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On Some Theoretic Inventory Control for Oblique Transference Via EOQ Probabilistic Model

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

Experts think organizational inventories hold a significant portion of total business capital. As a result, a more thorough and thoughtful analysis of the inventory problem enables firms to best utilize all of their resources for increased efficiency and effectiveness. In turn, this might assist organizations in achieving their objectives. This paper develops an inventory model for stochastic deteriorating conditions and broad discounts. While other factors were treated as deterministic, degradation was analyzed as a stochastic variable. We can use a variety of initiatives to cut costs and improve competitiveness in the face of the increasingly fierce competition. The business in this article faces significant pressure from customer cost pass-through. The main concerns should be how to organize manufacturing properly, manage inventory, and lower production costs. When developing ideas, buying materials, manufacturing items, and selling them to customers with after-sale services, manufacturing companies work off of market or client demand. Inventory

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management is a valued function for all firms. the main purpose of the inventory management department is to control the materials from the acquisition to sale, taking decisions of how much and when to buy the items avoiding excess or unplanned stockout. The shortages are legal, and some items are completely backordered. Some theoretical conclusions are drawn in order to maximize the anticipated total profit per unit of time, and using these conclusions, a practical and efficient solution method is created. It is crucial to note that the algorithm creates the best possible order quantity and backordering quantity solutions.

Keywords: Supply Chain; applied mathematics; inventory control; economic production quantity.

1 Introduction

When developing ideas, buying materials, manufacturing items, and selling them to customers with after-sale services, manufacturing companies work off of market or client demand [1]. A lengthy supply chain is also produced by the production processes, which begin with the supplier and travel toward the buyer in accordance with value-added sectors (initial material being processed, semi-finished products, products, commodities). Additionally, we must consider how to maintain a rapid flow of information, materials, and capital during the movement of materials with added value; how to resolve the conflict between supply and demand in various supply chain sectors; and how to create the most value and profit with the least amount of inputs, costs, and manufacturing time [2]. Adopting the optimum reordering and inventory maintenance strategies by evaluating costs and circumstances is the fundamental goal of inventory planning and control [3]. An activity known as inventory control makes sure that necessary organizational items are delivered to the appropriate operational segment (such as production, distribution, sales, engineering, etc.) with respect to time, place, quantity, quality, and cost. Raw materials, semi-finished goods, spare parts, and final goods are all included in the inventory, and their proper management would result in an effective work flow. Inventories also contribute significantly to increased dependability, solid planning, and resistance to change [4].

Adopting the optimum reordering and inventory maintenance strategies by evaluating costs and circumstances is the fundamental goal of inventory planning and control [5]. An activity known as inventory control makes sure that necessary organizational items are delivered to the appropriate operational segment (such as production, distribution, sales, engineering, etc.) with respect to time, place, quantity, quality, and cost. Raw materials, semi-finished goods, spare parts, and final goods are all included in the inventory, and their proper management would result in an effective work flow [6]. Inventories also contribute significantly to increased dependability, solid planning, and resistance to change [7].

In order to study the internal relationships between the value-added sectors of the supply chain with modeling, this research uses commonly used mathematical techniques along with abstract thinking and rigorous reasoning [8]. This will assist manufacturing organizations quickly adapt to market demands. In the meantime, we can implement timely production, delivery, and JIT manufacturing models to achieve capital fast turnover, maximize the value of the supply chain, reduce overstocking of products, and reduce capital expenditures during manufacturing so that we can quickly obtain demand information of the final consumption market to help the supply chain keep up with the changes in the market [9].

1.1 Statement of the Problem

Almost every firm needs supply chain management, or control over the raw materials to ultimate client domain. Senior executives recognize the strategic importance of supply chain management today. Inventory is heavily capitalized in industrial factories [10]. Controlling the money invested in raw materials, semi-finished goods, and finished items can also provide a significant opportunity for improvement.

Scientific inventory control techniques can give businesses a competitive edge1. In the traditional EOQ paradigm, each parameter is seen as having a fixed value and being deterministic. However, our suggested model also accounts for discounts, potential deterioration costs, and purchase and maintenance costs [11 12 13].

1.2 Focuses of Inventory Network the Executives

The typical goal of supply chain management is to reduce the overall cost associated with fulfilling a given product's requirement. The following things are included in the overall cost:

- Original price and additional purchase costs
- Cost of internal transportation
- Cost of infrastructure investment
- Manufacturing costs, both direct and indirect
- Costs of direct and indirect delivery
- Inventory expense
- Cost of implementing transportation
- Cost of external transportation

We can take into account a certain supply chain link and related costs when developing a model for a particular problem design [14].

Companies aim for the highest net profits possible:

Net Income= Total Income-Total Cost: - Companies can maximize net income by reducing total cost if the requirement is fixed, which also fixes the total money needed to satisfy the requirement [15].

Storage Theory Model: - Economic order quantity is the storage theory model that is the simplest. We can choose an ideal order quantity to reduce the overall inventory cost by balancing the costs of purchasing and storing. This model, which is about managing the storage of a single product, makes the following assumptions:

- ➢ The product's specifications are known, and a deadline has been set [16].

1.3 The Unit Product's Inventory Cost

The inventory cost for each unit product is a crucial element in the economic order quantity model and other inventory models, and it is influenced by the capital cost and other risk variables. is used in Fig. 1. In order to estimate the economic order quantity, we can use the economic order quantity model to calculate the value of q in a way that minimizes both the fixed ordering cost and the inventory cost, as shown in the following formula:

$$q^* = \sqrt{(2kD/h}$$

K is the fixed ordering cost; D denotes the total annual demand [17].

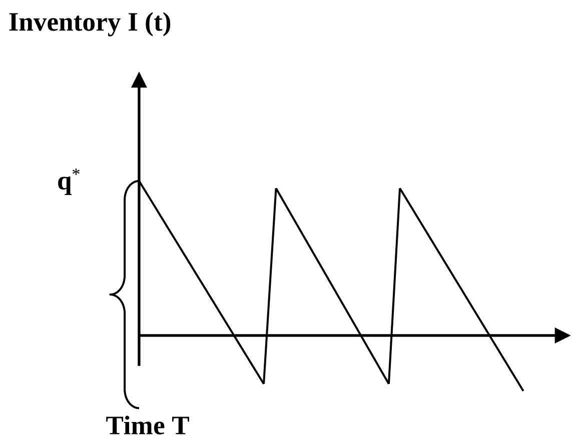

Fig. 1. Model for fixed economic order quantity

1.4 Optimal Assumption of Inventory

Model assumptions state that the probabilistic model that complies with the economic order quantity criteria is the ideal assumption. A small portion of the company's inventory costs are lower than breakage costs [18,19]. Additionally, the probability density of the required production line can satisfy the normal distribution rule, the breakage proportion should strictly be controlled under 2%, and the ideal inventory must be safe inventory that can provide supply and demand history data, as given by the following formula [20]:

$$s = z\sigma_D\sqrt{L}$$

S— Optimal inventory (safe inventory);
z— Safe factor controlling the breakage proportion below a certain level
σD— Standard deviation for the difference between supply and demand based on historical data
L— Lead time length, calculated based on days and 1 day for this company

$$\sqrt{(\mathbf{X1}-\overline{\mathbf{X}})+(\mathbf{X2}-\overline{\mathbf{X}})}+\sqrt{(\mathbf{X1}-\overline{\mathbf{X}})+\frac{(\mathbf{X1}-\overline{\mathbf{X}})}{\mathbf{n}}}$$

In the formula:

X_n= Supply and demand d-value per week for up-downstream unit in the supply chain
$\overline{X}$ = The average supply and demand d-value for a specific time period According to device settings, we can produce 278 pieces per hour at 100% yield and 100% utilization, with a minimum single chip cost of 0.482 dollars per piece. Note: Utilization rate refers to the percentage of effective working hours that make up the overall number of working hours; pcs stands for production capacity and Hr for hour. The cost of a single chip for various manufacturing volumes is available. The data distribution (production quantity-cost) is shown as follows using the EXCEL drawing feature.

Table 1.

Production quantity	785	1176	2086	2244	2301	2022	2602
Cost for single chip	1.12	1.01	1.02	0.78	0.87	0.97	0.65
Production quantity	2864	4423	6010	6033	6866	7242	8787
Cost for single chip	0.67	0.61	0.62	0.57	0.53	0.51	0.50

1.5 Assumptions

The following presumptions form the foundation of the inventory model:

(1) A single kind of products are purchased with an endless planning horizon, and these are capable of expanding prior to slaughter.
(2) Although the shortages are legal, these are wholly backordered.
(3) The products are killed and instantly inspected before being sold to customers.
1. To fill the deficiencies from the previous cycle, the backordering quantity is first examined.
(4) A 100% effective inspection process already exists.
(5) A chance proportion of the killed animals have poor quality.
(6) Items of poor quality are not repaired or replaced.
(7) Following inspection, all goods of subpar quality are rescued and sold as a single lot.
(8) The expense of feeding the items as they grow is directly related to the weight that these gain.
(9) Both the inspection process and the period of consumption incur holding costs for each weight unit of the slaughtered item that is kept in storage.
(10) The demand rate $D(s)$ is a polynomial functions of selling price of the perfect-quality items. It is as follows: $D(s)\ \pi - \rho s^n$.

2 Our Results

2.1 Inventory model development

Consider a situation where a company orders y newborn growing items from an outside supplier at the beginning of the growing period t_1. Each newborn growing item has an initial weight of w_0. In this moment, the total initial weight of the inventory is Q_0 yw_0. The growing items are fed, and eventually, they grow through time until an objective weight of w_1 is attained. Then the growing items are slaughtered at the end of the growing time t_1. At this point, the final weight of the inventory is Q_{t1} yw_1, and this total weight contains a percentage x of imperfect items. The portion of imperfect items is a random variable with a known probability density distribution $f(x)$, and its expected value is $E[x]$. The shortages are permitted, and these are fully backordered. Therefore, immediately, the inspection process starts to screen the items to complete the backordering quantity (B) at a rate of r units of weight per unit of time during the period t_2 in order to satisfy immediate shortages from the previous cycle. So, at the end of the inspection period t_2, the inventory model diminishes vertically by B units of weight. It is important to remark that the items continue to be inspected at the same rate r during the period t_3 till the total weight is screened. The length of the inspection time is $t_2 + t_3$. It is worth mentioning that, for the duration of t_3, the on-hand inventory declines by both removing the imperfect items and current demand rate.

In terms of math, the logistic growth function of the objects is represented by

$$w_t\,(t) = \frac{\alpha}{1+\beta e^{-\lambda t}} \tag{1}$$

As it was mentioned above, the growing items are slaughtered when their weight attains the objective weight of w_1 which occurs at the end of the growth period t_1. Hence,

$$w_1 \; = w_t\,(t = t_1\,) = \frac{\alpha}{1+\beta e^{-\lambda t_1}} \tag{2}$$

The duration of the growth period (t_1) is calculated by solving equation (2) for t_1. Thus,

$$t_1 = \frac{1n[\left(\frac{1}{\beta}\right)\left(\left(\frac{\alpha}{w_1}\right)-1\right)]}{\lambda} \tag{3}$$

In order to prevent selling items of inferior quality as good ones, the inventory must be reviewed before being sold. As a result, first, the backordering amount (B) from the previous cycle must be screened at an inspection rate r. So, the following formula is used to calculate how long the inspection period (t_2) is.

$$t_2 = \frac{B}{r^*} \tag{4}$$

After the inspection of the backordering quantity is conducted, the screening process continues until the total weight is screened due to the fact that there are pending $yw_1 - B$ units of weight to be inspected is performed during the inspection time t_3 which is given as follows:

$$t_3 = = \frac{yw_{1-B}}{r} \tag{5}$$

The things with subpar quality are taken out of storage after inspection time t_3 and sold. Now, only things of perfect quality are present in the inventory, and these are consumed during t_4. This is how the time t4 is calculated:

$$E[t_4] = \frac{yw_1 - B - Dt_3 - E[x]yw_1}{D(s)} \tag{6}$$

The shortages accumulation period (t_5) is obtained with

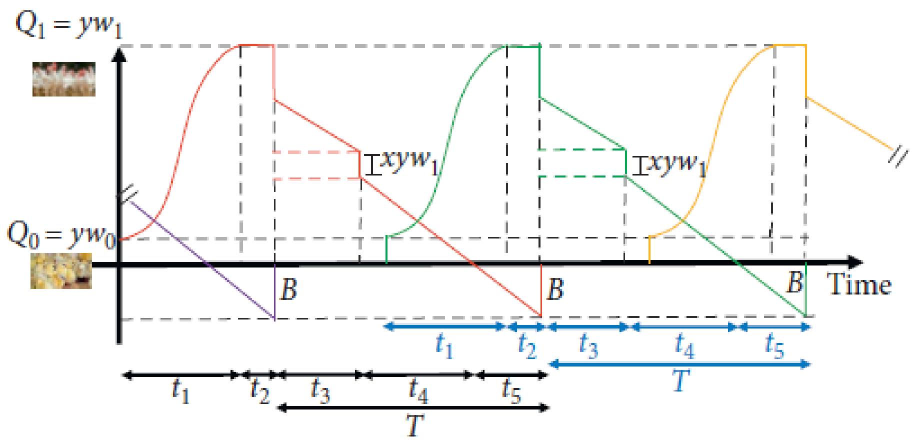

Fig. 2. Inventory movement for increasing goods with poor quality and shortages

$$t_5 = \frac{B}{D(s)} \tag{7}$$

The predicted cycle time T is defined as the sum of t_3, t_4, and t_5, with no loss of generality, in order to have more manageable equations. The estimated cycle time E [T] is computed from equations (5) through (7) as

$$E[T] = t_3 + E[t_4] + t_5 = \frac{yw_1(1-E[x])}{D(s)} \tag{8}$$

Revenue per Period Expected. The estimated total revenue E [TR] is calculated by adding the amount of all sales of imperfect and perfect products because the company sells both perfect- and imperfect-quality goods. At the conclusion of the inspection period t_3, the imperfect-quality goods are sold as a single batch at a lower price of v per unit of weight than the perfect-quality products, which are sold at a price of s per unit of weight. As a result, E [TR] represents the anticipated total revenue for each quarter.

$$E[TR] = syw_1(1 - E[x]) + vyw_1E[x] \tag{9}$$

❖ ***Total Cost (Periodically)***

$$E[TC] = Pc + Sc + Fc + E[Hc] + Zc + Bc + E[Ec] \tag{10}$$

This inventory model's goal is to maximize expected total profit, which is calculated by deducting anticipated total cost per period, or E [TC], from anticipated total revenue, or E [TR], each period. Then,

$$E[TP] = E[TR] - Pc - Sc - fC - E[Hc] - Zc - Bc - E[Ec] \tag{11}$$

Purchasing Cost (Periodically)

$$Pc = pyw_0 \tag{12}$$

❖ ***Setup Cost (Periodically)***

$$Sc = K \tag{13}$$

❖ ***Feeding Cost (Periodically)***

$$Fc = cy\int_0^{t1} wt_1\ (t)dt = cy\int_0^{t1} (\frac{\alpha}{1+\beta e^{-\lambda t}})dt = cy\ (\alpha t_1 + \frac{\alpha}{\lambda}\left[\ln\left(1+\beta e^{-\lambda t_1}\right) - \ln(1+\ \beta)\ \right] \quad (14)$$

❖ ***Expected Holding Cost (Periodically)***

The inventory carried out during $t_2 + t_3 + t_4$. The whole inventory held is calculated as the sum of the areas $A_1 + A_2 + A_3 + A_4 + A_5$ .so the expected holding cost is given by

$$E[Hc] = h[\frac{Y^2 w_1^2 E[(1-x)^2}{2D(s)} - \frac{yw_1(1-E[x])B}{D(s)} + \frac{B^2}{2D(s)} + \frac{y^2 w_1^2 E[x]}{r} - \frac{yw_1 E]x]B}{r} + \frac{yw_1 B}{r}] \quad (15)$$

Inspection Cost (Periodically)

$$Zc = zyw_1 \quad (16)$$

❖ ***Shortage Cost (Periodically)***

$$Bc = \frac{bB^2}{2D(s)} \quad (17)$$

❖ ***Holding Inventory's Operations***

$$E\left[\widehat{H}c\right] = \ \hat{h}\ \left[\frac{y^2 w_1^2 E\left[1-x)^2\right]}{2D(s)} - \frac{yw_1(1-E\ [x])B}{D(s)} + \frac{B^2}{2D(s)} + \frac{y^2 w_1^2 E[x]}{r} - \frac{yw_1 E[x]B}{r} + \frac{yw_{1B}}{r}\right] \quad (18)$$

This paper adopts mathematical modeling to fully research and collect data from the production site, which also makes use of the probabilistic model of EOQ to know the safe inventory that meets 98% of production lines; additionally, it uses curve-fitting and infinitesimal calculus to establish the production quantity. In order to successfully apply the optimal quantity of the model into real manufacturing and ultimately increase production capacity, yield rate, while simultaneously improving production efficiency and lowering costs. Almost every firm needs supply chain management, or control over the raw materials to ultimate client domain. Senior executives recognize the strategic importance of supply chain management today. Inventory is heavily capitalized in industrial factories. Controlling the money invested in raw materials, semi-finished goods, and finished items can also provide a significant opportunity for improvement.

Inventory management is a valued function for all firms. The main purpose of the inventory management department is to control the materials from the acquisition to sale, taking decisions of how much and when to buy the items avoiding excess or unplanned stock out.

3 Conclusion

Creates a model for an inventory some theoretical conclusions are drawn in order to maximize the anticipated total profit per unit of time, and using these conclusions, a practical and efficient solution method is created. It is crucial to note that the algorithm generates the best possible answers for order quantity, backordering quantity, setup cost, and demand elasticity, all of which have a direct impact on the company's ability to maintain its selling prices and, consequently, on the overall profit. Additionally, because a number of previously published inventory models are special cases, the suggested inventory model is a generalized inventory model. The approach that enables shortages with full backordering was determined to be more cost-effective than the one that prevents. Analyzes the inventory and production quantity in the supply chain to identify and address two fundamental issues during implementation.

Competing Interests

Authors have declared that no competing interests exist.

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