The cutoff transaction size and Gauss cost functions to the information value applying to the newsboy model

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\textbf{A R T I C L E I N F O}

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\textbf{A B S T R A C T}

In this paper, two models are considered which differ in terms of information completeness. The first model involves the retailer having incomplete information regarding the state of customers demand. The second model involves the retailer having full information on the state of customers demand. Step function (here called Gauss function) can be applied such as the cost for mailing letters or packages in the post office and for shipping goods in containers. Therefore, the holding and penalty costs are represented by the Gauss functions to fit in with these practical situations. In addition, we assume that customers with an order larger than a prespecified quantity (here called cutoff transaction size) are still assumed to be satisfied in an alternative way, against additional cost. Moreover, when the maximum demand is large, much more time may be required to determine the optimal solution. Thus, we adopt and modify the algorithm of the Golden Section Search Technique to determine the optimal order-up-to level $S$ and the cutoff transaction size $q$ systematically and provide illustrative numerical example.

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1. Introduction

Enormous quantities of information currently are being exchanged between manufactures and retailers, retailers and consumers, companies and investors, and also among parties sharing the same level of a vertical chain. The above situation is particularly true for customized products, and occurs most commonly between retailers and larger customers. Industrial retailer-customer relations recently have changed radically. Consequently, information value has recaptured the interest of academics and practitioners.

A message is valuable only when it can enable a decision maker to improve their predictions regarding an uncontrollable event such as market demand (e.g. Mock, 1971). Effective resource management requires somehow measuring the costs and benefits associated with resource use. While the costs generally can be ascertained, measuring their economic worth is frequently impossible. To enhance production, these firms can attempt to acquire more timely and accurate information regarding remanufacturing yields, or alternatively can attempt, to reduce the lead times of purchased parts (e.g. Ferrer & Ketzenberg, 2004).

Two main approaches have been used to incorporate information flow into inventory control and supply chains (e.g. Gavirneni, Kapuscinski, & Tayur, 1999). The first approach involves using the history of the demand process to more accurately forecast the demand distribution using Bayesian updates (e.g. Azoury, 1985; Lovejoy, 1990). Meanwhile, the second approach involves developing new analytical models (e.g. Chen, 1998; Gavirneni et al., 1999; Harirhan & Zipkin, 1995; Zheng & Zipkin, 1990; Zipkin, 1995). Therefore, this study is developing new analytical model and takes the point of view of the retailer and incorporates information flow between a retailer and customers.

There has been considered in the literature about the holding and penalty cost function. In some of the inventory models (e.g. Chang & Lin, 1991a; Chang, Lin, & Shen, 1996; Dekker, Frenk, Kleijn, & de Kok, 2000; Hollier, Mak, & Lam, 1995a, Hollier, Mak, & Lam, 1995b; Mak & Lai, 1995a, 1995b; Wu & Tsai, 2001; Wu, Lee, & Tsai, 2002), the holding and penalty cost functions are viewed as linear functions, that is, the holding and penalty rate are constant. In the other models (e.g. Chang & Lin, 1991b; Chen & Lin, 1989; Lin & Hwang, 1998; Lin & Tsai, 2003), the holding cost functions are viewed as concave functions with the properties $h(x) = 0$ for all $x \leq 0$ and $dh(x)/dx \geq 0$ and $d^2h(x)/dx^2 \leq 0$ for all $x \geq 0$. The penalty cost functions are viewed as concave functions with the properties $p(x) = 0$ for all $x \leq 0$, and $dp(x)/dx \geq 0$ and $d^2p(x)/dx^2 \leq 0$ for all $x \geq 0$. In this paper, the holding and penalty cost functions are viewed as Gauss functions which are applied such as the cost for mailing letters or packages in the post office and for shipping goods in containers.

In practice, many inventory systems must address sporadic demand patterns that may disrupt the inventory system. Customer
this work establishes a new algorithm based on the Golden Section
pound Poisson demand distribution (Adelson, 1966). In addition,
these two newsboy models with a cutoff transaction size and com-
fit in with some practical situations. Such situations occur com-
2.1. Model 1: uncertain demand model
orders exceeding the cutoff transaction size q units are treated as
special orders to be satisfied by special direct deliveries from the
factory to the customers to avoid disrupting the inventory system.
Customer orders less than or equal to q units are met from stock.
Subsequent papers, the inventory models of Dekker et al. (2000),
Hollier et al. (1995a, 1995b), and Mak and Lai (1995a, 1995b)
considered a cutoff transaction size. Those authors offered an
algorithm to determine the optimal values of reorder level s and
order-up-to level S for a given q. This algorithm practically replaces
the original order size distribution with a cutoff distribution, and
used the algorithm of Zheng and Federgruen (1991) to obtain the
optimal inventory policy.
According to the completeness of information, this work consid-
ers two models:
(1) Model 1: The retailer has incomplete information about the
state of customers demand, namely the expected total profit
of Dekker et al. (2000) is extended.
(2) Model 2: The retailer has full information regarding the state of
customers demand.

Precise expressions are derived for the expected total profit of
these two newsboy models with a cutoff transaction size and com-
pound Poisson demand distribution (Adelson, 1966). In addition,
this work establishes a new algorithm based on the Golden Section
Search Technique (e.g. Haftka, Curdaj, & Kamat, 1990) for consider-
Gauss function to obtain the optimal order-up-to level S and the
cutoff transaction size q. In the constantly changeful environment,
it is worth measuring the value of information for enterprise
decision making and whether enterprises will pay for information
that can help them to increase profits. Thus, while information is
always beneficial, this work attempted to investigate.

2. Model formulation
2.1. Model 1: uncertain demand model
This section extends the traditional newsboy model by incorpo-
ating a cutoff transaction size and the Gauss holding and penalty
cost functions. In this new model, we address a variant of the hold-
ing and penalty cost function by considering the Gauss functions to
fit in with some practical situations. Such situations occur com-
monly for mailing letters or packages in the post office or taking a
taxi. In addition, a customer’s order is only satisfied from stock
if it does not exceed a prespecified cutoff transaction size. Other-
wise, the customer is served in an alternative way, against addi-
tional cost.

Determining how the order size S and the cutoff transaction size
q maximizes the expected total profit over a single period. Conse-
quentially, the expected total profit for a period is given by:

\[
E(TP^1(S, q)) = \{\text{revenue} - (\text{ordering cost} + \text{holding cost} + \text{penalty cost})\} - (\text{overflow cost})
= E(TP^1(S, q)) - OC(q),
\]

where

\[
E(TP^1(S, q)) = \sum_{j=0}^{S} P_{rec} f_q(j) + \sum_{j=S+1}^{\infty} P_{rec} S f_q(j)
- \left[ cs + \sum_{j=0}^{S} h(S-j)f_q(j) + \sum_{j=S+1}^{\infty} p(j-S)f_q(j) \right],
\]

\[
OC(q) = \lambda E(\Pi(Y_i)_{i=1}^{q}) = \lambda \sum_{j=1}^{M} \Pi(j) a(j),
\]

\[
h(j) = \begin{cases} \left[-\frac{1}{j}\right] h, & 0 < j \leq S, \\ 0, & \text{otherwise}, \end{cases}
\]

\[
p(j) = \begin{cases} \left[-\frac{1}{j}\right] p, & 0 < j, \\ 0, & \text{otherwise}, \end{cases}
\]

\[
a_q(j) = \begin{cases} \sum_{i=1}^{M} a(i), & \text{if } j = 0, \\ a(j), & \text{if } j = 1, \ldots, q, \\ 0, & \text{otherwise}, \end{cases}
\]

and

\[
f_q(j) = \begin{cases} \exp(-\lambda(1-a_q(j))), & \text{if } j = 0, \\ (\lambda/j) \sum_{i=0}^{j} (j-i)a_q(j-i)f_q(i), & \text{if } j = 1, 2, \ldots. \end{cases}
\]

Our objective is to maximize the expected total profit over a single
period; in other words, it is to find the solution of the optimization
problem:
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