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Int. J. Production Economics 64 (2000) 257–265

international journal of
production economics

www.elsevier.com/locate/dsw

Customer order lead times for production based on lead time and tardiness costs

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Abstract

In practice decisions regarding customer order lead time and customer order processing are taken in different parts of the organization. Definite lead times are quoted by the sales department and job flow decisions are taken by the production department. This split up of decision responsibilities is in accordance with the differences in scope and control areas in complex organizations like job-shops or engineer-to-order firms. In this paper we present a simple economic model of sales and production in a job shop. Production aims at realizing the jobs by using its capacity to perform the operations of the jobs. Sales, using a model of the performance of production, aimes at maximizing expected profit by quoting lead times to customer orders, given that penalties are put on quoting long lead times and on tardy deliveries. Analysis of the model shows that for any combination of penalties on lead times and tardiness, there exist job flow times distributions for which it is optimal for sales to quote unrealistically short customer order lead times. Specifically if the job flow time has a high mean value and/or a high variance sales tends to quote a lead time with zero lead time penalty. In practice we often observe that the job flow times are long and have a high variance. The research presented in this paper shows why this may stimulate sales to neglect flow time information and to quote unrealistically short lead times. Our model shows that under a wide range of economic conditions a job flow time distribution with a small mean and a small variance seems to be a necessary condition for sales to quote realistic customer order lead times.

Keywords: Customer order lead time; Economic performance model

1. Introduction

In practice decisions regarding customer order lead times and customer order processing are taken in different parts of the organization. Definite lead times are quoted by the sales department and order flow are controlled by the production department. This split up of decision responsibilities is in accordance with the dynamics of the process. Customer orders arrive dynamically over the time, are released to the shop floor and processed according to certain priority rules. At the arrival of a customer order it is impossible to know exactly how the process on the shop floor will evolve. Therefore, order lead time quotations are based on certain assumptions about the shop order flow times. These assumptions contain errors which lead to uncertainty about the exact order flow time.

In this paper we study the assignment of economical optimal due dates to customer orders that

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0925-5273/00/$ - see front matter
PII: S0925-5273(99)00063-8

arrive at a job shop. We study the situation where customer orders arrive dynamically over time and are assigned a due date upon arrival. Each customer order leads to a job which is immediately released to the shop floor and, after processing in the shop, is completed. The job shop consists of a number of functionally organized work centers and each job requires a number of operations in different work centers. The due dates are assigned by a due date assignment system which may take job information into account. The processing of the jobs is controlled by the production department according to certain priority rules.

Both the production control problem and the due date assignment problem for job shops have been seperately studied. For a review of the literature we refer to [1]. Also the interaction between the due date assignment rules and the production control rules has been studied (see for instance [2–5]). In most of this research the performance is measured in terms of job flow times, job tardiness, or job lateness.

In this research we study the due date assignment problem in an economic setting. We study the situation where on the one hand a cost penalty is incurred as a function of the length of the quoted job lead time and, on the other hand, a cost penalty is incurred as a function of the tardiness of the job. This assumes that the firm in some way or the other is penalized for assigning longorder lead times; a penalty which decreases by assigning short lead times. Also it is assumed that the firm is penalized for late deliveries. In view of the management literature which reports the strategic importance of short and reliable lead times (see e.g. [6]) it is reasonable to assume that sales operates in such a reward and penalty structure.

In this paper we study the situation where this penalty structure is modelled with simple piecewise linear functions. We derive optimal due date policies for various instances of the penalty functions under a simplifying assumption regarding the job flow time distribution. In this research we assume a simple shop structure consisting of work centers each containing a single machine. We furthermore assume that jobs follow random routings on the shop floor and are processed at the work centers according to the first-come-first-served priority rule.

The remainder of this paper is organized as follows. In Section 2 we give an overview of recent related literature. In Section 3 we work out the research question in more detail, present a formal model of the problem and derive theoretical results. Section 4 discusses the application of the formal model for two kind of lead time policies: a common lead time for all work orders and a lead time which depends on the number of operations for the order. For various setups of penalty costs and job flow time distributions we compare the total costs of the economically optimal lead times with the total costs incurred when using 'conventional' (95% reliable) lead times. Finally in Section 5 the conclusions and directions for future research are given.

2. Literature review

The amount of research reported on job shop due date assignment and production control is very large. In this paper we only review recent research which focusses on economic oriented performance measures.

De et al. [7] examine the problem of assigning due dates to a given set of jobs and sequencing them on a single machine in order to minimize the cost of quoting long due dates and that of missing the quoted due dates. They establish solution properties for the problem and identify special cases which can be solved easily. Their research is restricted to the static single machine case. Vig and Dooley [8] do not explicitly consider the cost, but they develop a flow time estimator that improves average lateness and fraction tardy jobs. Li and Lee [9] provide a framework to measure the market impact of improvements in response to conjunction with other decisions such as price, quality and technology. They present a method for deriving the market share or demand rate for each firm as a function of the firms' decisions on price, quality and processing speed. They do not consider the problem for individual firms of optimizing their profit in situations where on the one hand the price a customer is willing to pay depends on the quoted lead time and on the other hand there are costs for missed due dates.