Available online at www.sciencedirect.com
SCIENCE DIRECT®
Int. J. Production Economics 91 (2004) 189–198
international journal of production economics
www.elsevier.com/locate/dsw

Exact, approximate, and generic iterative models for the multi-product Newsboy problem with budget constraint

Layek Abdel-Malek[a,*], Roberto Montanari[b], Libia Cristina Morales[a]

[a] Department of Industrial and Manufacturing Engineering, New Jersey Institute of Technology, Newark, NJ 07102, USA
[b] Dipartimento di Ingegneria Industriale, Università degli Studi di Parma, Viale delle Scienze, 43100 Parma, Italy

Received 1 August 2002; accepted 1 September 2003

Abstract

Because of the increased importance of inventory control/management in today's supply chain environment, we revisit the seminal work of Hadley and Whitin; that is the multi-product Newsboy problem with budget constraint. In this paper, we present exact solution formulae when the demand probability density function is uniform and generic iterative method (GIM), which yields optimum, or near optimum, solution for general continuous density functions of the demand. A salient feature of GIM is that as it progresses, one can compute the error allowing the user to stop when the desired level of accuracy is achieved. Illustrative examples are given in order to show the application of the proposed models.

Keywords: Inventory; Newsboy problem; Single period problem; Budget constraint

1. Introduction

With today's emphasis on supply chain management and the increased decentralization of manufacturing activities, there is a renewed interest in inventory control analysis. A significant number of articles has been lately published addressing the diverse aspects of the subject matter ranging from the analytical and case oriented works to those that are strategic in nature. Motivated by this interest, we revisit one of the seminal works developed earlier by Hadley and Whitin (1963); that is the Newsboy problem with budget constraint (also known as the capacitated single period problem (SPP)). One of the main reasons of our reconsideration is its importance to the current and rapidly growing practice of outsourcing, where many companies have to procure from domestic as well as global suppliers.

Simply described, the Newsboy problem deals with situations where the demand for a commodity is uncertain (random) and those items that are ordered but remain unsold or unused at the end of the cycle become obsolete. Hence, the buyer may incur a cost to dispose of them. On the other hand if the buyer initially decides to buy smaller amounts of these commodities, shortages may occur causing loss of revenue.

*Corresponding author. Tel.: +1-973-5963648.
E-mail address: malek@njit.edu (L. Abdel-Malek).

0925-5273/$ - see front matter
doi:10.1016/j.ijpe.2003.09.004

As one can see, the question becomes how to determine the quantity to be ordered to minimize the costs incurred. Answering this is the main objective of the classical Newsboy model.

When companies are outsourcing several of their products to outside vendors, budget usually presents a constraint reducing the quantities ordered. An example that comes to mind is in fashion industry. To place their orders, retailers have to attend shows long before the season for which the apparel is intended. Naturally, they do not know the exact amount of demand for the different fashion lines. Additionally, their budgets are limited and have to be allocated, optimally, among these competing lines. Hadley and Whitin (1963) have developed a numerical approach based on dynamic programming to solve such a problem, that is a multi-product problem with budget constraint. Nevertheless, they report that when the number of items to be procured is large, the dynamic programming approach becomes rather difficult. Therefore, the problem could become intractable. Addressing some of these difficulties is our intent. In this paper, we introduce models for solving the multi-product Newsboy problem with budget constraint. The developed models here yield an exact solution to the problem when the demand is uniformly distributed and near optimal solution when the demand is distributed otherwise. In the latter case of general demand distribution functions, one of the developed models is a generic iterative method (GIM) that converges rapidly toward the optimal solution and provides an estimate for the error at each iteration.

This paper is organized as follows. After this introduction, in Section 2, we give the background of the problem. Then in Section 3, the classical problem is presented. In Section 4, we introduce the models; exact, approximate and iterative. Section 5 is dedicated to numerical examples. In Section 6, we present concluding remarks.

2. Background

There are numerous articles that have appeared in the area of inventory control/inventory management dealing with a wide spectrum of issues in this diverse subject matter. One of the original articles in this area is traced back to Harris in 1915 (see Grubbström and Erdem, 1999). In his work Harris developed the optimum order quantity, EOQ, which had laid the groundwork for the wealth of literature that was published in this arena. In this section, however, we shall focus only on articles that are relevant to the single-period problem (SPP).

As mentioned in the introduction, Hadley and Whitin (1963) are credited for their initial work in the constrained Newsboy problem. Soon after, many popular texts in the areas of operations management, operations research and inventory control have treated this early model covering additional scenarios. Also, as will be seen in this section, publications extending this early model have ensued.

Two of the recent extensions of the Newsboy model have focused on the constrained multi-product problem. The first is by Erlebacher (2000) where he develops optimal and heuristic solutions for the capacitated Newsvendor problem. He begins by proving the optimality of the order quantities for two special cases; the first case is when the cost structure is the same for all considered items while the second case is concerned with uniform probability density function for the demand distribution of all items. Then, he proceeds by developing heuristics for a few general probability distribution functions. These heuristics are based on the results of the aforementioned cases. The second paper is by Vairaktarakis (2000) where he presents a robust Newsboy model for uncertain demands. He uses two types of scenarios to describe the demand's characteristics; interval and discrete scenarios. His approach is suitable for situations where the demand probability distribution is not known. These types of situations include cases of introducing new products, and those where historical data is not available.

Along the same lines, but earlier, Lau and Lau (1995, 1996) addressed the multiple-product Newsboy problem with one resource constraint, and multiple resource constraints, respectively. In Lau and Lau (1995) they extend the classical Hadley and Whitin result to cover problems where the demand distribution