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A goal programming model for production planning of perishable products with postponement

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Abstract

One of the important characteristics of perishable products that a decision-maker has to take into account seriously is that the price will drop significantly after a day, or a season. Hence, over-production and storage of such products is not recommended. In this paper, the production process for perishable products is proposed to be divided into two phases by applying the concept of postponement. Consequently, three production activities – direct production, master production and final assembly – will be considered. A preemptive goal programming model to solve aggregate production planning for perishable products is developed, in which three objectives are optimized hierarchically. A set of Hong Kong data has been used to test the effectiveness and the efficiency of the proposed model. Results demonstrate that the decision-makers can find the flexibility and robustness of the proposed model by adjusting the goal priorities with respect to the importance of each objective and the aspiration level with respect to desired target values.

Keywords: Production management; Goal programming; Perishable products; Postponement

1. Introduction

Postponement of production refers to a common intermediate product being manufactured in the first phase and, according to the differentiating options (such as colors, sizes and types), production line activities such as dyeing, compounding, final assembling, packaging and so on being postponed to a second phase – i.e. until customer orders are received (Aviv & Federgruen, 2001a; Aviv & Federgruen, 2001b; Van Hoek, 2001). Lee and Billington (1994) redesigned a European DeskJet Printer line of Hewlett Packard using the postponement strategy. Pagh and Cooper (1998) stated that the advantage of postponement is reduction or full elimination of risk and uncertainty in manufacturing and logistics operations. Garg and Tang (1997) investigated two points of postponement in the manufacturing stage – early postponement and late postponement – and investigated the importance of demand variabilities and correlations between, and relative magnitudes, of lead times in determining the appropriate points of differentiation. Aviv and Federgruen (2001b) studied the benefit

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of postponement with unknown demand distributions. Recently, Van Hoek (2001) reviewed the literature on postponement and identified postponement opportunities in operations.

In this paper, a postponement strategy is employed to solve production planning for perishable products in a situation with limited resources in production and dramatic growth in demand. Demand for perishable products is time-sensitive because the demand dramatically increases as the day approaches the end of life-cycle, such as the Christmas Day. On the other hand, a shortage of perishable products while the product is saleable may result in significant loss of revenue because perishable products cannot be profitable after a certain day. For instance, in manufacturing industries, people want to buy a Christmas gift in or before December only. Controlling the inventory of perishable products is crucial. However, there is little research that addresses aggregate production planning for perishable products.

Traditionally, the objective of aggregate production planning is either to maximize profit or minimize cost and is formulated to a single-objective function in linear programming. Recently, many researchers and practitioners are increasingly aware of presence of multiple objectives in real-life problems (Vincke, 1992). Baykasoglu (2001) noted that the aggregate production planning may consider minimization of costs, inventory levels, changes in work force levels, overtime wages in production, subcontracting, changes in production rates, number of machine set-ups, plant/personnel idle time and maximization of profits and superior customer service. Decision-makers always want to develop a model that can consider real-life situations with multiple objectives. To achieve this, in this paper, a preemptive goal programming model is formulated to determine optimal production loading plans.

As opposed to linear programming, which directly optimizes objectives, preemptive goal programming is used to manage a set of conflicting objectives by minimizing deviations between the target values and the realized results (Rifai, 1994). The original objectives are re-formulated as a set of constraints with target values and two auxiliary variables. Two auxiliary variables are called positive deviation d^+ and negative deviation d^-, which represent the distance from this target value. The objective of preemptive goal programming is to minimize the deviations hierarchically so that the goals of primary importance receive first-priority attention, those of secondary importance receive second-priority attention, and so on and so forth. Then, the goals of first-priority are minimized in the first phase. Using the obtained feasible solution result in the phase, the goals of second priority are minimized, and so on. With fast computational growth, both linear and non-linear GP can be solved using well-developed software such as Linear Interactive and Discrete Optimization (LINDO) or meta-heuristics such as simulated annealling, genetic algorithms, tabu search and so on (Jones, Mirrazavi, & Tamiz, 2002). An explicit definition of goal programming was given by Charnes and Cooper (1961).

The purpose of this study is to develop a preemptive goal programming model to optimize the production planning problem for perishable products under an uncertain environment, from which we can determine (1) how many finished products should be produced from raw materials directly (direct production), (2) how many semi-finished products should be produced from raw materials (master production), and (3) how many finished products should be produced from semi-finished products (final assembly) so that resources can be better utilized to meet any dramatic growth in demand and total costs (consisting of setup costs, production costs, labor costs, inventory costs, hiring costs and lay-off costs) can be minimized.

The organization of this paper is as follows. After this introduction, characteristics and issues of current operations in the toy company under investigation are reviewed. Then a preemptive goal programming model is formulated to solve the production planning problem for perishable products using a postponement strategy in Section 3, and a set of data from the toy company is used to test the effectiveness and efficiency of the proposed model in Section 4. Our conclusions are given in the final section.

2. Characteristics and issues of current operations

This study is particularly motivated by the problems faced by a company manufacturing plush toys, whose headquarters is in Hong Kong and the production plant is in China. The finished products are exported to the US and Europe. The company mainly produces two plush toy products – animal-type plush toy products with light songs (duck, bear, hop and dog) and Christmas-theme plush toy products with Christmas songs (snowman and Christmas tree). From the sales report, it is known that animal-type plush toy products can be sold