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Optimizing inventory decisions in a two-level supply chain with order quantity constraints

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ABSTRACT

A fundamental assumption in traditional inventory models is that all of the ordered items are of perfect quality. A two-level supply chain is considered consists of one retailer and a collection of suppliers that operate within a finite planning horizon, including multiple periods, and a model is formulated that simultaneously determines both supplier selection and inventory allocation problems in the supply chain. It is supposed that the ordered products dependent on the suppliers include a certain percentage of imperfect quality products and have different prices. In this paper, we study the impact of the retailer's financial constraint. On the other hand, suppliers have restricted capacities and set minimum order quantity (MOQ) policy for the retailer's order amount happened in each period. So, the problem is modeled as a mixed integer nonlinear programming. The purpose of this model is to maximize the total profit. The nutrients, fishery and fruitage industries give good examples for the proposed model. A numerical example is presented to indicate the efficiency of the proposed model. Considering the complexity of the model, a genetic algorithm (GA) is presented to solve the model. We demonstrate analytically that the proposed genetic algorithm is suitable in the feasible situations.

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1. Introduction

In today's competitive condition, the significance of supply chain management persuades systems to focus their attentions on the inventory policies. High inventory levels increase the responsiveness of the supply chain, but on the other hand, increase the holding cost of inventory. The classical economic order quantity (EOQ) is a commonly used method for inventory control. A basic assumption in the EOQ model is that all of the ordered products are of perfect quality; but this assumption is not true in the real world. In such a case, each of the products received from the suppliers may be of imperfect quality with a probability "*P*", but are not necessarily defective. Rezai and Davoodi [1] have shown a model to maximize the total profit. They assumed the point that the decision maker requires to make a decision about which products, with which quantities, to which suppliers and in which periods should be ordered. They supposed that the retailer has a maximum storage space to hold his products and suppliers have restricted supply capacities. On the other hand, it has been imagined that shortage is not allowed, but the point is that both maximum storage space and supply capacity restrictions in many demand cases are contradictory with the restriction of not allowed shortage and result in lack of any justified area for the offered model. Also, the goal function is dependent on the order amounts, but there is no restriction about the total order amounts,

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that should be less than or equal to the summation of demands in all periods. So, it seems that there exists demand for every order quantity.

Kang and Kim [2] have assumed a two-level supply chain consists of a supplier which serves a collection of retailers and orders are carried out by homogeneous vehicles. The problem was to determine the quantity of products delivered to the retailers in each period for minimizing the total cost, while each vehicle can visit multi retailer in a single trip. We consider a two-level supply chain, consists of one retailer and a collection of suppliers that operate within a finite planning horizon, including multiple periods. Each supplier satisfies one or more required product for the retailer. Therefore, as it is seen in Fig. 1, each of the products can be procured from a collection of suppliers. However, all suppliers have restricted supply capacities to meet the retailer's demand. The retailer orders products before each period, and the orders are received at the first of each period. A supplier-dependent ordering cost is employed for each happened order, which is not dependent on the variety and amount of the involved products. Deliveries are received by homogenous vehicles with limited capacities for the total space and the total weight. Each vehicle dispatches to the retailer from one supplier in a single trip. So, a fixed transportation cost occurs.

The received products from the suppliers are of imperfect quality (but are not necessarily defective). Hence, a 100% inspection process is performed prior to each period for separating perfect and imperfect products. Products with imperfect quality entirely can be sold at the first of every period with a discount price as a single batch. The retailer can store inventory to satisfy the demand over each period. Therefore, there is holding cost as a fraction of each period in which each product is stored.

Most suppliers use minimum order quantity policy for their retailers to achieve the economic scale of operation in supply. Thereby, minimum order quantity is a useful policy for suppliers in the real world. While, large minimum order quantities demonstrate significant challenges to the supply chain management; the minimum order quantity restriction can be applied to a special product or a group of products. Zhang and Zhang [3] have considered supplier selection and lot sizing problems under stochastic demand. The assumed aim was to select suppliers that have a restriction on the maximum and minimum order amounts, to allocate the order amounts among the selected suppliers properly for minimizing the total cost. In this study, we consider that each supplier sets minimum order quantity policy for the order amount of each product happened in each period. This means that, if the retailer's order quantity for each product in each period is less than the minimum order quantity determined with each supplier, then he faces to a proportionate penalty cost. But, if the retailer's order quantity is less than the specified minimum order quantity by the suppliers; therefore, he has two flexible options for ordering the products: (i) performs an order less than the determined minimum order quantity by the suppliers and pays the relative penalty cost or (ii) performs no order and loses the sales of the current period. However, there is no penalty cost for not performing an order.

The retailer has a restricted capital level for the total purchase cost over the planning horizon, and the capital level may either be sufficient or insufficient for beneficial operations. The retailer can order products, more than the demand of current period, but should be less than or equal to the summation of the current and the future demands. Therefore, demands of each period can be satisfied by the new received products or the held products from previous periods. If the retailer's order quantities are less than the demand of current period, then he confronts shortage. It is supposed that shortage is allowed, and the

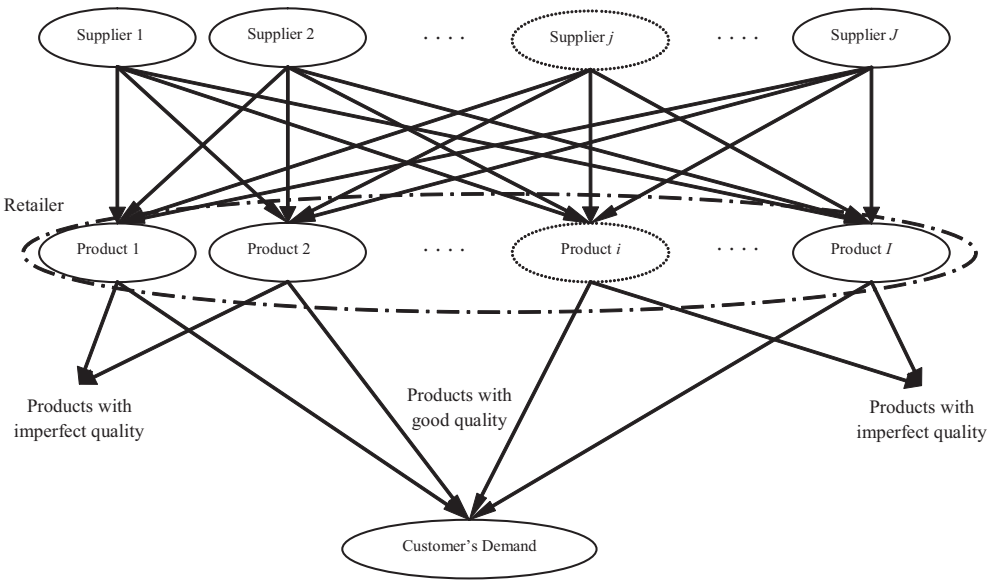

Fig. 1. Structure of the considered supply chain.

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