Chapter 6
Designing of Container Feeder Service Networks Under Unstable Demand Conditions

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ABSTRACT

The COVID-19 pandemic has greatly magnified supply challenges in all industries, and virus waves continue to cause an extraordinary amount of variation in both the demand for and the availability of necessary products. This uncertainty has also forced many organizations including container liner shipping to redesign their supply chain. Feeder services from hub ports are essential chain of shipping networks. This chapter addresses the design of feeder networks under consideration of demand fluctuations over the year. For this purpose, a perturbation-based variable neighbourhood search approach is developed in order to determine the feeder ship fleet size and mix, the fleet deployment, service routes, and voyage schedules to minimize operational costs. In the case study investigation, the authors consider the feeder network design problem faced by a feeder shipping company as a sample application. The performance of alternate network configurations is compared under dynamic demand conditions. Numerical results highlight the advantage of dynamic and flexible design of feeder service networks.

INTRODUCTION

Driven by the ever-increasing loading capacity of containerships, hub-and-spoke networks turned out to be the most economic mode of organizing global container shipping. In this kind of networks hubs are connected to the main intercontinental sea routes while regional ports with low transport demand are serviced by small and medium-sized feeder ships. The connections from the hub ports to the regional ports constitute the feeder network which provides the global containership liners access to local transportation markets and avoids the megaships' calling at too many ports.

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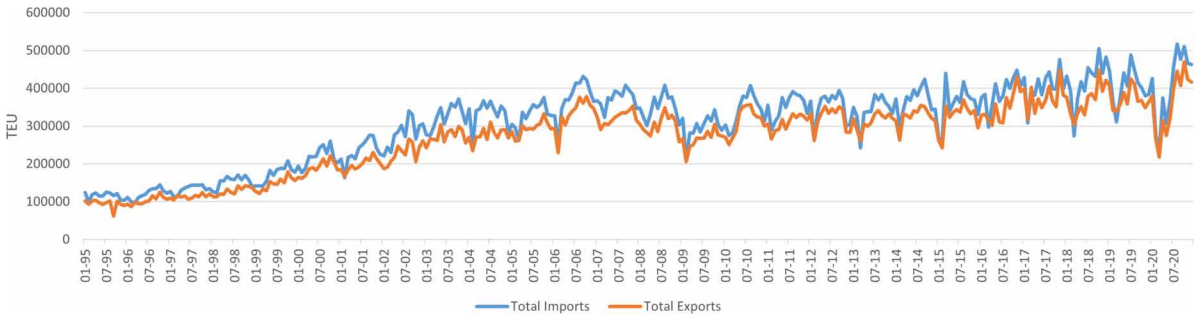
Global liner shipping as well as feeder service requires significant capital investment for the fleet of containerships and involves huge operational costs. High utilization of the fleet capacity is needed to secure the desired return on investment (Coskun et al., 2016; Polat & Güngör, 2019). Principally, the revenue of container shipping is affected by the transported container volume which in turn depends on the development of the world economy and world trade (Zachcial & Lemper, 2006). Specifically for feeder services there are close relationships to regional economic developments which strongly affect the transportation demand of export as well as import goods and raw materials. In addition to volume, the balance between import and export containers at ports is a critical factor. Theoretically, a feeder ship could carry up to twice of its slot capacity in a cyclic route if it departs from the hub port with all the import containers, delivers them to regional ports, simultaneously picks up export containers, and returns to the hub port loaded with export containers. When the trade is imbalanced at the ports, slots remain idle during the journey of the ship. In particular, trade imbalance in certain regions makes it difficult for feeder services to fully utilize the capacity of feeder ships operating in the network. Therefore, the design of feeder services plays a crucial role in maritime logistics.

Generally, in maritime transport demand fluctuates over the year with seasonal cycles, peaks at certain times of the year, and unexpected sharp drops and cancelations occur (Schulze & Prinz, 2009). For certain types of goods production and consumption varies over the year, e.g. following the harvest season for fruit or fish. While most of these factors are affecting only a single port or region, other factors like Christmas and Chinese New Year, create peaks in global trade. In addition, unexpected financial and political developments may cause demand fluctuations in intercontinental and regional container shipping. Figure 1 shows the monthly development of container traffic for a number of selected port (The Port of Los Angeles) from 1996 to 2020. The figure not only exhibits the periodic fluctuations but also highlights the impact of the economic crisis.

Figure 1. Monthly total container traffic at the Port of Los Angeles



The transportation demand of ports determines the necessary slot capacity for the shipping liners. Since demand is uncertain, shipping liners must carefully consider their capacity decisions. Shortterm fluctuations are further caused by contract conditions which allow shippers to pay for container transportation only when the container is loaded onto a vessel or delivered to its destination. This situation enables shippers to cancel their bookings before loading despite their long term contractual agreements. Hence, demand fluctuations have to be seen as a driving force in the design of service networks. Even small variations in the demand pattern could lead to entirely different service network designs (Andersen,