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Supply planning for multi-levels assembly system under random lead times

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Abstract: Production costs and inventory control in supply chain and are very important elements for companies. Finished products have to be produced at lowest costs. For this reason, planners must reduce average stock levels and determine optimal safety lead times. In this paper we deal with a model of a multi-levels assembly system. Several types of component and one type of finished products are considered. The demand in each period is known in advance and procurement lead times are independent random discrete variables with known probability distributions. In this study we try to determine optimal order release dates for components at last level of BOM to minimize the sum of the average inventory holding cost for components and the average backlogging and inventory holding costs for the finished product. A simulation model is proposed and a genetic algorithm is used to analyze and optimize the planned lead times.

Keywords: Random lead times, multi-level assembly system, inventory control, simulation.

1. INTRODUCTION AND RELATED PUBLICATIONS

In supply chain, the main uncertain parameters are procurement lead times, prices and demand. These parameters are rarely known and frequently have uncertain values. The variability of lead times is often caused by technical problems as machines breakdowns, limited capacity and reliability of transport times.

In the literature review, several works identify different types of supply variability. Demand, capacity, quality and lead time were identified by Wazed et al. (2009) as the major factors of uncertainty in a real manufacturing environment. In the field of MRP, several states of the art (Dolgui et al. (2013), Dolgui and Prodhon (2007), Damand et al. (2011), Koh et al. (2002) and Guide and Srivasta (2000)) studied the MRP parameterization under uncertainties and classified different techniques to tackle it.

The safety lead times and safety stocks are often introduced by planners to reduce the supply variability in order to define better anticipations (Van Kampen Tim et al. (2010)).

For example Molinder (1997) made clear that both demand and the lead time variability influence the level of optimal safety stocks and optimal safety lead times. The safety lead time is specified by Koh and Saad (2007) as a main parameter to handle variability in supply chain, such as late delivery.

In the literature, the lead time uncertainty seems to be insufficiently analyzed for a long time. The vast majority of the inventory literature promotes the study of demand uncertainties (Dolgui et al. (2008)).

This paper analyses the effectiveness of safety lead times in the presence of supply variability. We are interested in a multi-period model demand for multi-level assembly systems under uncertainty of components lead times and a known demand.

The rest of paper is organized into six sections. Firstly, we present a short review of previous work relating to the optimization of assembling systems under uncertainties for a one and a multi period models demand (section 1). The simulation study is proposed in section 2. A numerical example is given in section 3. Section 4 shows some results. Finally, we outline the work done in the conclusion and give some perspectives of future research.

We focus on the problem of supply lead time uncertainties. It continues the work done by Ben Ammar et al. (2012), Hnaien et al. (2009), Dolgui et al. 2008, Hnaien et al. (2007) and Ould Louly et al. (2002).

An analysis of the literature shows that, in the case of assembly systems, the lead time is often considered deterministic and rarely uncertain. From exiting studies, Dolgui et al. (1995) and Dolgui (2001) developed an approach based on the coupling of an integer linear programming and a simulation to model one level assembly systems under a deterministic demand and random lead times in the case of a lot for lot policy. Authors considered several types of finished product. Several types of components are needed to assemble a finished product and for each component an inventory holding cost is considered. In this study, both the number of components to be ordered at the beginning of each period and the number

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of products to be assembled during each period are determined.

Two other studies (Dolgui et al. (2009) and Ould Louly et al. (2008)) focus on one level assembly systems under lead time uncertainty. A generalization of discrete Newsboy model is considered to find optimal release dates which maximize the customer service level for the finished product and minimize the expected inventory holding cost for components.

This Newsboy model was also used in Ould Louly and Dolgui (2002). The demand was supposed known and the capacity was considered unlimited. A multi-period one-level assembly systems under components lead times uncertainties is considered. A Branch and Bound procedure was given in Ould Louly and al (2008a) to solve the same problem.

A two-level assembly system was studied by Tang and Grubbström (2003) in the case of both stochastics lead time and the process time for components at level one of BOM. Both the demand and the due date are supposed known. The capacity is considered unlimited. To determine the optimal safety lead times which minimize the total backlogging and inventory holding costs, a Laplace transform procedure was introduced.

Hnaien et al. (2009) treated only one-period demand, model a two level assembly system and developed a genetic algorithm to minimize the total expected cost which equals to the sum of the backlogging cost for the finished product and the inventory holding costs for components. Authors supposed that components at level 1 of BOM are stored and the finished product is assembled only after the given due date. Fallah-Jamshidi et al. (2011) exploit the same problem in a multi-objective context. An Electromagnetism-like Mechanism is proposed to reinforce the GA and to determine minimal expected costs.

Ben Ammar et al. (2010) proposed, for the case of multi-level assembly systems, a simulation model to calculate the expected value of the cost which is the sum of: (1) the average component holding cost, (2) the average backlogging and (3) the inventory holding costs for the finished product. A genetic algorithm is used to optimize this average total cost. An analytic model was proposed by Ben Ammar et al. (2013a) to calculate the expected total cost. This mathematical model seems to be more efficient than the simulation model. A Branch and Bound method was introduced by Ben Ammar et al. (2013b) to optimise the same problem. Authors evaluated the quality of solutions founded by the Genetic Algorithm. They deduced that the convergence of the algorithm depends on several parameters: (1) the number of components in the last level of BOM, (2) the number of levels of BOM, (3) the type of the BOM and, (4) the ratio “backlogging cost / inventory holding cost” for the finished product. However, the model is a one-period demand and there is not a dependency between the stocks in each period.

2. DESIGN OF THE SIMULATION STUDY

We are interested in the supply planning for multi-levels assembly system: the finished product is produced from components themselves obtained from other components.

To get closer to the industrial methods of planning of type MRP, we consider a discrete temporal environment and the system is considered as a push-system. The lead time is equal to the elapsed time from order release to delivery and time is viewed as discrete intervals called time buckets.

The model is a multi-period demand and there is a dependency between the stocks in each period.

We supposed that the finished product is produced from components that are obtained from other components (Figure 1). Each finished product demand D_t for a given period t (end of a period) is supposed to be known. The total number of periods in the MPS is equal to T. We note also that the capacity is supposed unlimited.

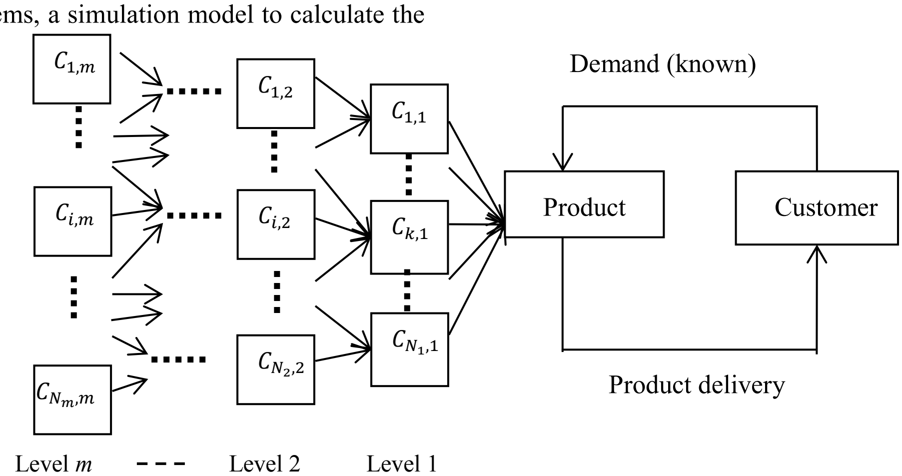

Fig. 1. A multi-level assembly-system.