Int. J. Production Economics 133 (2011) 451–457

Contents lists available at ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Optimal inventory control of empty containers in inland transportation system

Won Young Yun[a,*], Yu Mi Lee[a], Yong Seok Choi[b]

[a] Department of Industrial Engineering, Pusan National University, Busan, Republic of Korea
[b] Department of Logistics, Sunchon National University, Jeollanam-Do, Republic of Korea

ARTICLE INFO

Available online 8 July 2010

Keywords:
Empty containers
Inventory level
(*s*, *S*) inventory policy
Arena
OptQuest®

ABSTRACT

In this paper, we deal with an inventory control problem of empty containers in an inland transportation system. In inland container transportation, freights (containers) are transported between terminal and the customer's location by trucks, trains and barges. Empty containers are an important logistic resource and shipping companies try to operate and manage empty containers efficiently. Because of the trade imbalance between hub ports, empty containers should be periodically repositioned from surplus areas to shortage areas. However, it is not easy to exactly forecast the demand of empty containers, and we therefore need to build an efficient way to reposition the empty containers. In this paper, we consider a shortage area and propose an efficient inventory policy to control empty containers. We assume that demands per unit time are independent and identically distributed random variables. To satisfy the demand of empty containers, we reposition empty containers from other hubs based on the (*s*, *S*) inventory policy, and also consider the lease of empty containers with zero lead time. For the leased containers, we should return the number of empty containers leased to the leaser after the specified period. For a given policy, simulation is used to estimate the expected cost rate and we use the optimization tool, OptQuest® in Arena to obtain the near optimal (*s*, *S*) policy in numerical examples.

1. Introduction

The transportation demand of containers is rapidly increasing nowadays and the demand for empty containers is also increasing accordingly. Because of the trade imbalance, empty containers should be repositioned between shortage and surplus areas periodically and shipping companies need to have an inventory control policy to reposition the empty containers. Shipping companies reposition empty containers between hub areas, ports and depots. Because it usually takes a long time to reposition empty containers between hub areas and an efficient management of the empty containers is an important factor that can contribute to raising the productivity of shipping companies.

Crainic et al. (1993) dealt with the allocation problem of empty containers according to the dynamic and uncertainty of demand. Cheung and Chen (1998) considered how the dynamic container allocation problem can be formulated as a two-stage stochastic network model. They also studied optimization problems for repositioning empty containers and determined how many leased containers are needed at ports. Shen and Khoong (1995) proposed a network optimization model between ports and solved the problem using A Mathematical Programming Language (AMPL). Lam et al. (2007) proposed dynamic and stochastic models for a simple two-port and two-voyage problem. Li et al. (2004), (2007) proposed a new (*u*, *d*) policy for the distribution problem of empty containers between ports.

In this paper, we consider a port area that needs more empty containers, known as a shortage area (for example, Busan, Korea). Suppose that we should prepare a suitable number of empty containers to satisfy the customer's seasonally fluctuating demand. To satisfy the required number of empty containers, we can either reposition empty containers from the surplus area with a long lead time or lease empty containers. Thus, we consider the ordering (repositioning) and leasing policy under probabilistic demand and supply, with high and low demand seasons for the demand of empty containers. Holding, leasing and ordering costs are considered and we obtain optimum inventory policies to minimize the expected cost rate (long-run average cost per unit time) by an ARENA simulation.

2. Inventory control model

Fig. 1 shows an inland transportation network. Shipping companies store empty containers in depots, provide the empty

* Corresponding author. Tel.: +82 51 510 2421; fax: +82 51 512 7603.
E-mail addresses: wonyun@pusan.ac.kr (W. Young Yun), ymlee@pusan.ac.kr (Y. Mi Lee), drasto@sunchon.ac.kr (Y. Seok Choi).

0925-5273/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpe.2010.06.016

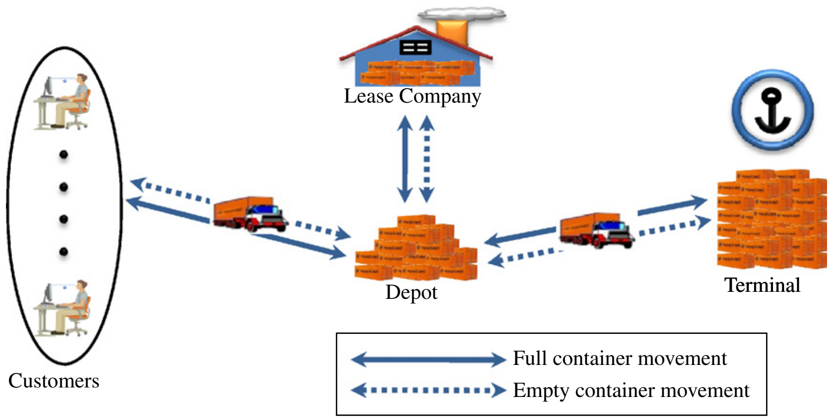

Fig. 1. Inland transportation network.

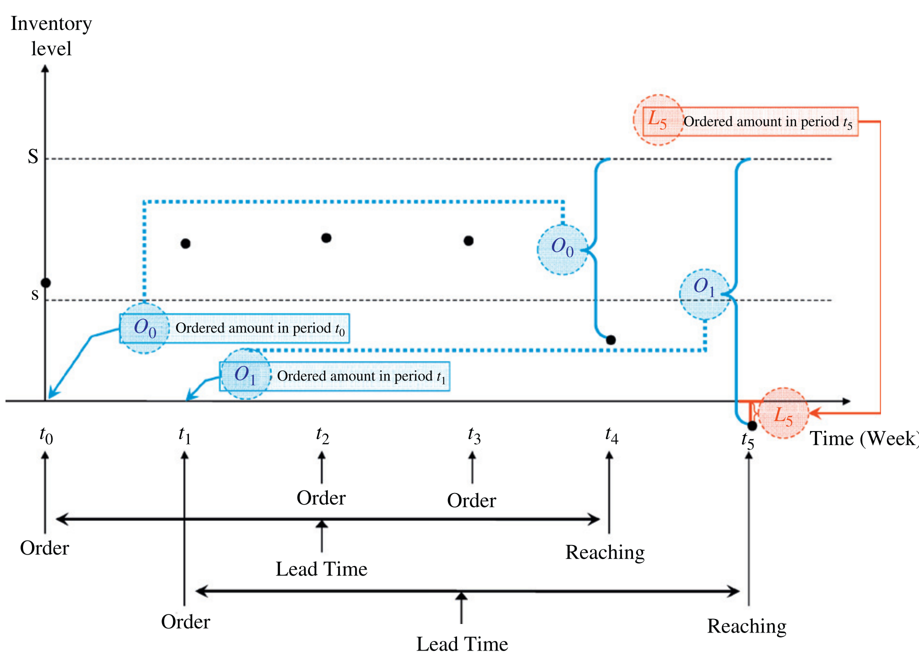

Fig. 2. Ordering and leasing policy using the (*s*, *S*) ordering policy.

containers for transportation of freights between terminal and customer locations, and sometimes lease empty containers if they need more empty containers immediately. In this paper, we consider a hub area, in which more empty containers are needed because the demand of empty containers is greater than the supply. To solve the imbalance problem, we should periodically reposition empty containers from surplus areas to a shortage area. In this paper, an inventory control problem of empty containers under probabilistic demand is studied under the following assumptions.

Assumptions

(1) 40 ft dry containers are considered.
(2) There are two seasons: low and high demand seasons.
(3) Demand and supply of empty containers per week are independent and identically distributed random variables.
(4) (*s*, *S*) ordering policy is used.
(5) There is a type of lease with zero lead time.
(6) The lead time of repositioning is constant.

Notation

S_1	order-up-to level at low demand season
s_1	order point at low demand season
S_2	order-up-to level at high demand season
s_2	order point at high demand season
LT	lead time of repositioning
D_i	customer's demand in period i
O_i	order amount in period i
L_i	lease amount in period i
H_i	stock level in period i
N_i	net stock at the beginning in period i
I_i	inventory level during the lead time in period i
V_i	return amount from customers in period i
C_f	fixed-ordering cost
C_o	ordering cost on each unit
C_l	leasing cost on each unit
C_n	inventory holding cost on each unit
TC_i	total cost in period i