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A genetic algorithm approach to optimize a multi-products EPQ model with discrete delivery orders and constrained space

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Abstract

The economic production quantity (EPQ) is one of the most applicable model in production and inventory control environments. Like other classical production and inventory control models, it is derived based upon assumptions that cause limited real-world applications. Continuous and constant-rate delivery of orders, infinite availability of warehouse spaces, and applicability on a single product are some of these assumptions. In order to make the EPQ model more applicable to real-world production and inventory control problems, in this paper, we expand this model by assuming that the orders may be delivered discretely in the form multiple pallets. In addition, we may have more than one product along with warehouse space limitation. Under these conditions, we formulate the problem as a non-linear integer-programming model and propose a genetic algorithm to solve it. At the end, we present a numerical example to demonstrate the application of the proposed methodology.

Keywords: Production and inventory control; EPQ; Multiple deliveries; Multiple products; Constrained space; Genetic algorithm

1. Introduction and literature review

One of the standard factors of any production process is material. The management of material concerns the regulation of the flow of materials to, within, and from the organization. The efficiency of the material flow can substantially influence costs as well as revenue generation capabilities. The management of material involves a balance between the shortages and excesses of stock in an uncertain environment.

With the globalization of business in recent years, firms are sourcing and distributing raw materials, components, and finished goods across the globe. Customers want their products quickly and reliably, even if they are coming from another continent, and they are often willing to look for other suppliers if products are frequently delivered late. As a result, inventory management and production planning and scheduling have become even more vital to competitive success.

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Inventory management and production planning and scheduling have been studied in considerable depth from a theoretical perspective. Yet, the application these theories have had is surprising limited in the leading firms. A major gap existed between the theoretical solutions and the real-world problems.

One of the most important problems in companies that utilize suppliers to provide raw materials, components, and finished products is to determine the order quantity and the points to place orders. Various models in production and inventory control field have been proposed and devoted to solve this problem in different scenarios. Two of the models that have been employed extensively are the economic order quantity (EOQ) and economic production quantity (EPQ) models [15,14]. However, these models are constructed based on some assumptions and conditions that bound their applicability in real-world situations.

In recent years, researchers have expanded the EOQ and EPQ models to increase their applications. For instance, Bayindir et al. [1] considered the EPQ model with general inventory cost rate function and piecewise linear concave production costs and proposed an effective solution procedure for economic order quantity. Moreover, while in the EPQ model it is assumed that the process has no setup wastage, Hou [9] studied an EPQ model with setup cost and process quality as functions of capital expenditure and developed an efficient procedure to find the optimal production run time, setup cost, and process quality.

Li et al. [12] developed EPQ-based models with planned backorders to evaluate the impact of the postponement strategy on a manufacturer in a supply chain and derived the optimal total average costs per unit time for producing and keeping end-products in a postponement system.

Chiu et al. [4] presented a procedure to determine the optimal run time for an EPQ model with scrap, rework, and stochastic machine breakdowns. In real life manufacturing systems, generation of defective items and random breakdown of production equipment are inevitable. In this research, a portion of the defective items was considered scrap, while another was assumed repairable. Finally, they presented the optimal run time within two-sided interval.

Goyal [8], Chung and Huang [5] discussed the EOQ model under conditions of permissible delay in payments. While an implicit assumption of their research was that the items were obtained from an outside supplier, the main purpose of their research was to extend the model to a case where the units are replenished at a finite rate. Furthermore, Biskup et al. [2] and Liao [13] expanded the model based upon the concept of permissible delay in the payments.

One of the most important aspects of extending an EPQ model is to fuzzify its parameters. For example, in the fundamental EPQ model both the demand and the production quantity are always fixed per day. However, in real-world situations, both have some disturbances every day. Lee and Yao [11], in their research, fuzzified both to solve the economic production quantity per cycle. Moreover, Chang and Chang [3] proposed a fuzzy extended EPQ model based on an elaborative modeled unit cost structure. This unit cost structure consisted of the various lot-size correlative components such as on-line setups, off-line setups, initial production defectives, and direct material and labor. In addition, Islam and Roy [10] formulated an EPQ model with flexibility and reliability consideration of production process and demand-dependent-unit production cost with fuzzy parameters. Their model was restricted by available limited storage space constraint. The inventory related costs and storage space were taken as fuzzy numbers and their model was solved by a modified geometric programming method.

In this article, we consider a multiple-products EPQ model in which not only there are limited warehouse spaces, but also the orders are delivered discretely in the form of multiple pallets. To do this first we define and model the problem in Sections 2 and 3, respectively. Then, in Section 4, we propose a genetic algorithm to solve the problem. In order to demonstrate the application of the proposed methodology, we provide a numerical example in Section 5. Finally, the conclusion and some recommendations for future research come in Section 6.

2. Problem definition

To define the problem, consider a production company that works with a supplier. The situation by which the company and the supplier interact with each other is defined as follows:

(a) The supplier produces all of the demanded products with known and constant rates.
(b) The demand of each product in the company is known with a constant rate.
(c) The supplier sends the orders to the company by pallets.