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Measuring the performance of lot-sizing techniques in uncertain environments

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Abstract

Cost-effectiveness and computational time are the traditional criteria for evaluating lot-sizing techniques. However, in evolving environments, frequent revisions of demand forecasts may induce various degrees of instability in planned orders, depending on the selected lot-sizing technique. In poorly flexible production systems, the cost of implementing these alterations may overcome the benefits from using a cost-efficient technique. In this paper, we evaluate lot-sizing techniques on the basis of two criteria. The first is the traditional cost-effectiveness criterion. The second, that we call *robustness*, is designed to capture some of the characteristic features of decision-making in uncertain environments. Robustness is related to the stability of the set-up streams when demand fluctuates. We propose and discuss several alternative measures of robustness. The simulation results clearly show an inverse relationship between cost-effectiveness and instability. Therefore, managers should take into account these two "opposite" dimensions in their decision process, under quite unforeseeable environments. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

In a production system, lot-sizing rules specify when to have material delivered or produced, as well as quantities required. An optimal solution to the single level lot-sizing problem is achieved using the *Wagner–Whitin algorithm* (WW, [1,2]), but a practical implementation of this procedure is complex and computationally heavy for realistic size problems. Heuristic approaches have been designed in order to find near optimal solutions at a lower computational cost. In the case of constant demand, *the economic order quantity* (EOQ) or the *periodic order quantity* (POQ, [3]) may be successfully employed. They unfortunately fail to give satisfactory solutions when demand is not regular. Thus, several distribution-independent algorithms have been designed, such as the *least unit cost* method (LUC, [3]), the *part-period algorithm* (PPA, [4]), *the incremental part-period algorithm* (IPPA, see [5] as well as [6]) or the *Silver–Meal algorithm* (SM, see [7]), based on relatively simple assumptions. Other more sophisticated and more accurate techniques also exist, like the *minimum demand technique* (MINS, [8]) or the *technique for order placement and sizing* (TOPS, [9]).

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An appraisal of lot-sizing techniques usually rests upon two traditional criteria, namely cost-effectiveness and computational time (see [10] or [11]). These criteria, despite their usefulness, ignore some practical aspects of the way lot-sizing decisions are implemented, especially when demand forecasts are continuously revised over time. Sure enough, in such a context, lot-sizing techniques do not exhibit the same degree of instability in planned orders. Therefore, we propose another evaluation criterion of lot-sizing techniques. We call *robustness* of a lot-sizing model the degree of stability in planned orders provided by the lot-sizing model in response to changes in demand estimates. Depending on the flexibility of the production system, the cost of frequently adjusting planned orders may exceed the benefit from following the prescribed changes. Hence, the evaluation of a technique can be made from a global point of view. In a system with low flexibility, implementing the change in planned orders required by a particular lot-sizing method can be so costly that the previous schedule – upon which personnel scheduling or machine loading may have already been based – is finally maintained. Therefore, when the cost of scheduled orders adjustment is high (i.e. when flexibility is low), using a robust technique can be considered as a proper choice. Conversely, in a production system characterized by a high degree of flexibility, it seems a priori efficient to follow the prescribed schedules.

In this paper, we examine how demand variability affects the production schedules generated by nine lot-sizing methods for single-level assembly. We compare both the cost-effectiveness and robustness of these methods. Several possible dimensions of robustness are discussed and charts of lot-sizing techniques corresponding to these dimensions are provided. Whatever the considered dimension is, the existence of a negative correlation between cost-effectiveness (linked with algorithmic complexity) and robustness is highlighted.

The paper is organized as follows. Section 2 begins with an overview of the related research. We then focus on the concept of robustness, and discuss its managerial implications as well as its different measures. In Section 3, we present an experimental framework designed to grasp some

basic intuitions concerning robustness and its importance in the problem of single level lot-sizing decisions. The results of numerical simulations are presented and analyzed in Section 4.

2. Robustness, flexibility and the evaluation of lot-sizing techniques

In any production system, planned orders usually vary in response to demand fluctuations. The stream of orders prescribed by a given lot-sizing technique experience changes when distinct demand patterns occur. These changes concern the size of orders as well as their periods of occurrence. This instability results from the technique's search for optimality. However, in a production system characterized by a low degree of flexibility, the costs of changing the production schedule may offset the benefits resulting from systematically following the prescription of the technique.

2.1. Related research

The general problem of planned orders instability in MRP systems – also called nervousness – has received theoretical attention at the end of the 1980s. Previous research essentially suggests several strategies for reducing instability. Various studies conclude that the use of safety stocks is an efficient way to cope with the problem of nervousness (see [12–15]). In their rather exhaustive work, Sridharan and Laforge examine how safety stock policies affect stability when demand uncertainty exists within the planning horizon. These authors find that the safety stocks may be effective only when used in a limited quantity. They even show that both schedule instability and total cost raise as safety stocks are increased beyond a threshold value.

It has also been proved that freezing a portion of the master production schedule (MPS) is an efficient way of reducing instability. Sridharan et al. (see [16]) examine the impact on stability of two methods of freezing the MPS (a period-based freezing method and an order-based freezing one), several lengths of the MPS freeze interval, and various lengths of the planning horizon in which