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A study of the total inventory cost as a function of the reorder interval of some lot-sizing techniques used in material requirements planning systems

S.N. Sánchez, E. Triantaphyllou*, D.B. Webster, T.W. Liao

Department of Industrial and Manufacturing Systems Engineering, Louisiana State University, 3128 CEBA Building, Baton Rouge, LA 70803-6409, USA

Abstract

This paper compares the total inventory costs (TIC) of five lot-sizing techniques. The add-drop heuristic (ADH) is a capacitated technique and the lot-for-lot (L4L), fixed period quantity (FPQ), least unit cost (LUC) and the silver-meal heuristic (SMH) are uncapacitated techniques. The TIC is considered as a function of the reorder interval (RI). This comparison is based on the assumption that if both capacitated and uncapacitated techniques produce identical RIs, then their TICs must also be identical (although uncapacitated techniques do not reflect this fact). Empirical results suggest that the ADH technique yields considerably better (i.e. lower) TICs when the demand levels and the number of items are low. On the other hand, these results suggest that for high demand levels, the TICs of the four popular lot-sizing techniques are close to the near optimal cost obtained by the (most time-consuming) ADH technique. Some theoretical results on the performance of uncapacitated techniques are also presented. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Total inventory cost; Lot-sizing techniques; Reorder interval; MRP lot-sizing techniques

1. Introduction

This paper examines the total inventory cost (TIC) as a function of the reorder interval (RI) of five lot-sizing techniques used in material requirements planning (MRP) systems. Its main purpose is to compare the TIC of a new and near optimal lot-sizing technique called the add-drop heuristic (ADH) (Hill, Raturi & Sum, 1988; Hill & Raturi, 1992) with the TIC of four popular techniques (Haddock & Hubick, 1989). These popular techniques are the lot-for-lot (L4L), fixed period quantity (FPQ), least unit cost (LUC)

* Corresponding author. Fax: +1-225-388-5990.
E-mail address: trianta@.lsu.edu (E. Triantaphyllou).

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Nomenclature

N	Number of items
M	Number of parent-items
B	Number of periods in the planning horizon
b	A period in B such that $1 \leq b \leq B$
i	Item number ($i = 1, \ldots, N$),
j	Parent number ($j = 1, \ldots, M$),
d_i	Total demand for item i
d_{ij}	Demand of item i due to parent j
H_i	Holding inventory cost of item i per unit per period
K_i	Setup cost for item i
$p(i)$	Set of parent-items for item i
$r(i)$	Set of work centers in the routing of item i
w	Work center or machine w for $w = 1, \ldots W$
m_i	Exponent of the reordering policy
n_i	Reorder interval of child-item i
$q_w(n)$	Average time in the queue, (as computed in Yao, 1985)
S_{iw}	Setup cost of item i at machine w
st_{iw}	Setup time of item i at machine w
t_{iw}	Run time for item i at machine w
C_w	The capacity of work center or machine w
L_w	Average load for work center w
P_w	Penalty cost for capacity violations. All P_w values were set equal to 10^{10} for $w = 1, \ldots, W$, as in Hill and Raturi (1992))

and the silver-meal heuristic (SMH). MRP lot-sizing techniques are inventory control tools that allow users to make decisions on the timing and quantities of inventory parts (Orliky, 1975). Therefore, knowing the performance of these techniques is very important in manufacturing control environments because it allows a user to identify the conditions under which new techniques, such as the ADH, are more advantageous over other techniques.

Traditionally, MRP lot-sizing techniques are benchmarked by comparing the TICs and computational times they produce to solve a given inventory problem (Berry, 1972; Lee, Ristroph, Zhu, & Ruangdet, 1983). Often, the TIC is defined by the sum of the cost of placing orders (i.e. the setup cost) plus the cost of carrying unused inventory from one period to subsequent periods (i.e. the holding cost) (Solomon, 1991).

When lot-sizing techniques only use the setup and holding costs, they are referred to as *uncapacitated* techniques because they do not include any type of constraints in the available resources (i.e. production capacity is unlimited) (Solomon, 1991). The L4L, FPQ, LUC, and SMH are examples of uncapacitated techniques. On the other hand, lot-sizing techniques are referred to as *capacitated* techniques when in addition to the setup and holding costs, the cost structure also considers some constraints on the available resources (i.e. the capacity is finite) (Solomon, 1991). The ADH technique is a capacitated technique, which satisfies a production capacity constraint in each period of the planning horizon.