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Introducing a new ordering policy in a two-echelon inventory system with Poisson demand

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ABSTRACT

In this paper we introduce a new ordering policy for inventory control in a two-echelon inventory system consisting of one central warehouse and a number of non-identical retailers. The warehouse uses a modified one-for-one policy, but the retailers apply a new policy which is different from the traditional inventory policies described in the literature of inventory and production control systems. In this system, each retailer constantly places an order for one unit of product to the central warehouse in a predetermined time interval; i.e., the time interval between any two consecutive orders from each retailer is a fixed number and the quantity of each order is one. We then show how the inventory costs can be determined for this system. The most important advantage of this policy is that the warehouse is facing a uniform and deterministic demand originated by each retailer. Furthermore, a numerical example is provided to compare the performance of the new policy with the performance of the one-for-one policy in a two-echelon inventory system in terms of the total system cost.

1. Introduction

We consider a two-echelon inventory system consisting of one central warehouse and a number of non-identical retailers (Fig. 1). We assume the retailers face independent Poisson demand and unsatisfied demand will be lost. The transportation time for an order to arrive at a retailer from the warehouse is assumed to be constant. The warehouse orders to an external supplier. The lead time for an order to arrive at the warehouse is assumed to be constant.

Andersson and Melchiors (2001) consider a similar model, but in their model they adopt the one-for-one ordering policy for both the retailers and the warehouse. In the new policy called one-for-one period (Haji and Haji, 2007) the quantity of each retailer's order is one, and the time interval between two consecutive orders from each retailer is fixed. An important advantage of this easy-to-apply policy is that its application amounts to a uniform and deterministic demand for the central warehouse on the part of each retailer. For this policy, the total system cost in steady state, consisting of holding and shortage costs of all retailers and holding cost of the warehouse is evaluated. In this study, the optimal time interval between any two consecutive orders for each and all retailers which minimizes the total system cost is determined.

The paper is organized in 6 sections. Section 2 is devoted to literature review. Section 3 describes motivation and advantages of using this new policy in a two-echelon system. In Section 4, cost evaluation for the steady state is presented. Section 5 gives some numerical results and Section 6 provides the conclusions.

2. Literature review

Inventory policies in two-echelon inventory systems are reviewed here. Sherbrooke (1968) assumes $(S-1, S)$

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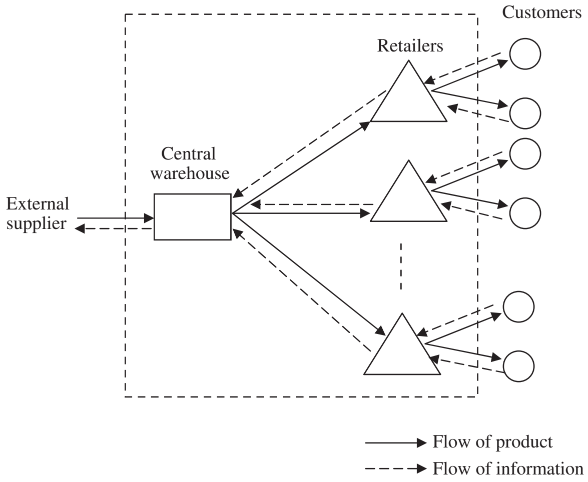

Fig. 1. Two-echelon inventory system.

policy in base-depot supply system for a repairable item. Graves (1985) considers a multi-echelon inventory model for a repairable item with one-for-one policy. He presents an exact model for finding the steady state distribution of the net inventory level. Axsäter (1990) investigates a two-echelon inventory system in which the inventory policy of each echelon is $(S{-}1, S)$ and unsatisfied demand is backordered. Then, Axsäter (1993) formulates his previous model by applying (r, Q) policy for each echelon. Axsäter et al. (1994) generate an approximate method for inventory costs in a two-echelon inventory system with compound Poisson demand, in which the inventory policy of each echelon is order up to Nahmias and Smith (1994) consider a two-echelon inventory system with a distribution center and a number of retailers. All installations apply order up to S policy. The demand in retailers has negative binomial distribution and a fraction of unsatisfied demand in the retailers is lost. Matta and Sinha (1995) investigate a two-echelon inventory system consisting of a central warehouse and a number of retailers. Each retailer applies (T, S) inventory policy with an identical review interval T and different maximum inventory level S. the central warehouse applies (T, s, S) policy, where T is the same review interval as that of retailers; s is its reorder points, and S is its desired maximum inventory level. Forsberg (1995) presents another method to evaluate costs of a two-level inventory system with compound Poisson demand. Later, Forsberg (1996) considers an exact evaluation of (r, Q) policies for two-level inventory systems with Poisson demand. Then Forsberg (1997) evaluate (r, Q) policies for two-level inventory systems with a general distribution inter-arrival times for customer. Axsäter and Zhang (1999) consider a two-level inventory system with a central warehouse and a number of identical retailers. The warehouse uses a regular installation stock batch-ordering policy, but the retailers apply a different type of policy. When the sum of the retailers' inventory positions declines to a certain "joint" reorder point, the retailer with the lowest inventory position places a batch quantity order. Ganeshan (1999) introduces a three-level inventory system consisting of a number of identical retailers, one central warehouse, and a number of identical suppliers. The inventory control policy in warehouse and retailers is (r, Q). The warehouse lot size is split equally between the suppliers. In this model the objective function consists of ordering, inventory holding, and transportation costs. Shortage is backordered and according to service level the expected units short per replenishment cycle are considered as a constraint. Andersson and Melchiors (2001) propose an approximate method to evaluate inventory costs in a two-echelon inventory system with one warehouse and multiple retailers. All installations use $(S{-}1, S)$ policy. The retailers face Poisson demand and unsatisfied demands in the retailers are lost. Seo et al. (2002) develop an optimal reorder policy for a two-echelon distribution system with one central warehouse and multiple retailers. Each facility uses continuous review batch ordering policy. They propose a new type of policy to utilize the centralized stock information more effectively. They define the order risk policy, which decides the reorder time based on the order risk representing the relative cost increase due to an immediate order compared to a delayed one. Marklund (2002) introduces a new policy for inventory control in a two-level distribution system consisting of one warehouse and a number of non-identical retailers. The retailers use (r, Q) policies, but the warehouse applies a new (α_0, Q_0) policy which leads to placing an order of Q_0 units as soon as a certain service level α_0 is reached. In this paper, a technique for exact evaluation of the expected inventory holding and backorder costs for the system is presented. Axsäter (2003) in a two-echelon distribution inventory system presents a simple technique for approximate optimization of the reorder points. The system is controlled by continuous review installation stock (r, Q) policies. The technique uses normal approximations both for the retailer demand and the demand at the warehouse. Axsäter (2005) introduces a rule for determining reorder points in a two-echelon inventory system with a central warehouse and a number of retailers in which the retailers face stochastic demand and the inventory control policy is installation stock (r, Q). Seifbarghi and Akbari (2006) investigate the inventory system consisting of one central warehouse and many identical retailers controlled by continuous review policy (r, Q). The demands of retailers are independent Poisson and stockouts in retailers are lost sales. They develop an approximate cost function to find optimal reorders for given batch sizes in all installations. Kanchanasuntorn and Techanitisawad (2006) investigate a periodic inventory-distribution model based on Matta and Sinha's (1995) model to deal with the case of fixed-life perishable product and lost sales at retailers. Zhang et al. (2007) considered an integrated vendor-managed inventory (VMI) model for a single vendor and multiple buyers in a two-echelon inventory system and proposed the optimal investment amount and replenishment decision for all the buyers and the vendor. Haji and Sajadifar (2008) considered an inventory system with information exchange consisting of one supplier and one retailer in which the retailer faces independent Poisson demand and applies continuous review (R, Q)-policy. The supplier starts with m initial batches (of size Q), and places an