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Int. J. Production Economics 73 (2001) 59–82

international journal of production economics

www.elsevier.com/locate/dsw

Comparison of (s, S) and (s, nQ) inventory control rules with respect to planning stability

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Received 8 October 1998; accepted 26 September 2000

Abstract

The application of a rolling horizon planning framework in inventory control causes different order release decisions in successive planning cycles. These lead to the so-called planning system nervousness. In this paper for a single-stage inventory system with arbitrary stochastic demand it is shown analytically how the setup-oriented planning stability concerning deviations of planned orders in all periods of a given stability horizon is influenced by the use of (s, S) and (s, nQ) control rules. It turns out that the reorder point s does not affect stability whereas the lot size determining parameters $S - s$ and Q as well as the level of uncertainty have a considerable impact. The paper is concluded with directions for further research. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Nervousness; Planning stability; Rolling horizon; Inventory control

1. Introduction

In the context of inventory control usually simple policies like (R, S), (s, nQ) or (s, S) policies are applied. These policies are investigated with respect to the optimal determination of their parameters according to their performance in terms of costs and service. Since in most practical applications inventory policies are used in connection with a rolling horizon planning framework, a third performance criterion implicitly exists: the measure of planning stability. It is worth noting that replenishment decisions are usually determined on the basis of quasi-deterministic models of the stochastic environment connected with a regular updating of all relevant parameters and succeeding replanning activities. This situation is typical for the wide-spread MRP applications whereas the above-mentioned procedure leads to so-called period order quantity (POQ) planning or fixed order quantity (FOQ) planning at each level of the production structure depending on the lotsizing procedure. The use of these planning rules can be interpreted as employing an (s, S) rule or an (s, Q) policy in a multi-period deterministic environment (see [1]) which evolves by using forecasts instead of stochastic data.

The rolling horizon planning leads to replanning activities caused by permanent processing of new information in successive planning cycles. As a result formerly fixed order decisions are replanned in later periods. This discontinuity in maintaining former order releases is known as the nervousness syndrome

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PII: S0925-5273(00)00151-1

(see [2]). The lack of planning stability can turn out to be a significant problem because it often generates a considerable amount of short- and medium-term adjustment efforts as well as a general loss in planning confidence. Especially in a multi-stage MRP production environment, nervousness on the top level (MPS level) is propagating throughout the system. In fact, due to MRP time-phasing, nervousness in future periods on the MPS-level may influence planning stability at the beginning of the planning process on lower stages in an MRP system. In many cases the consequences of replanning activities cannot be valued in terms of costs, therefore we will treat planning stability as an independent attribute for assessing an inventory control system (similar to the attribute of customer service).

Defining a nervousness measure, we can distinguish between short-term planning instability (which measures nervousness with respect to only the first period's order decision) and long-term planning instability (which considers the entire planning horizon). Moreover we may differentiate between quantity adjustments, which are denoted by quantity-oriented instability, and pure changes in order setups, i.e. if in a new planning cycle a new setup is scheduled or, vice versa, if a formerly planned setup is canceled. This latter type of nervousness is described by setup-oriented instability (see, e.g., [3]).

In order to treat planning stability as a specific performance criterion, we have to define a general numerical stability measure. In simulation studies which examine the influence of different planning parameters on nervousness only ad-hoc measures of planning stability are used (see, e.g. [4–7]). A systematic development of nervousness measures is given in [3,8–14]. In this paper we will refer to the measures described in [3,8–12,15].

The above-mentioned simulation studies do not give a systematic insight into the relationship between planning stability and inventory policies. In [13,12] a comprehensive investigation of reorder-point lot-sizing policies is given, but its informative value is limited, since the simulation approach cannot provide an analytical description of the dependence of nervousness on inventory control rules.

Analytical results are presented in [10] where the performance of the (s, S) and (s, nQ) policy for uniformly and exponentially distributed demand with respect to a short-term setup-oriented planning stability is analyzed. In [8], for the same short-term consideration as in [10], setup- as well as quantity-oriented stability of orders for more general demand distributions are examined for (s, S), (s, nQ) and (R, S) policies. In [9] the long-term setup-oriented stability performance of an (s, S) policy is analyzed.

In this paper the same analysis is provided for an (s, nQ) policy. We will show the main analytical results and we will discuss the priority of both inventory control rules under the aspect of nervousness. For a more detailed discussion of the results presented in this paper the reader is referred to [15]. Here, we consider arbitrary stochastic demand to show analytically the influence of the demand distribution on our stability measure. In our analysis, differing with [8,10], we treat the long-term planning stability in order to capture its effect at all levels of the system (see above). In this context, we consider all periods within a so-called stability horizon which contains those planning periods where deviations in planned orders are perceived to be disadvantageous. This implies that plan changes in periods which exceed the stability horizon are not relevant with respect to planning stability. Since in some cases it seems to be reasonable to assume that replanning activities in periods near the beginning of the stability horizon are more critically than those in future periods (see, e.g. [13]), we modify the measure of planning stability proposed in [3,8–12] by introducing a weight parameter which reflects the (possibly) decreasing relevance of plan changes with progressing number of periods within the stability horizon. With suitable values for the weight parameter we can describe the short-term consideration as well as the case that all periods are weighted equally. This facilitates a comparison of our results to the outcome of [8,10] with respect to an (s, S) and (s, nQ) policy. Moreover, we consider the setup-oriented planning stability, because in many practical situations the fixed effort connected with replanning an order release, independently of the exact amount of adjustment, is mainly annoying in the execution of a planning process.

The remainder of this paper is organized as follows. In Section 2 a measurable formalization of nervousness under rolling planning conditions is given. Section 3 contains a steady-state analysis for