q2=0}^{Q}\sum_{q2=0}^{Q}\sum_{r=0}^{R}(v_{q1r} * v_{q2(r+1)} * y_{q1q2})$$

Results

This study has two main sets of results. The first one is the allocation of vessels for a nine-month shipping season. The result we obtained from Phase 1 is a list of vessels assigned to the trade lanes for associated commodities along with the number of trips they should make for the season. The second set of results is the monthly assignments of vessels to the trade lanes along with the sequence of trips for each month, with the objective of minimizing the ballast time.





Expected Contribution

The project will provide the company with a network optimization model that will serve them as a strategic decision-making tool to minimize the operational cost and the ballast time.

The network optimization model that was developed for the Great Lakes region can be also used in bigger scale problems such as network design for ocean shipping services.

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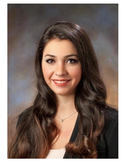

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