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Profit maximization in simultaneous lot-sizing and scheduling problem

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ABSTRACT

This paper extends the simultaneous lot-sizing and scheduling problem, to include demand choice flexibility. The basic assumption in most research about lot-sizing and scheduling problems is that all the demands should be satisfied. However, in a business with a goal of maximizing profit, meeting all demands may not be an optimum decision. In the profit maximization simultaneous lot-sizing and scheduling problem with demand choice flexibility, the accepted demand in each period, lot-sizing and scheduling are three problems which are considered simultaneously. In other words the decisions pertaining to mid-term planning and short-term planning are considered as one problem and not hierarchically. According to this assumption, the objective function of traditional models changes from minimizing costs to maximizing profits.

In this paper, two mathematical models are developed for the problem, and the efficiency of them is evaluated in different problem sets. These two models are different in the method of lot-sizing.

1. Introduction

Lot-sizing and scheduling are important problems in the field of production planning. Most of the time, decisions about these two problems are made hierarchically. In this method, the lot-sizing problem is solved at first and then the result is used for the sequencing and scheduling problem [1]. The problem which was named the general lot-sizing and scheduling problem (GLSP) [2] considers lot-sizing and scheduling problems simultaneously due to their dependency.

In most of the models for production planning and especially in lot-sizing and scheduling problems, the objective function is minimizing costs. In these models, the assumption is that all the customers' demands should be met. However, in a business with a goal of maximizing profit, satisfying all potential demands may not always be an optimal solution [3]. In this situation, the appropriate selection of demand (to be met) is an effective step for demand management.

In this paper, the profit maximization in simultaneous lot-sizing and scheduling problem with demand choice flexibility is studied. The accepted demand in each period can vary between its upper and lower bounds. The upper bound could be the forecasted demand and the lower bound could be the organization commitments towards customers or the minimum production level according to the production policy. In other words, the amounts of accepted demands, lot-sizing and scheduling are problems which are considered simultaneously. According to these assumptions the objective function of the problem is maximizing the revenue of sales minus the production, inventory holding, and setup costs. The result of this model is the amount of accepted demand for each product in each period, the size of production lots, and the sequence of them. In

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this problem, the mix product problem which pertains to mid-term planning and lot-sizing and scheduling problems, which relate to short-term scheduling, are considered in one problem. Because the basic problem was first named GLSP, we use PGLSP as a name for our problem, but it is wise to say that if we wanted to name the model by considering its basic model rather than the concept of GLSP we should name it PCLSPSD.

The proposed problem will result in better decisions especially when mix of products is decided in mid-term planning while short term decision is about scheduling of different machines. This model is presented based on the characteristics of industries like the moquette weaving industry. In this type of industry setup times and costs are considerable so it is wise to use the simultaneous lot-sizing and scheduling models. Besides that selecting the demand without considering back order costs is also possible, and predicting the exact amount of demand is impossible, so it is more reliable to define upper and lower bounds for demand. Wholesalers accept this policy, so sometimes the amount of products they deliver is less than their orders. For preserving the percentage of products and enhancing the service level, the lower bounds are greater than zero.

We have a few products in this company in different models and colors. The planning period of two weeks and the planning horizon of 8 weeks are suitable for the company.

2. Literature review

Because the presented problem in this paper, which is a new problem, is a combination of GLSP and demand choice flexibility, we discuss the related literature of these two problems.

In the mentioned problem, (GLSP), lot-sizing and scheduling are considered simultaneously. For modeling this problem there are two distinctive approaches. In first approach there are two kinds of time buckets, small buckets, and large ones. Small buckets or positions are within the large buckets or periods. The positions are used for sequencing. This approach was first presented by Fleischmann and Meyr [2]. Meyr [4] extended GLSP to deal with sequence-dependent setup times. Koçlar [5] represented a new model for GLSP with sequence-dependent setups by using the combination of the Meyr approach [4] for modeling and transportation problem. The basic idea in this model is to disaggregate the production variables by relating each production quantity to the period at which it will be required.

The second approach is based on the capacitated lot-sizing problem (CLSP) with sequence-dependent setup times (CLSPSD). This problem is related to the traveling salesman problem (TSP) or the vehicle routing problem (VRP). Setup costs in GLSP are like distance cost in TSP. Because TSP is an NP-hard problem, CLSP with sequence-dependent setup is also NP-hard [6]. Gupta and Magnusson [6] used this approach for modeling simultaneous lot-sizing and scheduling. Almada-Lobo et al. [7] have demonstrated that the Gupta's model does not avoid disconnected sub tours. Almada-lobo et al. [8] presented a more efficient model in comparison with the models using the Meyr approach [4] for scheduling.

Simultaneous lot-sizing and scheduling is noticed in many practical situations. Pattloch et al. [9] represented a heuristic algorithm for production lot scheduling in the tobacco industry. Quadt [1] discussed the lot-sizing and production scheduling for flexible flow-line and represented a case study in a semiconductor factory. This problem was modeled and solved for soft drink production [10,11], a steel casting factory [12] and an animal food plant [13]. These studies emphasized the importance of considering lot-sizing and scheduling at the same time due to their interactions.

For many firms, the most important decisions relating to production are those that determine the product mix for a given period of time. There may be a number of products that the company could produce and sell in the period and the problem is to decide how much of each product to schedule [14]. This problem is known as the product mix problem. The problem is to find a production plan that can maximize the net profit of the company by considering the resource constraint and each product demand. This problem only calculates the amount of production and does not take into account lot-sizing and scheduling problems. The amount of production should be within its upper bound and lower bound. PGLSP is a combination of the product mix problem and GLSP which pertain to mid-term planning and short-term scheduling, respectively.

In most production planning problems with the assumption of responding to all demand, the objective function is to minimize costs because the revenue of selling all products is fixed. Flexibility in demand choice results in changing this objective to maximizing the sales revenues minus different costs.

Haugen et al. [15] studied profit maximization capacitated lot-sizing problem (PCLSP) and represented a mathematical model for it. In this model, demand is a function of price, and price is a variable in the model. In this problem the demand is determined indirectly by the model. The objective function maximizes sales revenue minus different costs. In another paper Haugen et al. [16] studied the large scale of the same problem.

Geunes et al. [17] represented a model that implicitly decides, through pricing decisions, the demand levels of the firm which should be satisfied in order to maximize the profit. Merzifonluoğlu and Geunes [18] studied a planning problem which determined the optimal level of demand, production, and inventory for every planning period when flexibility exists in selecting demands and their delivery timing. They used a variable in their model which determines the percentage of accepted demand with the objective of maximizing the profit. Shen [3] studied the demand choice flexibility in a supply chain and with the objective of profit maximization.

3. PGLSP definition and formulation

PGLSP is described as follows