Storage Inventory Model

Subjects: Operations Research & Management Science

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The inventory-carrying scheme associated the proposed model consists of both rented and owned warehouse facilities, where the cost increases linearly with time. The numerical and visual simulation concludes the mathematical approach to analyzing the proposed inventory model in Mathematica software. The results show that a price hike enhances profit despite the negative impact on demand creation. Also, promotion frequency favors profitability, suppressing the corresponding costs. Another managerial intuition is revealed through the numerical result that the stock should be held in a rented warehouse when deterioration in the owned warehouse increases, despite the cost of a rented warehouse.

Inventory Model stock Demand time-dependent holding cost partially backlogged shortage EOQ model advertisement

1. Introduction

Demand is an essential aspect of marketing. Demand is typically assumed to be constant in inventory problems. Still, in reality, demand may be dependent on one or more decision variables such as time [1], selling price [2], stock level [3], the frequency of advertisement [4], the green level of the product [5], deterioration [6], and the warranty period of the product [7]. Retailers are very concerned with determining the best prices for the products they will be selling. The retail price significantly influences the design of consumption. In a developing country, a consumer typically pays close attention to a product with a low price. In the food industry, the demand for fresh products, including fish, meat, eggs, vegetables, fruits, and various processed foods in restaurants and hotels, is typically determined by price. Retailers could provide lower prices to increase consumer demand. The average profit may be at its best at a high demand rate. Therefore, the average gain is connected to the unit selling price throughout demand. Thus, the selling price is a very crucial decision variable.

On the other hand, in today's aggressively competitive globe, marketing advertisements are widely recognized as they are crucial in enhancing the potential for business and entering new markets. In addition to leaving a long-lasting impression on a customer's memory, successful advertising promotes brand loyalty over time. Advertising has a significantly more significant impact on new markets and products since it helps consumers become aware and informed, which ultimately changes their thinking. Therefore, the demand function for a product may depend on the unit selling price and the promotion of the product simultaneously [8].

Researchers have recently been quite interested in inventory models with a price discount policy. Suppliers sometimes provide quantity discounts to motivate retailers or buyers to order more. In control theory, suppliers typically provide mainly one or two deals, such as incremental and all-unit quantity discounts. The all-unit discount policy gives consumers a discount on each unit of the product, whereas in the incremental discount policy, the consumers receive a discounted price for the additional units they buy after crossing some fixed levels and keep paying the total cost of each of the initial units until they reach the said certain level. The presence of all-unit discounts is one of the charming features of the small business setting. Because marketing strategies are being implemented worldwide, all-unit discount facilities are essential in the competitive business.

A holding cost is typically seen as a constant in inventory control policy [9]. However, this presumption about deteriorating goods is only sometimes valid. This is because holding costs rise with time due to deterioration. Keeping costs increase over time for pharmaceuticals, fruits, vegetables, etc. Therefore, it is essential to consider the time dependency of the holding cost function in the inventory control problem.

The inventory system assumes that the retailer or any organization has a total storage capacity for holding items. However, the retailer's warehouse can only keep a certain amount of inventory due to some limitations like funds, land investment, and worker input. Also, all organizations aim to enhance their consumer bases by adopting various actions at any given time. It is crucial to have enough and simple access to the products in the system so that customers are not turned away during periods of high demand. Most business organizations aim to retain enough stock to prevent any shortage situations. Retailers are motivated to place additional orders to take full advantage of this policy. They need big spaces to maintain and store appropriate items to achieve these. Business organizations may depend on a two-warehouse system to deal with these issues. A warehouse that is owned by the organization is known as an owned warehouse (O.W.), and a warehouse that is acquired on a rental basis to keep additional inventory is known as a rented warehouse (R.W.). It is a realistic and accepted practice to assume that the costs associated with maintaining inventory and depreciation are higher in an R.W. than in an O.W. due to considerations like shifting items, material handling, operating charges, etc. Because of this, the inventory managers store products in an O.W. before an R.W. but use up the R.W. stocks first, that is, before using up the O.W. stocks.

In general, it is noted that buyers or retailers must complete a full payment for the items they buy from a manufacturer or supplier. However, in the current extremely aggressive business environments, manufacturing companies give a variety of offers to buyers/retailers to capture their attention and increase product sales. There are various sorts of strategies that have been outlined by numerous researchers in the existing literature. One of the most widely used policies in inventory research is the credit policy or trade credit policy approach. Suppliers or manufacturers use a trade credit policy strategy to give their retailers several options to grow their organizations through specific deals. The suppliers or manufacturers give their retailers a certain amount of time to pay for the goods they have bought. This kind of idea is typically called the "single-level trade credit policy approach" or "permissible delay in payment" [10][11]. Additionally, when sellers offer their customers a credit facility, this kind of credit facility is known as the "two-level trade credit policy approach" [12][13]. The buyer does not need to pay any extra amount as interest on the credit amount within the period of credit, and an appeal will be charged if the credit

period exceeds. However, the supplier has the benefit of encouraging the customer to buy more of their goods. As a result, a trade credit policy will increase the supplier's profit and reduce the cost of holding. In addition, because there is less stock invested for the trade credit facility, the buyer may earn interest from the selling amount.

2. Inventory Model

2.1. Inventory Model with Various Kinds of Demand Function

Demand is a business or enterprise's most important component. Over the past few years, scholars have examined the many types of demand. As an outcome, the investigators have built inventory models that account for diverse types of demand. For instance, Shah et al. [14] introduced a deteriorating economic order quantity model for non-instantaneous products in which the demand function is nonlinear and dependent on the unit selling price and frequency of advertisement simultaneously. Bhunia et al. [15] introduced a worsening inventory model that considers demand as a function of the selling price, advertisement frequency, and time. An EOQ model for a production system that produces defective items, considering that the demand function decreases exponentially with time, was investigated by Jaggi et al. [16], who found that this model is suitable for business environments where new products are introduced every day. Tripathi [17] developed an EOQ model by using a quadratic time-dependent demand as a variable. Namdeo et al. [18] presented a deteriorating pricing model whose demand is simultaneously dependent on the items' prices and on-hand stock level. Shaikh et al. [19] prepared an EOQ model with a time-dependent ramp-type demand rate. Handa et al. [20] examined the inflation effect in their production inventory policy, in which they considered that the market demand depends on the time and selling price. An EOQ model for perishable products was examined by Mishra [21], taking stock and time-dependent demand as variables. Recently, Khan et al. [22] presented an inventory model whose demand is nonlinear and dependent on stock. After this, Shah and Shroff [23] proposed a pricing model with time-dependent trapezoidal-type demand.

2.2. Inventory Model with Quantity Discount

Hadley and Whitin [24] first incorporated the notion of a quantity discount in an economic order quantity model. Suppliers sometimes provide quantity discounts to motivate retailers or buyers to order more. In control theory, suppliers typically provide mainly one or two discount policies, such as incremental and all-unit discounts. Researchers have recently been quite interested in inventory control theory, considering an all-unit price discount strategy. For instance, Shi et al. [25] established an inventory policy in which the demand function is price-dependent and additive stochastic by considering that the supplier provides all-unit quantity discounts to buyers or retailers through a mixed integer nonlinear programming model and a generalized disjunctive programming model. An inventory model with an all-unit discount was presented by Taleizadeh and Pentico [26], and they illustrated the model by comparing the EOQ models without a discount and with an all-unit discount. An EPQ model where the demand function is dependent on the stock level of the product was addressed by Alfares [27], considering the all-unit quantity discount. Shaikh et al. [28] discussed an EOQ model while assuming that the all-unit price discount policy and demand rate are dependent on the stock level and unit selling price. After that, this work was explored by Khan et al. [29], taking the holding cost as being linearly dependent on time and assuming that the unit carrying

charge is directly proportional to the unit purchase cost. Rahman et al. [30] added an EOQ model while considering deterioration, demand patterns, purchasing cost, etc., as interval-valued numbers by considering two scenarios: one with shortages and one without shortages in all-unit quantity discount environments. A decision support framework for installment prepayments in an inventory system with a power demand rate was investigated by Khan et al. [31], incorporating all-unit discounts from the manufacturer or supplier to the retailer. They explored that when the total capital cost of a prepayment is less than the transaction cost of a single installment, the retailer should prefer a single installment prepayment policy. Recently, Momena et al. [32] presented a learning-based EOQ model while considering an all-unit price discount facility in a fuzzy environment. Khan et al. [33] examined how applying an all-unit discount impacts the total average profit of an inventory model with power demand patterns.

2.3. Inventory Model with Time-Varying Holding Cost

A holding cost is typically seen as a constant in inventory control policy [9]. However, this presumption about deteriorating goods is only sometimes true. Therefore, it is vital to linearly consider that the holding cost is time-dependent when making inventory decisions. In this regard, Ferguson et al. [34] first introduced an inventory policy for perishable products, nonlinearly considering the holding cost rate per unit as a function of time. By taking cost as a linear function of time, Mishra [35] incorporated an EOQ model. A partial back-ordering inventory strategy for perishable products was studied by Dutta and Kumar [36]. In this article, they assumed that the carrying cost depends on time and found that low stock levels should be maintained to avoid high holding costs. Pervin et al. [37] explored an integrated supply chain design by considering that time is dependent on the holding cost. Garai et al. [38] discussed a pricing model by analyzing the time-varying carrying cost in a fuzzy environment through trapezoidal fuzzy numbers. Pando et al. [39] formulated an inventory model by assuming a linear and nonlinear price-dependent demand in both time and stock levels. Furthermore, Swain et al. [40] investigated the EOQ design for perishable items by taking the holding cost as a function of time under consideration. A green pricing strategy was developed by Paul et al. [41], taking variable holding costs into account. Recently, Kumar et al. [42] discussed the combined effect of advertisement and selling price on customers in the inventory model by considering time-dependent carrying costs. The holding cost is taken as a linear function of time and is directly proportional to the unit purchasing cost.

2.4. Two-Warehouse Inventory Model

Numerous research articles have been published in the previous few decades incorporating the two-warehouse concept into different inventory models. Hartley [43] suggested the first two-warehouse model for the inventory system in his book, *Operations Research: A Managerial Emphasis*. Other researchers also tried to create issues with the two-warehouse arrangement. In this area, Yang and Chang [44] introduced a two-storage inventory design for perishable products with an allowed payment delay, considering that the inflation effect and shortages are partially back-ordered. After that, Bhunia et al. [45] explored the study by Yang and Chang [44] by considering that time depends on the partial backlogging rate and analyzing different cases on the trade credit time. Xu et al. [46] discussed a two-storage inventory model by comparing other dispatching policies such as last-in-first-out, modified last-in-first-out, and first-in-first-out policies. Tiwari et al. [47] analyzed a two-warehouse inventory model using

particle swarm optimization's meta-heuristic algorithm. Chakraborty et al. [48] investigated a two-warehouse inventory setup with three-parameter Weibull distributed deterioration and the ramp type time-varying demand curve under the permitted payment delay. Jonas [49] studied a two-layer supply chain containing one distributor and one buyer in a two-warehouse setup, where the holding cost per unit for storing the item in an R.W. decreases over time. Ghiami and Beullens [50] developed a two-echelon supply chain in a two-warehouse setup considering a continuous resupply policy, i.e., the items in an R.W. are regularly relocated to an O.W. to keep their total capacity as demand depends on stock. A two-warehouse inventory model for perishable products was introduced by Khan et al. [51], considering that the rate of deterioration in an R.W. is lower than that of an O.W. since an R.W. has superior preservation services compared to an O.W. Xu et al. [52] explored a deteriorating inventory model by considering the selection of an item that can be stored in an O.W. or an R.W. or both an O.W. and R.W. Thilagavathi et al. [53] discussed a two-storage inventory problem, where the supplier offers three slots of payment to the retailer for the purchasing amount; the slots are "prior payment with a discount", "posterior payment with a penalty", and "to be paid at the time of replenishment". Most recently, a two-echelon supply chain model with two warehouses was analyzed by Padiyar et al. [54] with cloudy fuzzy inflation.

2.5. Inventory Model Based on Trade Credit Policy

Since trade credit allows customers to buy products without an instant payment, many organizations utilize this to increase their economic strength and attract new customers. Many researchers have focused more on trade credit in the past two decades and have included various trade credit policies in their pricing models. The notion of trade credit policy was first brought on by Goyal [55]. Following that, multiple researchers have applied this policy in their pricing models. For instance, Taleizadeh [56] discussed an inventory system with a single-layer trade credit policy by allowing for multiple prepayments for the credit amount. A two-level trade credit financing supply chain model was analyzed by Wu et al. [57]. Sarkar et al. [58] introduced a deteriorating inventory system using a two-level trade credit policy where the supplier offers a full trade credit to the buyer or retailer. In contrast, the buyer provides a partial trade credit to the customer. A green inventory system considering a single-level trade credit policy from vendor to buyer was developed by Tiwari et al. [59]. Numerous researchers [60][61][62] have recently developed models using single-level trade credit facilities from supplier to retailer. The concept of a single-level trade credit facility from retailer to customer is used in [63][64][65], and two-level trade credit policies have been used in their inventory model [66][67].

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