INVENTORY ANALYSIS OF A MANUFACTURING INDUSTRY THROUGH EOQ MODEL: A CASE STUDY

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Abstract

The computation of inventory turnover ratios to optimize the inventory costs by using basic Economic order Quantity (EOQ) model has been presented in this paper. Various inventory related costs have also been computed for ten items of a manufacturing industry. The turnover ratios of these items have been computed for the last four years. The comparison of total variable costs for managing the inventory by using the EOQ has been done with the total cost without EOQ model. The results reveal that there is more than 18% reduction in the total variable costs by using EOQ model.

Key words: Turnover ratio, EOQ model, Total variable costs, manufacturing industry.

1. INTRODUCTION

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Inventory refers to the stockpile of production firm; offering for sale and the components that make up the production. The basic function of inventory is to act as a buffer to uncouple the various activities of a firm so that all do not have to be pursued at exactly the same rate. Effective inventory management requires an effective control system for the inventories. In managing inventories, the firm's objective should be in consonance with the shareholders, wealth maximization principle. To achieve this, the firm should determine the optimum level inventory. Efficiently controlled inventories make the firm flexible. Inefficient control results in unbalanced inventory and inflexibility–the firm may sometimes run out of the stock and sometimes may pile up unnecessary stocks. This increases the level of investment and makes the firm unprofitable. The maintenance of inventory also helps a firm to enhance its sales effort. For one thing, if there are no inventories of finished goods, the level of sales will depend upon the level of current production. A firm will not be able to meet demand instantaneously. There will be a lag depending upon the production process. If the firm has inventory, actual sales will not have to depend on lengthy manufacturing process.

The inventory serves as a bridge gap between current production and actual sales. A related aspect is that inventory serves as a competitive marketing tool to meet customer demands. Inventories constitute the most significant part of current assets of a company like in India. On an average**,** inventories are approximately 60% of current assets in public limited companies in India. A firm neglecting the management of inventories will be jeopardizing its long run profitability and may fail ultimately. It is possible for a company to reduce its level of inventories to a considerable degree. The reduction in "excessive" inventories carries a favourable impact on a company's profitability.

2. Literature Review

The familiar economic order quantity (EOQ) model was presented by F.W. Harris (1913). Even though Harris's original paper was disseminated widely, it apparently was unnoticed for many years before its rediscovery in 1988. During this period much confusion was developed over the origin of the EOQ model. His paper explored the early literature on this model and traced the evolution of the confusion. Harris's original 1913 essay was reprinted following this paper. The model developed by Harris is commonly referred to as the Economic Order Quantity (EOQ)

model, and is also known as the lot sized model or Wilson's formula. Pal and Mandal (1997) studied an EOQ economic order quantity model for items deteriorating at some constant rate with demand changing at a known and at a random point of time in the fixed production cycle. Cheng et al. (2006) considers the inventory model with random procurement lead time. Using infinitesimal dividing method, the exact (Q, r) inventory cost model of single supplier procurement was presented, which is proved equal to the traditional model. Main properties of the model are analysed strictly. Darwish (2008) studied the classical economic production quantity and it was generalized by considering a relationship between the setup cost and the production run length. The dependency between the setup cost and run length can be related to process deterioration and learning and forgetting effects. Two models are developed, the first of which is for the case when shortages are not allowed and the other one permits shortages. The cost functions associated with these models are proved to be convex and optimal solutions were determined. His results showed that the relationship between setup cost and production run length has a significant impact on the optimal lot size and average total cost in the EPQ model. Numerical examples were presented to demonstrate the utility of the models.

Emery and Marques (2011) studied the effect of various parameters on the level of raw material inventories. Their contribution to inventory practice is the confirmation role for payment policy that reduces rather than increases the demand for raw materials inventories. It is well known that suppliers offer their customers delayed payment terms to reduce the financial opportunity cost of storage which increases the customers' demand for inventory. This affect is apparent in the simplest EOQ model where the opportunity cost is part of the holding cost in the denominator of the term under the radical. At the same time, the account payable created by delayed payment gives the customer some influence over the supplier. Kotb et al. (2012) studied the production process control using statistical quality control process with subgroup ranges. The analytical solution of the economic order quantity model of multiple items with varying leading time using Lagrangian multipliers was derived. The varying leading time crashing cost was considered to be continuous function of leading time. The optimal order quantity was deduced as a decision variable. Finally the model was illustrating by applied example and the average of the subgroup ranges approach is used to confirm that the production process is in control. Ahmed and Sultana (2013) worked in inventory modeling for an imperfect production process and

outcomes of their research were analyzed and separated; based on the basic modeling approach in which the reliability adjustments were made. The basic models used in these works were mainly EOQ, EPQ; entropy cost based model, stochastic model and some other approaches like: spare parts inventory model, model specific to product life cycle stage and some more. Rego and Mesquita (2014) studied large-scale simulation on spare parts demand forecasting and inventory control to select best policies with in each SKU category. Simulations were conducted over 10,032 SKUs of an automaker that operates in Brazil, considering nine years of demand data. Rezaei and Salami (2015**)** examined the inventory classification problem from a different perspective and proposed a novel optimization model for ABC inventory classification in form of interval programming problem. They stated that several inventory classifications have been proposed in the literature, almost all of which have two main shortcomings in common. They claimed that it provides optimal results instead of an expert-based classification and it does not require precise values of items parameters, which were not almost always available before classification**.** Babai et al. (2015) studied the inventory performance of multi-criteria classification methods. A number of multi-criteria inventory classification (MCIC) methods have been proposed in their paper. They found that; most of the literature focuses on the development and the comparison of ranking methods of stock keeping units (SKUs) in an inventory system without any interest in the original and most important goal of this exercise; which is the combined service-cost inventory performance.

1. Products and Industry

This industry was founded in March 1972, and it is the leading manufacturers and supplier of high tensile fasteners such as bolts, screws, nuts and similar parts for automobile and other industrial sectors. It is also catering the needs of various sectors such as wind energy, oil & gas, locomotives, automobiles, agriculture equipments (Tractors), machine building and different industrial items. The endeavor of the company is to provide high level customer satisfaction. This industry is located in northern part of the India and four units of this industry are spread over an area of 1, 00,000 square meters and have a total production capacity of 25,000 metric tons (MT) per annum. The core competency of this group lies in its ability to resource quality material and manufacture complete custom design solution. The global vision and providing

fastener solutions for more than three decades has now made the company as one of the global leaders for manufacturing high tensile precision fasteners and cold forged components.

This industry is one of the largest exporters of fasteners in India. Whereas 35% of the total sales is contributed from the products exported to various countries such as United States of America (USA), Australia, Canada, Denmark, Dubai, France, Germany, Hong-Kong, Indonesia, Japan, Malaysia, Singapore, South Africa, Switzerland, Sweden etc. The Company is a partner of the Global Fastener Alliance (GFA).

4. Economic Order Quantity (EOQ) model

The purpose of using the EOQ model in this research is to find out the particular quantity, which minimize total inventory costs that are the total ordering and carrying costs. The basic EOQ model is most popular and most widely used in the industries. Following assumptions are considered for implementing this model.

(i) The demand rate for the year is known and evenly spread throughout the year.

(ii) The cost of the ordering remains constant.

(iii) The lead time is constant (lead time is the latency time it takes a process to initiate and complete the procurement).

(iv) Prices of materials are fixed and no quantity discounts are allowed.

(v) The optimal plan is calculated for only one product.

(vi) There is no delay in the replenishment of the stock, and the order is delivered in the quantity that was demanded, i.e. in whole batch.

(vii) The procurement is instantaneous.

4.1 Formulation

The economic order quantity (EOQ) can be calculated from the Mahapatra (2010):

$$EOQ = \sqrt{\frac{Annual\ consumption\ in\ units \times cost\ per\ order}{price\ per\ unit \times carrying\ cost\ expressed\ as\ a\ percentage\ of\ total\ investment}}$$

Total Holding cost= C (Q/2)

No. of order = D /Q

Total Ordering cost = F (D/Q)

Where, C= carrying cost, D = Annual demand and F= Ordering cost per order

4.2 Methodology

This sub-section deals with the data collection and how these data were analyzed and the research design. The data related to the inventories have been collected from the reliable source of the concerned industry. Research methodology represents the strategies involves in collecting and analyzing data in order to have meaningful interpretations of the research findings.

4.3 Inventory Turnover Ratios

The inventory turnover ratios are basically used for analysis of short-term financial position or test of the stock level. The short term obligations of a firm can be met in time only when it is having sufficient current assets. So to win the firm & the efficient use of current assets (inventory) position must be strong. But a very high degree of inventory level is not good for a firm being tied up in the current assets.

4.4 Calculation of Inventory Turnover Ratios

The inventory turnover ratio establishes the relationship between costs of goods sold and average inventory. This ratio indicates the efficiency of the firm in producing and selling its products. It is calculated by dividing the cost of goods sold by the average inventory; as given below:

$$Inventory\ turnover\ ratio = \frac{cost\ of\ goods\ sales}{Average\ inventory}$$

Average inventory = Total inventory/2

$$Holding\ period\ of\ Inventory = \frac{365}{Inventory\ turnover\ ratio}$$

4.4.1 Raw materials turnover ratios

With the help of raw material turnover ratio, it can be ascertained that how many times the stock of raw material converted into sales during the year. The data of raw materials for industry 'X' are collected for last four financial years.

$$Raw\ material\ turnover\ ratio = \frac{Cost\ of\ goods\ sold}{Average\ stock\ of\ raw\ materials}$$

Table 1 shows the calculation of turnover ratio for raw materials.

Table 1 Calculation of Turn over ratio for raw materials

YEAR	2010-11	2011-12	2012-13	2013-14
Opening stock (in units)	47926633	337147297	235913157	151363869
Closing stock (in units)	337147297	235913157	151363869	192334134
Total (in units)	385073930	573060454	387277026	343698003
Average Inventory (in units)	192536965	286530227	193638513	171849002
Cost of good sold (in rupees)	3104226861	3434858655	3195927096	3513633752
Inventory turn over ratio	16.12	11.98	16.50	20.45
Holding period (in days)	22.64	30.45	22.12	17.85

4.4.2 Work in-progress inventory turnover ratios

The Work in-progress inventory turnover ratio ascertains that how many times the stock of work in progress material converted into sales during the year. The Work in-progress inventory turnover ratio may be computed as:

$$Work\ in\ progress\ turnover\ ratio = \frac{Cost\ of\ goods\ sold}{Average\ stock\ of\ work\ in\ process\ inventories}$$

Table 2 shows the calculation of Turn over ratio for work in-progress inventory.

Table 2 Calculation of turn over ratios for work in-progress inventory

YEAR	2010-11	2011-12	2012-13	2013-14
Opening stock (in units)	207930537	376343190	496518246	734907883
Closing stock (in	376343190	496518246	734907883	779932987

units)				
Total (in units)	584273727	872861436	1231426129	1514840870
Average Inventory (in units)	292136864	436430718	615713065	757420435
Cost of good sold (in rupees)	3104226861	3434858655	3195927096	3513633752
Inventory turn over ratio	10.62	7.87	5.19	4.63
Holding period (in days)	34.34	46.37	70.31	78.68

4.4.3 Finished goods inventory turnover ratios

The finished goods inventory turnover ratio ascertains that how many times the stock of finished good material converted into sales during the year. The finished goods turnover ratios may be computed as:

$$Finished\ goods\ \ turnover\ ratio = \frac{Cost\ of\ goods\ sold}{Average\ stock\ of\ \ finished\ goods}$$

Table 3 shows the calculation of Turn over ratio for finish goods inventory.

Table 3 Turn over ratios for finished goods inventories

Opening stock (in units)	**2010-11**	**2011-12**	**2012-13**	**2013-14**
Closing stock (in units)	419095398	369275612	454478159	500687534
Total (in units)	369275612	454478159	500687534	488770642
Average Inventory (in units)	788371010	823753771	955165693	989458176
Cost of good sold (in rupees)	394185505	411876886	477582847	494729088
Inventory turn over ratio	3104226861	3434858655	3195927096	3513633752
Holding period (in days)	7.87	8.33	6.69	7.10
Opening stock (in units)	46.34	43.76	54.54	51.39

4.5 EOQ Analysis of various products

Fifteen products have been considered for cost comparisons by using existing and EOQ methods. Table 4 shows the product specifications and cost comparison for product nos. 1, 2 and 3 by existing and EOQ methods.

Table 4 Specifications and comparison of costs for product nos. 1, 2 and 3

	Product 1	**Product 2**	**Product 3**
Product Code	L0102216014C3XP	L0102216020C3XP	L0102208008C16P
Part no.	P24-3	PLM28-3	PLM30-3
Product Specifications	Slotted shoulder bolt 1022M6*16/M5SS-303 PRECISION	Slotted shoulder bolt 1022M8*6/M6SS-303 PRECISION	Slotted shoulder bolt 1022M8*10/M6SS-303 PRECISION

	Product 1		**Product 2**		**Product 3**	
Cost (in rupees)	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**
Holding Cost	7.99	7.99	9.72	9.72	11.25	11.25
Ordering or Setup Cost	361.43	361.43	372.61	372.61	382.47	382.47
Quantity per order	2900	1774.69	3233.30	1724.45	3195.00	1614.26
No. of order in a year	12	20	12	22	12	24
Order Cycle	30.42	18.25	30.42	16.59	30.42	15.21

Time(in days)						
Annual Ordering Cost	4337.16	7228.6	4471.32	8197.42	4589.64	9179.28
Annual Holding Cost	11581.26	7087.3	15719.39	8383.7	17979.21	9083.95
Annually Total Cost	15918.42	14315.9	20190.71	16581.12	22568.85	18263.23
Saving	1602.52		3609.59		4305.62	
Percentage	10%		17.8%		19%	

Table 5 shows the product specifications and cost comparison for product nos. 4, 5 and 6 by existing and EOQ methods.

Table 5 Specifications and comparison of costs for product nos. 4, 5 and 6

	Product 4	**Product 5**	**Product 6**
Product Code	L0102208012C16P	L0102208016C16P	L0102208020C16P
Part no.	PLM-1	PLM-3	PLM-5
Product Specifications	Slotted shoulder bolt 1022M4*4/M3SS-303 PRECISION	Slotted shoulder bolt 1022M4*6/M3SS-303 PRECISION	Slotted shoulder bolt 1022M4*10/M3SS-303 PRECISION

	Product 4		**Product 5**		**Product 6**	
Cost (in rupees)	**Analysis of various cost by**	**Analysis of various cost by EOQ**	**Analysis of various cost by Existing**	**Analysis of various cost by EOQ**	**Analysis of various cost by**	**Analysis of various cost by**

	Existing method	method	method	method	Existing method	EOQ method
Holding Cost	6.31	6.631	6.31	6.31	11.25	11.25
Ordering or Setup Cost	350.62	350.62	350.68	350.68	382.47	382.47
Quantity per order	3250	2082.14	3166.7	2053.93	3233.3	2072.51
No. of order in a year	12	19	12	18	12	19
Order Cycle Time(in days)	30.42	19.21	30.42	20.28	30.42	19.21
Annual Ordering Cost	4207.44	6661.78	4208.16	6312.54	4209.72	6665.39
Annual Holding Cost	10250.96	6567.37	10002.87	6487.97	10246.10	6567.59
Annually Total Cost	14458.40	13229.15	14211.03	12800.21	14455.82	13232.98
Saving	1229.25		1410.82		1222.84	
Percentage	8.5%		9.9%		8.4%	

Table 6 shows the product specifications and cost comparison for product nos. 7, 8 and 9 by existing and EOQ methods.

Table 6 Specifications and comparison of costs for product nos. 7, 8 and 9

	Product 7	Product 8	Product 9
Product Code	L0102210008C16P	L0102210028C16P	L0102210050C16P
Part no.	PLM-6	PLM-12	PLM-15
Product Specifications	Slotted shoulder bolt 1022M5*4/M3SS-303 PRECISION	Slotted shoulder bolt 1022M5*14/MSS-	Slotted shoulder bolt 1022M5*25/M3SS-303 PRECISION

		303 PRECISION	

	Product 7		Product 8		Product 9	
Cost (in rupees)	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**
Holding Cost	7.69	7.69	8.54	8.54	9.90	9.90
Ordering or Setup Cost	359.53	359.53	365.01	365.01	373.75	373.75
Quantity per order	3116.7	1869.81	3283.3	1834.88	3108.3	1678.16
No. of order in a year	12	20	12	21	12	22
Order Cycle Time(in days)	30.42	18.25	30.42	17.38	30.42	16.59
Annual Ordering Cost	4314.36	7190.60	4380.12	7665.21	4485.00	8222.50
Annual Holding Cost	11986.71	7191.31	14024.85	7837.76	15386.83	8307.22
Annually Total Cost	16301.07	14381.91	18404.97	15502.97	19871.83	16529.72
Saving	1919.16		2902		3342.11	
Percentage	11.7%		15.76%		16.8%	

Table 7 shows the product specifications and cost comparison for product nos. 10, 11 and 12 by existing and EOQ methods.

Table 7 Specifications and comparison of costs for product nos. 10, 11 and 12

	Product 10	Product 11	Product 12
Product Code	L0102212028C16P	L0102212040C16P	L0102216016C16P
Part no.	PLM-23	PLM-25	PLM-29
Product Specifications	Slotted shoulder bolt 1022M6*14/M3SS-303 PRECISION	Slotted shoulder bolt 1022M6*20/M5SS-416 PRECISION	Slotted shoulder bolt 1022M8*8/M6SS-416 PRECISION

	Product 10		Product 11		Product 12	
Cost (in rupees)	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**
Holding Cost	11.84	11.84	16.83	16.83	12.28	12.28
Ordering or Setup Cost	386.25	386.25	418.38	418.38	389.05	389.05
Quantity per order	2933.3	1515.35	2696.7	1268.36	3150.0	1547.84
No. of order in a year	12	22	12	26	12	24
Order Cycle Time(in days)	30.42	16.59	30.42	14.04	30.42	15.21
Annual Ordering Cost	4635.00	8497.5	5020.56	10877.88	4668.60	9337.20
Annual Holding Cost	17367.72	8972.14	22694.36	10674.19	19335.43	9501.02

Annually Total Cost	22002.72	17469.64	27714.92	21552.07	24004.03	18838.22
Saving	4533.08		6162.85		5165.81	
Percentage	20.6%		22.2%		21.5%	

Table 8 shows the product specifications and cost comparison for product nos. 13, 14 and 15 by existing and EOQ methods.

Table 8 Specifications and comparison of costs for product nos. 13, 14 and 15

	Product 13	**Product 14**	**Product 15**
Product Code	L0102216020C16P	L0102216040C16P	L0102220020C16P
Part no.	PLM-30	PLM-33	PLM-39
Product Specifications	Slotted shoulder bolt 1022M8*10/M6SS-416 PRECISION	Slotted shoulder bolt 1022M8*20/M6SS-416 PRECISION	Slotted shoulder bolt 1022M10*10/M8SS-416 PRECISION

	Product 13		**Product 14**		**Product 15**	
Cost (in rupees)	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**	**Analysis of various cost by Existing method**	**Analysis of various cost by EOQ method**
Holding Cost	12.30	12.30	21.51	21.51	27.72	27.72
Ordering or Setup Cost	389.19	389.19	448.50	448.50	488.50	488.50
Quantity per order	3233.3	1567.07	3305.0	1286.06	3330.0	1186.73

No. of order in a year	12	25	12	31	12	34
Order Cycle Time(in days)	30.42	14.60	30.42	11.77	30.42	10.74
Annual Ordering Cost	4670.28	9729.75	5382.00	13903.5	5862.00	16609.0
Annual Holding Cost	19882.10	9636.13	35543.71	13830.99	46155.55	16448.82
Annually Total Cost	24552.38	19365.88	40925.71	27734.49	52017.55	33057.82
Saving	5186.5		13191.25		18959.73	
Percentage	21.12%		32.2%		36.4%	

Table 9 shows the overall cost comparison and cost saving for all the ten products.

Table 9 Overall cost comparison and saving of all the 15 products

Product Nos.	**Overall cost Comparisons**			
	Existing Method	**Recommended Method**	**Saving (in Rs.)**	**Saving (in percentage)**
	Total annual cost (in Rs.)	**Total annual cost (in Rs.)**		
1	15918.42	14315.9	1602.52	10.0
2	20190.71	16581.12	3609.59	17.8
3	22568.85	18263.23	4305.62	19.0
4	14458.40	13229.15	1229.25	8.5
5	14211.03	12800.21	1410.82	9.9
6	14455.82	13232.98	1222.84	8.4
7	16301.07	14381.91	1919.16	11.7
8	18404.97	15502.97	2902.00	15.8

9	19871.83	16529.72	3342.11	16.8
10	22002.72	17469.64	4533.08	20.6
11	27714.92	21552.07	6162.85	22.2
12	24004.03	18838.22	5165.81	21.5
13	24552.38	19365.88	5186.50	21.1
14	40925.71	27734.49	13191.2	32.2
15	52017.55	33057.82	18959.7	36.4
Total	**347598.4**	**272855.3**	**74743.1**	**18.13%**

So it is clear from table 9 that total cost savings for 15 products = Rs. 74743.1

Total cost savings for 15 products in percentage= 18.13%

5. Results and discussion

The results obtained from this case study are summarized as follows:

2. It is found from Tables 1, 2 and 3 that the holding period for raw material inventory is increasing gradually from year to year.
3. The economic order quantity, inventory turnover ratio and holding period for various products have been found out in the presented case study.
4. It is also observed that the use of EOQ models, reduces the cost of variable inventory and if the industry follows and implements the recommended inventory model, it can reduce the total cost by more than 18 %.
5. The holding period of raw material inventory increases due to decrease in demand of fasteners in international market. In the year 2013-14, the holding period decrease up to 17.85 days due to the increases in demand of fasteners. Inventory turnover ratio decrease in the financial year 2010-11 to 2011-12 from 16.11 to 12.98 which shows the decrease in the sale of fasteners. In next two years inventory turnover ratio increase gradually from 16.5 to 20.44 which shows the increase in the sales of firm.
6. The turnover ratio is continuously decreasing from year to year for the work in-progress inventory and holding period increases from 2010-11 to 2013-14, which shows that company manages a large amount of work in progress inventory to meet the demand of variety of products.

6. Conclusions

The job of the financial manager is to reconcile the conflicting view points of the various functional areas regarding the appropriate inventory level in order to fulfill the overall objective of maximizing the owner's wealth. Thus, inventory management like the management of other current assets, should be related to the over-all objective of the firm.

There are many medium and small scale industries which are still using their conventional methods of procurement without considering the EOQ models of inventory management. By using the EOQ models, these industries can save a lot of money in procurement of raw materials; semi finished and finished components; procured from other sources. The cost savings of Rs. 74,743 have been obtained by using the EOQ model on only fifteen products and this amount of saving can be increased for many other products with EOQ models. One of the limitations of this study is that basic EOQ model was implemented only in some products of the industry; while it can be applied for all the products to minimize the total cost and increase the profit of industry.

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