Inventory Management of a Pharmaceutical Company using EOQ Model

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Abstract: *This study aims to reduce the inventory cost of a pharmaceutical company by implementing the EOQ (Economic Order Quantity) model. Collection of data on four different products showed that the company named "Healthcare Pharmaceuticals Limited" was suffering from an extra inventory cost because of not having any standardized ordering procedure thereby resulting in a higher cost of carrying excess inventory or having a shortage of inventory to fulfill the demand. Through the implementation of the EOQ model on this data, we were successful to lower the inventory cost to as much as 76% for some products which is very satisfactory. The EOQ model can minimize the sum of the annual order costs and the annual holding costs. The annual holding costs equal the annual order costs at this level. EOQ model can minimize the total cost of holding and ordering inventory. Economic order quantity (EOQ) is a calculation method that companies perform in order to represent their ideal order size, which allows the Inventory managers to calculate EOQ with a view to minimizing holding costs and excess inventory. So, the model can be found cost effective by the company to meet the customer need according to the demand and at the same time keeping the inventory cost inexpensive. Overall, calculating EOQ can help a company to make better decision when it comes to storing and managing inventory as it improves overall efficiency. Many inventory managers use their gut feelings when it comes to calculate the amount of order instead of calculating how much order is actually needed. Calculating using the EOQ model is a smart way to sum up how much order you actually need to make. Ambiguity in some parts of the result may result from the misrepresentation of the historical data by the company or from the limitations inherited in the model itself.*

Keywords: *Inventory, EOQ model, ROQ mode, Stock- out Cost*

1. Introduction

In today's business world where customers need vary consistently and randomly, the management of inventory can play a significant role on business growth. The main concern of a company is always to manage the inventory such a way that the cost is reduced thereby increasing the profit. Hence, inventory cost reduction is one of the major branches of inventory management. Whereas an efficient inventory cost management can lead to the extension and sustenance of a business empire, a poor and ineffective knowledge of ordering policy may result in a demolition of the company making the inventory cost reduction a crucial turning point of any organization. The inventory cost is the accumulation of purchase cost, ordering cost, inventory carrying cost and shortage costs [1]. Often the inventory managers find themselves in a dilemma of deciding the correct size of the order. If the order quantity is too small, it will be required by the company to order multiple times eventually leading to an increase of the ordering cost, though the carrying cost is low. Additionally, the company can suffer from stock outs, market loss etc. for not having the goods in the time of demand. On the other hand, ordering big quantity can be life-saving from those problems but the carrying cost will be increased significantly as more storage space, store staff will be required. Besides, storing the items for a longer time can degrade their quality. Thus, a proper balance between carrying costs and ordering cost is very necessary. This leads to the development of an effective inventory model that will decide a lot size with minimum total inventory cost.

A lot of models have been suggested to minimize the inventory cost such as lot by lot size, least unit cost, least total cost [2], economic order quantity [3], periodic order quantity, least period cost, Wagner-Whitin algorithm etc. [4]. Among them economic order quantity (EOQ) is one of the oldest and simplest models that intends to find the ideal order quantity a company assuming that demand, holding and ordering costs all remain constant. By doing so, this production-scheduling model can find the optimum total inventory cost over given period of time. The basic model for the EOQ was first proposed by Ford W. Harris in 1913 and gradually improved over time. Knowledge of economic order quantity is of vital importance as it can lead to a proper inventory cost management. If this is not taken into consideration, the company will be burdened with accumulating high amount of goods in times of low demand or depleting the warehouse when the demand is very high. Either of these can be fatal for economic growth of the company. The goal of EOQ model is not only to identify optimal number of units that need to be ordered but also to determine a company's reorder point. A reorder point is a situation when the inventory falls below a certain predefined level, and a company

should purchase an inventory again so that it can avoid the emptying of the warehouse in time of high demand.

2. Background

A lot of companies in our country do not have any standard ordering procedure. These companies do not know when to make stock ordering decisions. To make the situation worse, they keep the staffs who are inexperienced and do not have the slightest idea of using mathematical models that could be much more economical and time saving. Decisions are made merely relying on the intuitive feeling without any rationale. Eventually, the company has to encounter a colossal amount of inventory cost which may have detrimental effect on business growth. The same thing was happening with the "Healthcare Pharmaceuticals Limited", a company which has been manufacturing branded generic products for local and overseas market in Asia, Africa, and CIS region. Recently, they manufactured four pharmaceutical products where they handle the items randomly and sustained a high inventory cost. The company was failing to balance between the number of orders to be made and the market demand. Due to this issue, the company overspent a lot of money which were causing serious issues within the company. So, a solution was needed to improve the situation.

3. Literature Review

Inventory Management

The literature review was carried out in a top to bottom approach. Firstly, we talked about the inventory management which is comprised of all the important aspects related with inventory. Secondly, the inventory cost was discussed as a vital tool which fall under the inventory management. Lastly, we connected the inventory cost and its optimization with the EOQ model.

According to Tony Wild [5], the objectives of the inventory management is to optimize three things namely, customer services, inventory costs, and operating costs. He also added, optimization should not be done to one of these at the expense of others. Others [6] explained that the two major concerns of the inventory control are to provide the product at the right time and right place and to ensure a proper lead time. For some of the researchers [7], determining and controlling the stock level are also pivotal to the good inventory management. The key factors associated with them are customer need, product availability and maintenance cost. As a result, inventory management is the set of policies and procedures that define what level of stock should be maintained, when it should be supplied, and how large the order should be [8]. All these things will lead to the optimal inventory cost.

Inventory Costs

The inventory costs basically fall into three categories as follows:

Ordering Cost: This cost comprises of all the costs related to the ordering of the product. It includes the salaries of those ordering the product, cost of expediting the inventory, administrative cost, progress chasing, inspection cost etc. [9,10].

Holding Cost: Holding cost encompasses those costs related to the keeping or carrying the products for a specific period of time. Inventory storage costs such as rent, costs associated to the handling of goods, warehouse and stock-keeping staff, stock losses/ wastage, taxes etc. all are included in the holding cost [9].

Shortage Cost or Stock-out Cost: When there is not sufficient stock to meet customer demand shortage cost occurs which creates the customer dissatisfaction and contributes to lost margin on sales [10].

The EOQ model

As the EOQ model tells us about the optimal quantity to order, when it should be ordered, total cost, average inventory level, how much should be ordered each time and the maximum inventory level [9]. The researched pharmaceutical company appreciated the EOQ model so that it can sustain the optimal amount of the required item only which in return will enable them to invest as little as possible to the inventory. Moreover, the model worked well as a sales forecasting technique which can be used not only in various industrial engineering businesses but also in both operational and financial companies [11]. Besides, the EOQ model can identify certain applications in inventory while calculating the cost tradeoffs. In addition, it can simulate such inventories which avoid the cost of changeable product rates [12]. So, taking all the advantages into consideration, we applied the EOQ model for calculating the inventory costs by determining the optimum inventory level per year.

To use the EOQ model we need to understand several terms like annual requirements, distribution cost per month, holding cost per unit. Annual requirements are the number of units that are required or demanded annually by the customers. It is usually estimated from the historical data that are kept in the logbook of the company. The company incurs expenses when it delivers the products from the inventory to the location of the end customer. Distribution cost is the sum total of all those expenses that the company undertake to

ensure the delivery. So, the distribution cost per month is a monthly estimate of the total distribution cost. Finally, the holding cost per unit is calculated by dividing the total holding cost of a year by its annual requirements. Once we know these three quantities the value of the EOQ is measured using the follow formula-

$$EOQ = \frac{\sqrt{2 \times distributionCostPerMonth \times AnnualRequirement}}{HoldingCostPerUnit}$$

After knowing the value of EOQ, new annual holding cost can be found which will provide the difference between the previous inventory cost and the new cost. Eventually, we can have an idea about the optimal quantity of orders that should be purchased by the company.

EOQ Challenges

As discussed earlier, the EOQ is a very old model which is modified over time according to the business requirements. So, the basic model is based on some assumptions that should be taken into account while dealing with the calculation of EOQ. The assumptions can be listed as the following [9]-

- The demand rate is constant (no variations), recurring, and known.
- The carrying cost and ordering cost are independent of the quantity ordered (no discounts).
- The lead time is constant and known. Therefore, the ordering times given result in new orders arriving exactly when the inventory level reaches zero.
- The formula can handle only one type of item at a time.
- Orders arrive in a single batch (no vendor stockouts or backorders).

Although, the EOQ model is still useable by ignoring one or more of the above requirements, it is strongly suggested to keep them in mind for getting an accurate picture of the EOQ value.

The ROQ model

Reorder quantity is the total number of product units you request from a manufacturer or supplier on an inventory replenishment purchase order. The exact amount should not be so high that you have too much capital tied up in inventory and subsequent warehousing costs, but not so low that there's not enough safety stock and you risk selling out before you can get the next batch of inventory. Reorder quantity ensures that you order enough to last until your next order.

The reorder quantity calculation is done by using a formula that multiplies average daily units sold by the average lead time:

Reorder Quantity = Avg. Daily Units Sold x Avg. Lead Time

Average Daily Usage: How many units of your product are sold per day.

Average Lead Time: How long it takes from when a purchase order is placed with a supplier to when you receive the inventory. ALT is measured in days.

If you reordered inventory on June 1, and that new inventory is ready to be used to full-fill customer orders on June 30, then your ALT is 29 days.

4. Material and Methods

The goal of this research was to apply EOQ formula to minimize the inventory cost of the "Healthcare Pharmaceuticals Limited" as the goal of the EOQ formula is to identify the optimal number of product units to order. If achieved, a company can minimize its costs for buying, delivering, and storing units. An Economic order quantity can easily help in deciding what would be the best optimal order quantity at the company's lowest price. It is possible to reduce the inventory cost by knowing two things. One being the optimal order quantity and the other is of knowing the dates when to reload the orders. Therefore, this research sought to find out a convenient inventory level which in turn will minimize the inventory cost. Ultimately, a mathematical modeling of the ordering process was necessary for the company which would work on the historical data and will provide a straightforward optimal quantity to reduce inventory cost.

We have got our initial data (Table 1) from "Healthcare Pharmaceuticals Limited". We have worked with 4 medicinal products. Here in Table-1, we have got Annual Requirement of each box of a product per year. We also have Distribution Cost & Holding Cost for the products.

Table1

Products	Annual Requirement (AR)	Distribution Cost	Holding Cost	Total Annual Cost
Esomeprazole	21500	15000.00	2100000.00	2115000.00
Azithromycin	19050	8000.00	1700000.00	1708000.00
Tiemonium Methylsulphate	8600	3000.00	1300000.00	1303000.00
Cefixime	4200	3500.00	1500000.00	1503500.00

Here, Total Cost = Distribution Cost + Holding Cost

Let,

Annual Requirement = AR

Distribution Cost per month = DC

Holding Cost per unit = HC

Economic Order Quantity = EOQ

We Know,

$$DC = \frac{DistributionCost}{12}$$

$$HC = \frac{HoldingCost}{AnnualRequirement}$$

$$EOQ = \sqrt{\frac{2 \times DC \times AR}{HC}}$$

Therefore,

$$\text{EOQ of Esomeprazole} = \sqrt{\frac{2 \times 1250 \times 21500}{97.67}} = 741.82$$

$$\text{EOQ of Azithromycin} = \sqrt{\frac{2 \times 666.67 \times 19050}{89.24}} = 533.51$$

EOQ of Tiemonium Methylsulphate

$$= \sqrt{\frac{2 \times 250 \times 8600}{151.16}} = 168.66$$

$$\text{EOQ of Denver} = \sqrt{\frac{2 \times 291.67 \times 4200}{357.14}} = 82.83$$

Table2

Products	Annual Requirement (AR)	Distribution Cost/month (DC)	Holding Cost/unit (HC)	EOQ
Esomeprazole	21500	1250.00	97.67	741.82
Azithromycin	19050	666.67	89.24	533.51
Tiemonium Methylsulphate	8600	250.00	151.16	168.66
Cefixime	4200	291.67	357.14	82.83

Now, Annual Holding Cost Using $EOQ = EOQ \times HC \times 12$

Table3

Products	EOQ	Distribution Cost/unit(DC)	Actual Annual Holding Cost	Annual Holding Cost Using EOQ	Savings (%)
Esomeprazole	741.82	97.67	2100000.00	869482.60	58.60
Azithromycin	533.51	89.24	1700000.00	571314.27	66.39
Tiemonium Methylsulphate	168.66	151.16	1300000.00	305941.17	76.47
Cefixime	82.83	357.14	1500000.00	354964.79	76.34

Now for Table 4, let,

Actual Distribution Cost = ADC

Annual Distribution Cost Using EOQ = ADQ

Therefore,

$$ADC = \frac{AR \times DC}{EOQ}$$

And,

Annual Inventory Cost Using EOQ = ADC + ADQ

Actual Annual Inventory Cost = Total Annual Cost [Table 1]

Difference of Inventory Cost = Actual Inventory Cost – Annual Inventory Cost Using EOQ

$$Difference = \frac{Difference\ of\ Inventory\ Cost}{Actual\ Annual\ Inventory\ Cost} \times 100$$

Table4

Products	Actual Annual Inventory Cost	Annual Inventory Cost Using EOQ	Difference of Inventory Cost	Difference (%)
Esomeprazole	2115000.00	905711.05	1209288.95	57.18
Azithromycin	1708000.00	595119.04	1112880.96	65.16
Tiemonium Methylsulphate	1303000.00	318688.72	984311.28	75.54
Cefixime	1503500.00	369754.99	1133745.01	75.41

ROQ Calculation

Now for ROQ calculation from our initial data:-

Average daily usage (ADU) of,

Esomeprazole: 21500=> 21500/365=> 58.90

Azithromycin : 19050=>19050/365=> 52.19

Tiemonium Methylsulphate : 8600=> 8600/365=> 23.56

Cefixime: 4200=> 4200/365=>11.50

We know that,

Reorder Quantity = ADU × ALT

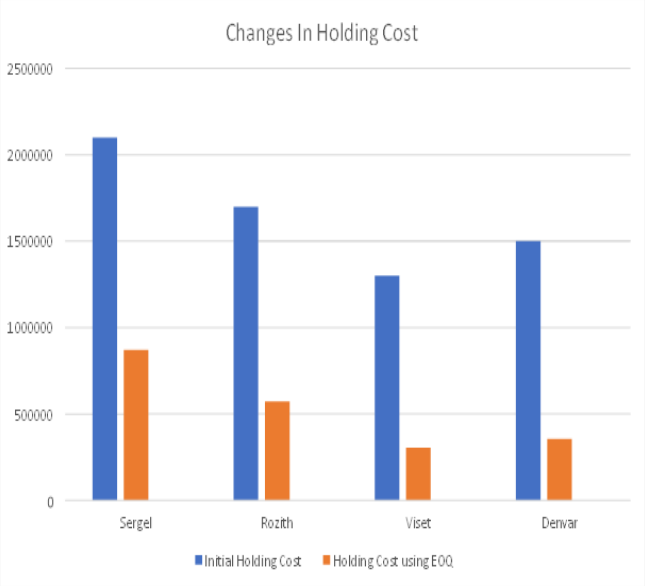
Now,

Esomeprazole = 58.90× 29 = 1708.1

Azithromycin = 52.19× 29 = 1513.51

Tiemonium Methylsulphate = 23.56× 29 = 683.24

Cefixime = 11.50× 29 = 333.5



Here, it is visible that holding cost is reduced greatly using EOQ model from the initial data set.

5. Results

Before implementing EOQ, we can see in the initial data from "Healthcare Pharmaceuticals Limited" is that the actual holding costs was very high as they did not take into consideration of any mathematical model to make the inventory cost economical. The implementation of the EOQ on the data at hand was found to be cost effective and highly satisfactory. Firstly, we successfully found distribution cost/month and holding cost/unit of each product which is shown in table 2. Then we found the annual holding cost using EOQ of each product which is shown in table 3. After implementing EOQ model, the annual holding cost becomes much less than the actual annual holding cost, which is actually a drastic change of the holding costs of the products.

After EOQ implementation, we can see result from (Table-3)

- ✓ Esomeprazole makes 58.60% savings
- ✓ Azithromycin makes 66.39% savings
- ✓ Tiemonium Methylsulphate makes 76.47% savings
- ✓ Cefixime makes 76.34% savings.

From Table-4, its visible that,

Esomeprazole has difference of inventory costs of 1209288.95.

Azithromycin has difference of inventory costs of 984311.28.

Tiemonium Methylsulphate has difference of inventory costs of 1112880.96

Cefixime has difference of inventory costs of 1133745.01

6. Discussion

By calculating ROQ, we can easily have the sufficient amount of products that we need to order so that we don't run out of products before the next order, which means we can easily have the required number of products that we need rather than using our own assumptions. It saves holding costs.

On the other hand, Economic order quantity is a great way to grasp how much product needs to be purchased to maintain an efficient ecommerce supply chain as well as keeping costs down too. Having extra items in inventory can quickly increase storage costs. Inventory costs can also go up depending on how you order, what gets damaged, and what products never sell. If you're constantly re-ordering products that have low velocity, EOQ can help determine how much to order in a certain time period.

EOQ can help you better understand how much you need to re-order and how often. By calculating how much you need based on how much you sell in a given period of time, you can avoid stockouts without having too much inventory on hand for too long. You may be surprised that ordering in smaller quantities may be more cost-effective for your business or it could be the opposite- calculating EOQ can help determine this. Overall, calculating EOQ can help you make a better decision when it comes to storing and managing inventory.

Without proper inventory management, you're at risk of running out of money and having too much inventory (that could potentially expire or become obsolete before you sell it), or running out of stock and losing customers. Having the right amount of product is a balancing act & EOQ is more effective in inventory management than ROQ

7. Conclusions

This research was not only able to fulfill the goal it was destined for but also helped us to understand the importance of EOQ (Economic Order Quantity) model. EOQ plays an important role helping organizations to use proper cost for demand of their products instead of overspending against products demand as Economic Order Quantity (EOQ) model is useful to minimize inventory cost. As a result, it found extensive functionality in numerous aspects in business management. As the research suggests, the Healthcare Pharmaceuticals Limited" should adapt EOQ to strengthen their business strategy by reducing the inventory cost as a first step. Finally, the research can

be continued by implementing other models as well on the available data which will enable us to see the difference between the results and decide the most cost-effective approach.

References

[1] Hira D.S., Gupta P.K., 2009, Operations Research, S. Chand & Company Ltd., New Delhi, India.

[2] Chase R.B., Aquilano N.J., Jacobs F.R.., 2002. Operations Management for Competitive Advantage, Tata McGraw Hill, New Delhi, India.

[3] Sharma J.K., 2009, Operations Research theory & Applications, MacMillan Publications, New Delhi, India.

[4] Evans, J. R. (1985). An efficient implementation of the Wagner-Whitin algorithm for dynamic lot-sizing. *Journal of Operations Management*, *5*(2), 229-235.

[5] Wild, T. (2017). *Best practice in inventory management*. Routledge.

[6] Reid, R., & Sanders, N. (2007). *Operations Management*: Education 2nd edition. Stevenson, W., & Chuong, S. (2014). *Operation Management*. McGraw-Hill.

[7] Ho, C.J. (1989). Evaluating the impact of operating environments on MRP system nervousness. *The International Journal of Production Research*, *27*(7), 1115-1135. Muller, M. (2019). *Essentials of inventory management*. HarperCollins Leadership.

[8] Piasecki, D. (2001). Optimizing economic order quantity. *International Journal of Logistics Management, 11*(5), 484-503.

[9] Roach, B. (2005). Origin of the economic order quantity formula; transcription or transformation? *Management Decision*