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Supply planning under uncertainties in MRP environments: A state of the art

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Abstract

Inventory control in a supply chain is crucial for companies desiring to satisfy their customers demands as well as controlling costs. This paper examines specifically supply planning under uncertainties in MRP environments. Models from literature that deal with random demand or lead time uncertainties are described and commented. Promising research areas emerge from this survey. It appears that lead time uncertainty has been ignored in the past, in spite of their significant importance. In particular, an interesting topic concerns assembly systems with uncertain lead times, for which the main difficulty comes from the inter-dependence of components inventories. Another promising issue, which is also presented, relates to supply planning under simultaneously demand and lead time uncertainties, which is certainly of great interest for both the academic and industrial communities.

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1. Introduction

Inventory control takes an important part in production systems. An improper policy of inventory control leads either to shortages, which generate expenses, or to needless stocks, which decrease capital assets. Thus, efficient supply planning methods to order the correct quantity of components at the right time should be developed.

This is especially true when uncertainties occur. Koh, Saad, and Jones (2002) classify them in two main categories: input (as external supply or demand reliability) and process (as machine breakdown, etc.). To minimize the influence of these uncertainties, enterprises implement safety stocks, but stock is expensive. So, the problem is to control inventories and to avoid stockout while maintaining a high level of service.

Efforts to reduce the random factors are necessary, but another aspect of possible progress should not be neglected, namely: improving methods for supply planning under uncertainties (Maloni & Benton, 1997).

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In this supply chain the decisions are related to the following questions:

- What are optimal moments and optimal quantities to supply?
- Which product to manufacture, when and how much?
- Which demands to satisfy, with what products and at what quantities?

The choice of replenishment policies is important and depends on the type of product. Hautaniemi and Pirttilä (1999) propose a classification of the items to select an appropriate method.

Demand forecasts give information on the final needs; this information should be transmitted from the distribution centers to the production sites and to the raw material suppliers by means of the planning activities (Ballou, 1999). For this, the Material Requirement Planning (MRP) techniques are widely used. There exist a lot of inventory control software based on the MRP approach. In a deterministic environment, the MRP logic gives an optimal just-in-time schedule. But, for supply planning in a stochastic environment, this method needs some parameterisation.

The previous states of the art can be find in the following papers. Yeung, Wong, and Ma (1998) propose a review on parameters having an impact on the effectiveness of MRP systems under deterministic or stochastic environment. Yücesan and De Groote (2000) give a survey on supply planning under uncertainties, but they focus on the impact of the production management under uncertainty on the lead times by observing the service level. Process uncertainties are considered by Koh et al. (2002) and Koh and Saad (2003). Very recently, Mula, Poler, Garcia-Sabater, and Lario (2006b) present a review for production planning under uncertainty. They categorize papers into four modelling approaches (conceptual, analytical, artificial intelligence and simulation).

This is a new survey on supply planning under uncertainties in MRP systems (a first version of this paper has been presented at the 16th IFAC World Congress (Dolgui, Louly, & Prodhon, 2005)). In literature, a number of models exists for dealing with random demand. The principle results are analyzed in this paper. In addition, it analyses the lead time uncertainties, and shows new and promising research areas especially concerning assembly systems with uncertain lead times, for which the main difficulty is in the inter-dependence of components inventories. Finally, only few papers deal simultaneously with uncertainties caused by the demand and lead time. Yet, considering both aspects in the same time is a more realistic approach, and should interest the academic as well as industrial community. This is highlighted in this survey.

This paper is organized as follows. Section 2, the MRP systems and its parameters are presented. More frequent types of uncertainties are discussed. Section 3 deals with an analysis of literature concerning MRP parameterisation in the case of nervousness of the system under uncertainties. Section 4 presents the literature concerning demand uncertainties. Lead times and both lead time and demand uncertainties are discussed in Sections 5 and 6, respectively. Finally, in Section 7 a conclusion and some perspectives are given.

2. MRP approach

2.1. The basic principles of MRP systems

The goal of MRP is to determine a replenishment schedule for a given time horizon. For example, lets consider the following bill of materials (BOM) (see Fig. 1), for a finished product. If the latter is a direct assembly of several components, the system is said to be one-level and *multi-item*. If there are other levels in the BOM, thus we have a *mutli-level* system.

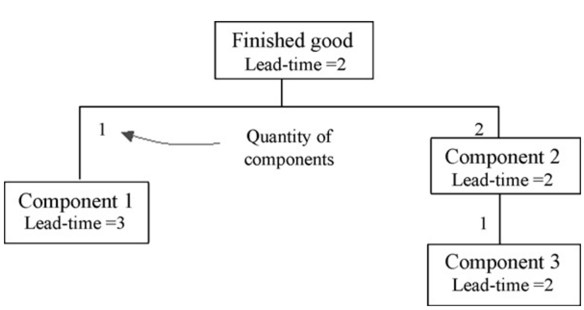

Fig. 1. Bill of materials.

Level 0 Finished good Lead time = 2	Period	1	2	3	4	5	6	7	8	9	10
	Gross need (MPS)	0	0	0	50	10	40	20	30	50	60
	Available inventory	20	20	20	20	0	0	0	0	0	0
	Net need	-20	-20	-20	30	10	40	20	30	50	60
	Manufacturing/order	0	30	10	40	20	30	50	60	0	0

Quantity = 1

Level 1 Component1 Lead time = 3	Period	1	2	3	4	5	6	7	8		
	Gross need (MPS)	0	30	10	40	20	30	50	60		
	Available inventory	100	100	70	60	20	0	0	0		
	Net need	-100	-70	-60	-20	0	30	50	60		
	Manufacturing/order	0	0	30	50	60	0	0	0		

Quantity = 2

Level 1 Component 2 Lead time = 2	Period	1	2	3	4	5	6	7	8		
	Gross need (MPS)	0	60	20	80	40	60	100	120		
	Available inventory	140	140	80	60	0	0	0	0		
	Net need	-140	-80	-60	20	40	60	100	120		
	Manufacturing/order	0	20	40	60	100	120	0	0		

Quantity = 1

Fig. 2. Master Production Schedule.

Finally, if the production of the finished product need several successive operations, the system is said *multi-stage*. The needs for the finished product are given by the Master Production Schedule (MPS) (Fig. 2), and the ones for the components are deduced from pegging.

Let introduce the following notation:

- $S(i)$ inventory for the period i;
- $N(i)$ net needs for the period i;
- $G(i)$ gross needs for the period i;
- $O(i)$ released orders for the period i;
- Δt lead time.

The available inventory for the first period $S(1)$ is given. For each subsequent need, the value is calculated from the net needs of the previous period:

$$S(i) = \max\{0, -N(i-1)\} \quad (1)$$

The net needs of the period i are obtained as follows:

$$N(i) = G(i) - S(i) \quad (2)$$

The released order quantity is

$$O(i) = \max\{0, N(i - \Delta t)\} \quad (3)$$

2.2. MRP under uncertainties

The main problem which often arises in the MRP systems is derived from the input data uncertainties, especially the time and the quantity uncertainties (see Fig. 3).

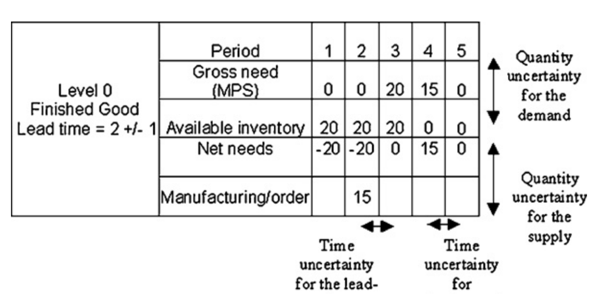

Fig. 3. Input data uncertainties.

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