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ScienceDirect
European Journal of Operational Research 182 (2007) 400–412
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

O.R. Applications

Allocation of empty containers between multi-ports

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Received 23 February 2004; accepted 31 January 2006
Available online 19 October 2006

Abstract

Owing to imbalances in international trade activities, shipping companies accumulate a large number of unnecessary empty containers in the import-dominant ports, whilst request a large number of empty containers in export-dominant ports. The logistics challenge to shipping companies is to better manage and control their containers, which consist of company-owned containers and leased containers. The multi-port empty container allocation problem is concerned with the allocation of empty containers from supply ports to demand ports. In this paper, optimal pairs of critical policies, (U, D) for one port, which are importing empty containers up to U when the number of empty containers in the port is less than U, or exporting empty containers down to D when the number of empty containers is larger than D, doing nothing otherwise, are adapted to multi-port case so that decision-makers can make decisions about allocating the right amounts of empty containers to the right ports at the right time. This allocation problem has been formulated and the heuristic methods are designed according to that the average cost using (u, d) policy at one port is convex in u and d. Furthermore, the examples show that, using the heuristic algorithm, the result in the inland line case is quite close to the lower bound, even the distance is not so close in the global line case.

Keywords: Containerization; Inventory; Heuristics

1. Introduction

Maritime transportation is one of the world's steady growth industries in the world. Management in maritime transportation consists of having to deal with the coordination of materials and goods flows among suppliers, manufactures, distributors and customers by means of a fleet of vessels. Since the 1970s, the containerization of cargo transportation has been the norm in worldwide maritime services, because of its manifest advantages in the rationalization of shipments, security, facility of handling and the facilitation of multi-modal transportation. All shipping companies compete on freight rates, transit times and customer

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0377-2217/$ - see front matter
doi:10.1016/j.ejor.2006.09.003

services to provide container transportation services. The competitive edge of a shipping company can be increased by better control of its container fleet, i.e., by reducing expenditure and becoming more responsive to shippers' demands. Due to the imbalance in international trade activities arising from different economic needs in different countries, the supply and demand patterns of empty containers at different ports are also quite different (Cheung and Chen, 1998). For instance, shipping companies accumulate a large number of unnecessary empty containers in the Middle East, whilst some export ports such as Hong Kong often face a shortage of empty containers. Since shipping companies pay substantial operational expenses to maintain their container fleets, they need to manage and schedule the movement and inventory of empty containers efficiently. The aim of this paper is to formulate a strategic empty container allocation policy between multi-ports so that decision-makers can make decisions regarding the allocation of empty containers, with specific emphasis on the policies to reposition surplus empty containers from supply ports to demand ports, or to lease additional empty containers from leasing companies for demand ports, so as to meet shippers' demands and to prepare for future shippers' demands.

The current planning process can be described as follows. One of the business activities of a shipping company is to plan how to dispatch loaded containers from shippers to receivers. A shipping company uses vessels as the main mode of transport to carry containers from one port to another over its sea transportation network. Usually, the vessels carry containers loaded with imported goods and empty containers transferred from previous ports. After the vessel arrives at the terminal, the loaded containers are unloaded from the vessel and are transported to their destination by road or rail. At the final destination the containers are then unloaded and empty containers are returned to the shipping company. The shipping company will reuse empty containers to meet other demands or will store them at a container yard for future requirements. Then, the imported, stored and returned empty containers will be available on demand. On the other hand, requests for empty containers are made by shippers who need to export goods. To meet these requests, the shipping company should provide enough empty containers to shippers, then the shippers can pick up those empty containers and move them to their own premises to load them. After that, the loaded containers are returned to the terminal at the same port. As a consequence, a shipping company can determine the total number of empty containers that are being requested.

Due to the imbalance in trade among different countries, it is not surprising that some ports may require more containers than that are currently available to them, and some ports may store surplus empty containers, where inventory cost is associated. Hence, in practice, each port may either be a demand port if demand is greater than supply, or a supply port if vice versa. At demand ports, the shipping company usually turns to leasing companies to hire sufficient empty containers to fulfill the shippers' demands. Leasing companies have storage terminals where their clients go to pick up containers or to return containers. To reduce expenditure and to be more responsive to shippers' demands, the challenge to shipping companies is to successfully allocate surplus empty containers from supply ports to demand ports and to lease the minimum number of empty containers from leasing companies.

Although there is a substantial amount of literature on the subject of container terminal operations (Sheikh et al., 1987; Lai and Lam, 1994; Bostel and Dejax, 1998; Holmberg et al., 1998; Vis and de Koster, 2003; Preston and Kozan, 2001; Cheung et al., 2002), work on the allocation of empty containers in the shipping industry has been scarce, especially with regard to simple repositioning methods. In a recent survey of the literature on container fleet management models in freight transportation, Dejax and Crainic (1987) noted that relatively little effort had been made to develop models focusing on container transportation issues. They reviewed the contributions in this area from simple static models and methods to formulations that integrate the dynamic and stochastic nature of the problem. Previously, existing literature by Aronson (1989), Crainic and Delorme (1993) and Dejax and Crainic (1987) has focused mainly on the technical aspects of the problem, rather than the business aspects. Lai et al. (1995) studied container logistics and allocation problems and used a simulation and heuristic approach to investigate a logistical policy to save operation costs and prevent lost sales due to the unavailability of empty containers when requested. Hall (1999) developed and applied methods for measuring flow imbalances and randomness on transportation networks, and discussed the implications for imbalance costs. Crainic and Laporte (1997) identified some of the main issues in freight transportation planning and operations, and presented a variety of appropriate operational research models, methods and computer-based planning tools. Crainic et al. (1993) provided a mathematical formulation for container allocation and distribution problems under the conditions that demand and supply data are stochastic in