

# A genetic algorithm to solve the general multi-level lot-sizing problem with time-varying costs

N. Dellaert<sup>a</sup>, J. Jeunet<sup>b,\*</sup>, N. Jonard<sup>c,d</sup>

<sup>a</sup>Department of Operations Management, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, Netherlands

<sup>b</sup>Laboratoire de Recherche en Gestion, Université Louis Pasteur, 61 Avenue de la Forêt Noire, 67070 Strasbourg Cedex, France

<sup>c</sup>CNRS, Bureau d'Economie Théorique et Appliquée, 61 Avenue de la Forêt Noire, 67070 Strasbourg Cedex, France

<sup>d</sup>Maastricht Economic Research Institute on Innovation and Technology, P.O. Box 616, 6200 MD, Maastricht, Netherlands

Received 17 May 2000; accepted 14 June 2000

---

## Abstract

The multi-level lot-sizing (MLLS) problem in material requirements planning (MRP) systems belongs to those problems that industry manufacturers daily face in organizing their overall production plans. However, this combinatorial optimization problem can be solved optimally in a reasonable CPU only when very small instances are considered. This legitimates the search for heuristic techniques that achieve a satisfactory balance between computational demands and cost effectiveness. In this paper, we propose a solution method that exploits the virtues and relative simplicity of genetic algorithms to address combinatorial problems. The MLLS problem that is examined here is the most general version in which the possibility of time-varying costs is allowed. We develop a binary encoding genetic algorithm and design five specific genetic operators to ensure that exploration takes place within the set of feasible solutions. An experimental framework is set up to test the efficiency of the proposed method, which turns out to rate high both in terms of cost effectiveness and execution speed. © 2000 Elsevier Science B.V. All rights reserved.

*Keywords:* Genetic algorithm; Lot-sizing; General product structure

---

## 1. Introduction

Material requirements planning (MRP) is an old field of study within business, but it still plays an important part in coordinating replenishment decisions for complex finished goods. There are actual reasons to believe that the rise in consumers' demands and expectations, and the subsequent increase in product complexity will make the need for

production coordinating devices even more accurate. However, we are not only in an era of rising product complexity but also in an era of fierce competition which definitely calls for adequate cost-saving tools. For this certainly MRP is not enough, as its basic philosophy is only to ensure that the right number of components is planned at the right time to meet the demand for end items. MRP therefore only provides a feasible solution to the multi-level production inventory problem, whereas ideally one would aim at a sequence of replenishment quantities through time at the various levels of manufacturing that keeps the total

---

\* Corresponding author.

E-mail address: jeunet@cournot.u-strasbg.fr (J. Jeunet).

relevant cost as low as possible while satisfying the demand for end items. Therefore, determining a proper lot-sizing policy definitely is a key dimension of inventory control, as placing proper batches can allow for significant reductions in inventory-related costs.

Optimal solution algorithms exist for this problem [1], but only very small instances can be solved in reasonable computation time for the problem is NP-hard, not mentioning the mathematical complexity of the technique that might deter many potential users. Several approaches to solve variants of the MLLS problem have been developed, with further assumptions made on the product and/or cost structure (see [2–5]), but execution times remain desperately high. Last, it should also be added that even when the time constraint is made as slack as possible, branch-and-bound algorithms available from standard software packages sometimes fail in finding optimal solutions. Hence heuristic techniques that offer a reasonable trade-off between optimality and computational feasibility are highly advisable.

One alternative, which is often implemented in practice, consists in applying single-level decision rules – just like the economic order quantity – to each level of the product structure (see [6,7]). Though simplicity surely obtains, neglecting the fact that placing a lot for an item somewhere in the product structure often triggers lots for the sub-components of this item has dramatic consequences in terms of cost effectiveness. Of particular interest are the approaches in which the multi-level nature of the problem is explicitly taken into account. Blackburn and Millen [8] suggested several cost modifications to account for interdependencies among levels of the product structure. Coleman and McKnew [9] developed a four-pass procedure based on the incremental part period algorithm (IPPA). The procedure embeds an original look-down routine used to compare at each level the net benefit resulting from the lumping of each period's requirement, until the bottom of the product structure is reached. Contrary to both previous approaches, the method developed by Bookbinder and Koch [10] is not only designed to address pure assembly product structures but also general structures, a feature being extremely common in real

settings. Dellaert and Jeunet [11] resort to randomization as a means of accounting for interdependencies among stages and achieve fairly good results compared to the previous techniques. However, although these approaches usually outperform sequential methods, they are unable to guarantee an optimal solution.

In this paper, we develop a hybrid genetic algorithm (GA) to solve the MLLS problem with no capacity constraints and no restrictive assumption on the product structure. Our primary incentive for this study is to find a solution method which is relatively moderate in CPU-time and intuitively appealing to potential users for a problem field of which Segerstedt [12] says 'MRP and other methods without clear capacity constraints will no doubt continue to be used in practical installations for decades to come'. We consider the most general statement of the problem in which costs may vary from one time period to the next. Though the possibility of allowing time-varying costs could be considered a striking assumption, it should be recalled that the cost of carrying items in inventory includes the expenses incurred in running a warehouse, the costs associated with special storage requirements, deterioration, obsolescence and taxes, and primarily the opportunity cost of the money invested which is very likely to fluctuate as a result of changes in investment opportunities. Similarly, the set-up cost attached to replenishment decisions embeds learning effects (getting used to a new set-up, procedures and material has a cost in terms of scrap costs) and evolves in response to changes in the work force, especially when it is subject to frequent turnover.

Our strategy here has been to design specific genetic operators that constrain search to the set of feasible solutions rather than letting the algorithm explore any possibility and relying on sophisticated penalty schemes. To increase search-efficiency, we have further reduced the set of solutions to the MLLS problem by defining adequate bounds on the ordering periods. We first tested our technique against optimality, and then moved to larger problems for which only heuristic methods can be employed. When small instances are considered, the GA almost instantaneously (1 second on average) provides solution of very high quality.

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات