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ORIGINAL RESEARCH

Application of queuing theory in inventory systems with substitution flexibility

S. M. Seyedhoseini · Reza Rashid · Iman Kamalpour · Erfan Zangeneh

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Abstract Considering the competition in today's business environment, tactical planning of a supply chain becomes more complex than before. In many multi-product inventory systems, substitution flexibility can improve profits. This paper aims to prepare a comprehensive substitution inventory model, where an inventory system with two substitute products with ignorable lead time has been considered, and effects of simultaneous ordering have been examined. In this paper, demands of customers for both of the products have been regarded as stochastic parameters, and queuing theory has been used to construct a mathematical model. The model has been coded by C++, and it has been analyzed due to a real example, where the results indicate efficiency of proposed model.

Keywords Inventory management · Substitution flexibility · Simultaneous ordering · Stochastic demand · Queuing theory

Introduction

One of the challenges in supply chain management is to find optimal policy for inventory system, the main objective of inventory management is to balance conflicting goals like optimization of stock costs and shortage costs (Arda and Hennet 2006). Using flexible inventories is one of the ways to reduce inventory costs. Flexibility could be considered in different ways, for example, through using product substitution, postponement (Tibben-Lembke and Bassok 2005) and lateral transshipments (Herer et al. 2006).

In substitution systems, flexible stock (mostly more expensive) will be used only when regular (cheaper) item stockout (Deflem and van Nieuwenhuyse 2011). For instance, if inventory of regular product cannot satisfy its demand, a higher quality item can be used as a substitute inventory (Liu and Lee 2007).

In summary, it is clear that despite many contributions in inventory management, there is little consideration due to substitution inventory models. In this paper, a stochastic stock control model has been proposed for two substitute products when lead time is ignorable, where the main contributions are summarized as follows.

- Demands have been considered as stochastic parameters.
- To prepare a comprehensive model, bi-level Markov process has been used.
- All the steady-state equations have been solved in terms of one state.

This model can be applied probably for inventory systems where demand is uncertain and two way substitutions can be used. For example, some items of dairy inventories have mostly stochastic demand, and some of them can use substitution with each other.

The reminder of this paper is organized as follows. In "Literature review", a brief literature review has been presented. In "Model development and analysis", first we represent a mathematical model for an inventory system with substitute products. The model is validated and some numerical examples are tested in "Solving approach". We conclude our study in "Numerical results".

S. M. Seyedhoseini · R. Rashid · I. Kamalpour · E. Zangeneh (✉)
Department of Industrial Engineering, Iran University of Science and Technology, Narmak, 16844 Tehran, Iran
e-mail: e.zangeneh@live.com