Maritime Inventory Routing

The Challenge

A large petrochemical company annually transports significant volumes of vacuum gas oil (VGO) from supply points in Europe to refineries in the United States. Optimizing these transportation costs can provide significant cost savings.

The goal is to find an optimal schedule for routing a heterogeneous pool of seagoing ships in the loading, transporting and discharging of a single bulk product to and from multiple ports while maintaining all capacities, constraints and restrictions related to inventory to specific ports. This problem is defined as follows. Given:

- Set of ports at which product is either produced or consumed.
- Set of heterogeneous vessels (some of them may be already chartered).
- Time horizon for planning.
- Daily amount of production or consumption of product at each port.
- Initial inventories of product and inventory limits at each port.
- Load or discharge quantity ranges at each port.
- Travel time between ports.
- Draft limits and other port restrictions.
- Cargo capacity and port cargo minimum for vessels.
- Transportation cost calculation parameters.

The objective is to minimize total transportation cost minus added value by transported product while the routes of specific vessels, the timing of each particular leg of the voyages, and quantities of product loaded and discharged are determined by the solution of the problem such that all constraints are satisfied. This problem already has several complicating characteristics including: flexible cargo sizes, port draft limits, daily changing production and consumption rates, vessels may load and discharge at multiple ports, vessels may revisit ports, limited berth availability at ports, and route-, cargo size- and timing-based transportation costs.

The Solution

An optimisation approach was developed based on a time-indexed mixed-integer column generation formulation. The branch-price-and-cut algorithm contains several innovations, in both cut generation and pricing, and can solve practically sized problems to optimality and produce high-quality solutions for especially difficult instances.

The Benefits

A solution approach partly inspired by our research is embedded in a decision support tool developed internally at ExxonMobil. The tool significantly improves the analytical capability of traders and schedulers and yields both transport cost savings and trading profit opportunities. The decision support tool for optimizing the ship schedule while managing the

inventory levels at the refineries may be run anywhere from a few times a week to several times per day depending on available volumes of VGO, the current state of the shipping market, and VGO values in both the United States and Europe. After analysing the result of the optimisation, ship chartering decisions are made for only the first few weeks of the planning horizon, which leaves the flexibility to change the schedule and alter decisions further out into the future.

C-OPT Researchers involved: Faram Engineer and Martin Savelsbergh

Centre for Optimal Planning and Operations
Analytics and Decision Support for
Infrastructure, Transport, and Logistics