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A Comprehensive Critical Analysis of the Economic Order Quantity Model in Inventory Management

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ABSTRACT
This paper examines the pivotal role of inventory procurement in manufacturing and related ventures, emphasizing efficient control mechanisms. It focuses on the widely used Economic Order Quantity (EOQ) model, evaluating the consequences of deviating from optimal order quantities. The study extends to materials management, highlighting how effective inventory control reduces expenses related to employee and machinery idle time, emphasizing the urgency of material requirements. Recognizing the substantial impact of material costs on product expenses, the paper underscores the need for a well-designed inventory management system. Through detailed case study analysis, the research explores EOQ implementation nuances and its influence on total inventory costs, offering insights for refining strategies and enhancing operational efficiency.

1. Introduction

Inventory management is a pivotal aspect of operations for businesses, influencing both cost structures and service levels. Among the various models employed to optimize inventory control, the Economic Order Quantity (EOQ) model stands out as a widely used and foundational tool. The EOQ model aims to find the ideal order quantity that minimizes total inventory costs by balancing holding costs and ordering costs. This paper embarks on a critical analysis of the EOQ model, exploring its theoretical underpinnings, historical evolution, and practical applications [1-5]. Through a nuanced examination, the study aims to unravel the strengths and limitations of the EOQ model, providing insights into its effectiveness in contemporary inventory management scenarios.

The Economic Order Quantity (EOQ), also referred to as Economic Purchase Quantity (EPQ), is the most efficient order quantity that reduces both holding costs and ordering costs in the realm of inventory management.[i] As one of the earliest classical production scheduling models[ii], it was conceptualized by Ford W. Harris in 1913, with credit also attributed to R. H. Wilson and K. Andler for their extensive analysis and application [6-10].

Effective inventory management is paramount, overseeing the planning and control of inventory from raw material acquisition to the storage of completed items. The fundamental challenges in inventory management boil down to determining the optimal order quantity and the timing of placing orders[11-14]. Focusing on key contributors to inventory costs, namely Purchase Cost, Ordering Cost, Carrying Cost (or Holding Cost), and Stockout Cost, this discussion centers on the critical considerations in managing inventory expenses.

Purchase Cost: This constitutes the primary cost incurred by the buyer for acquiring inventory from the supplier. Once an appropriate selection is made, the business organization proceeds to place orders for the right quantity and quality, ensuring timely delivery to the designated location. The total cost of inventory encompasses expenses related to bringing the inventories to their current location and a ready-to-use state, incorporating handling, insurance, freight-in, and other costs directly associated with inventory in usable condition.

Ordering Cost: Commencing from order processing and extending through order placement to the receipt of inventory into the stores, ordering costs encompass activities such as preparing purchase requisitions, managing purchase orders, handling invoice procedures, and covering transportation costs, including associated taxes. These costs are integral to determining the economic order quantity for an inventory item.

Carrying Cost: The proper storage of inventory necessitates the allocation of funds to ensure safety and security. Some inventories require special conditions, including specific temperatures, in order to prevent damage, resulting in substantial carrying costs. Examples [iii]of carrying costs involve inventory insurance, warehouse storage fees, inventory taxes, and potential opportunity costs in the form of non-interest deposits.

Stockout Cost: Representing income lost that could have been earned if the right quantity of material was available at the right time, stockout costs arise when circumstances prevent the fulfilment of customer demand[iv]. In situations where a buyer approaches a seller to purchase products, and the seller fails to meet the demand due to inventory shortages, income is forfeited as a result of the missed opportunity to fulfill the buyer's needs.

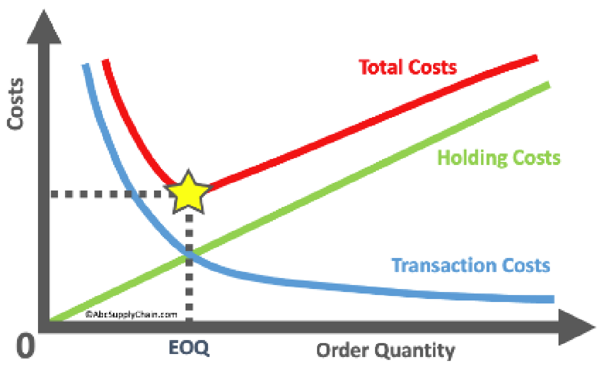

Fig 1. Order Quality

Total Cost: This is the Aggregate of Purchase Cost, Ordering Cost, Carrying Cost and Stockout Cost. As Shown in Figure 1.

2. Assumptions of Eoq Model

The EOQ Model relies on several key assumptions[v] that form the basis for its application in inventory management. Firstly, it assumes that the annual consumption of inventory remains constant, characterized by a known and unchanging demand rate. This assumption allows the model to operate under the premise of a stable and predictable usage pattern, simplifying the calculation of the optimal order quantity.

Secondly, the EOQ Model assumes that ordering costs remain constant. This implies that the expenses associated with the procurement process, from initiating orders to receiving and managing inventory, do not fluctuate. The assumption of constant ordering costs facilitates a straightforward analysis of the trade-off between ordering and holding costs, a fundamental aspect of EOQ calculations. Furthermore, the model presupposes that the unit price of inventory remains constant over time. This assumption implies a static cost per unit of inventory, contributing to the model's simplicity by excluding considerations related to price fluctuations or discounts, which could complicate the determination of the economic order quantity.

Additionally, the EOQ Model assumes a constant lead time, meaning the time interval between placing an order and receiving the inventory remains consistent. This assumption allows for a streamlined analysis, as variations in lead time can introduce complexities in managing inventory levels and affect the model's accuracy. Lastly, the absence of a safety stock level is assumed in the EOQ Model. This implies that there is no buffer stock held to account for uncertainties in demand or supply disruptions. While this assumption simplifies the model, it is essential to recognize that in real-world scenarios, uncertainties may necessitate the consideration of safety stock to ensure adequate inventory levels during unexpected fluctuations in demand or supply chain disruptions.

3. The Advantages of Eoq Model

The Economic Order Quantity (EOQ) model plays a multifaceted role in efficient inventory management.[vi] Firstly, it excels in minimizing holding or carrying costs by identifying the optimal order quantity that strikes a balance between holdings and ordering costs, ensuring that the carrying costs associated with excess inventory are kept to a minimum. In addition to this, the EOQ model serves as a valuable decision-making tool for management, aiding in the determination of the most appropriate order quantity size for a given time. This strategic aspect of the model contributes to streamlining inventory processes and maintaining an optimal balance between supply and demand, thereby enhancing overall operational efficiency.

Furthermore, the EOQ model functions as a robust mechanism for controlling ordering costs. By recommending the procurement of optimum quantities in a single order, the model helps prevent shortages of materials at specific points in time, thereby minimizing the potential costs and disruptions associated with frequent and unplanned order placements. Another critical aspect of the EOQ model lies in its ability to significantly reduce opportunity costs. By avoiding excessive investments in idle inventory, the model not only safeguards funds that would otherwise be tied up in surplus stock but also mitigates the opportunity cost associated with allocating resources to non-income-generating assets. Ultimately, the EOQ model is valued for its simplicity, offering a straightforward approach to calculations and estimations. Its user-friendly nature enhances its applicability across diverse industries and contexts, making it an accessible and effective tool for organizations seeking to optimize their inventory management processes with precision and ease.

4. The Disadvantages of Eoq Model

The EOQ model's assumption of constant annual consumption introduces complexities when confronted with practical scenarios characterized by seasonal fluctuations, where demand patterns are inherently variable [vii]. This limitation underscores the challenge of aligning the model with the dynamic nature of real-world demand, necessitating a more adaptive approach in the face of fluctuating consumption patterns. Moreover, the model's vulnerability to external factors can impede its efficacy in real-world applications. Instances of inventory unavailability, extended lead times, transportation disruptions, and worker strikes represent external variables that the EOQ model does not explicitly accommodate, rendering it susceptible to operational challenges when faced with unpredictable events. Incorporating mechanisms to address these external factors would enhance the model's resilience and applicability in a broader range of circumstances.

Forecasting annual demand, a fundamental component of the EOQ model, is acknowledged as a complex task. In dynamic business environments, accurately predicting future demand becomes inherently challenging, introducing an element of uncertainty that may compromise the model's effectiveness in pre-emptively optimizing inventory levels. Furthermore, the EOQ model's assumptions, such as the absence of safety stock, constant lead time, and constant unit price of inventory, are not always reflective of practical realities. Safety stock acts as a buffer against uncertainties in demand and supply, and variations in lead time and unit

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prices are common occurrences in supply chain dynamics. Recognizing these deviations from assumptions is crucial for organizations seeking to implement the EOQ model in a manner that aligns with the nuances and challenges of real-world inventory management.

As mentioned earlier, the primary concerns in material control revolve around determining the quantity to be ordered at a specific time and deciding when to initiate an order. When determining the most cost-effective order quantity, the emphasis is on identifying the optimal order size, taking into account factors like material carrying costs.

The Economic Order Quantity (EOQ) represents the optimal quantity for ordering, where the sum of holding costs and purchasing costs is minimized. This quantity is calculated using a specific formula, taking into account various costs associated with inventory management. The evaluation encompasses holding costs, which include interest on capital invested in stores, material carrying charges, rent of space for storage, salaries, and earnings of the store-keeping department, losses due to pilferage and deterioration, store insurance fees, stationery, supplies, and taxes on goods inventory. Ordering costs, associated with placing purchase orders, are also considered and involve expenses such as rent for the space of purchase department, salaries and wages of officers and staff, depreciation on department equipment and furniture, postage, telegraph charges, telephone bills, stationery, consumables, travel expenses, inspection costs, and other related expenses.

It is important to note that finance costs viii related to material acquisition, such as interest on borrowed funds, are excluded from the material cost. Charges like letter of credit charges, which pertain to credit or transaction risks, are part of bank charges and contribute to administrative overheads. In cases where goods are stored in bonded warehouses and clearance is delayed due to financial constraints affecting payment to the bank, these storage-related payments are excluded from the calculation of material costs and are instead accounted for in the financial accounts.

Material costsix may encompass imputed costs that are not accounted for in financial records. In economic terms, the term 'imputed' refers to an assigned or estimated value when there is no definitive monetary criterion for a particular purpose. In the estimation of national income, for instance, the wages of housewives are imputed. Similarly, in agricultural activities, the wages or salaries of the owner are imputed. Imputed costs bear a resemblance to opportunity costs, representing the foregone alternatives. An instance of an imputed cost in project evaluation is the interest on internally generated funds that, although not actually paid, is considered for assessment.

In the calculation of the economic ordering quantity, it is crucial to prioritize minimizing the incurred costs. Consequently, the optimal order size is identified as the quantity at which costs are minimized, specifically at the intersection point where the costs of holding stock and ordering converge.

5. Case Study on Applied Research

Let's take an Example, which will make clear the concept of EOQ Model and at the same time also prove the effect of Placing order more than EOQ Units and Less Than EOQ Unit with one order size in Total Cost of Inventory.

Case Study

A Company Produces One Product on which, Component A is Requires as a raw material. The Following Particulars are collected for the year 2022.

Annual Demand of Component A: 8,000 Units.

Cost of Placing Order: Rs. 200 Per Order.

Cost Per Unit of Component A: Rs. 400

Carrying Cost Per Annum: 20%

A New Supplier Approached to the Company and willing to offer Quantity Discount of 4% on the Purchase of Component a Provided the order size is 4,000 Unit at a time.

Solution:

Present EOQ= 200 Units.

2 * 8000 Units * 200 Per Order Divided by Rs. 400 * 20%

	Present EOQ Level (200 Units)	New EOQ Level (4000 Units)
Cost of Purchase -	Rs. 32,00,000	Rs. 30,72,000
	8000 Units * Rs. 400 Per Unit	8000 Units * Rs. 384 Per Unit
Ordering Cost –	Rs. 8,000	Rs. 400
	8000 Units / 200 EOQ Units * 200 Per Order	8000 Units / 4000 EOQ Units * 200 Per Order
Carrying Cost	Rs. 8000	Rs. 153,600
	½*200 Units * Rs. 80 Per Unit	½*4000 Units * Rs. 76.8 Per Unit
TOTAL COST	Rs. 32, 16,000	Rs. 32, 26,000

Research Results and Case Study Output Theory.

In the above scenario, it is evident that increasing the Economic Order Quantity (EOQ) units in one order size from 200 units to 400 units would lead to the company placing orders only twice a year, consequently reducing the annual ordering cost from Rs. 8000 to just Rs. 400. However, this comes at the expense of a substantial increase in carrying costs, soaring from Rs. 8000 to Rs. 153,600, as the company orders more than required at a given point. Additionally, despite availing a quantity discount of 4% on the price paid, the total cost experiences an increase of Rs. 10,000 (Rs. 32,26,000 - Rs. 32,16,000).

Considering these effects, it becomes apparent that while quantity discounts lower the price of Component A and minimize the cost of orders, they simultaneously lead to a

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significant rise in carrying costs, resulting in an overall cost increase for the company if quantity discounts are pursued.

6. Conclusions

In conclusion, it is evident that placing orders exceeding the Economic Order Quantity (EOQ) results in the storage of excess inventory, elevating the cost of carrying or holding inventory, while placing orders below the EOQ necessitates frequent orders, thereby increasing the ordering cost. In order to reduce both ordering costs and inventory holding costs, the company should contemplate placing the Economic Order Quantity (EOQ) at the appropriate moment. However, the company may explore quantity discounts from the supplier if ordering the supplier's desired quantities at once. In such cases, a comprehensive evaluation of the total inventory cost (Purchase Cost + Ordering Cost + Carrying Cost) is essential for making informed decisions.

In summary, this paper reaffirms that the EOQ model proves effective in inventory management and control, ensuring minimal funds are invested in inventory at any given time and mitigating the risks of stockouts or excessive stock handling. Successful implementation of the EOQ model relies on effective forecasting of annual usage demand, maintaining strong relationships with suppliers and transporters to manage lead time, considering seasonal factors affecting prices, and ensuring inventory quality. By formulating and implementing the EOQ model, organizations can enhance operational efficiency, capitalize on opportunities, improve cash flow cycles, and achieve the overarching objectives of cost control and reduction.

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