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ABC ANALYSIS AND IMPLEMENTATION OF EOQ MODEL IN A MANUFACTURING INDUSTRY: A CASE STUDY

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ABSTRACT

Inventory is considered as a significant investment affecting the financial decisions of an industry. This paper represents the conduction of ABC Analysis, determination and optimization of total variable inventory costs for the raw material inventory of an Orthoses manufacturing company through the implementation of basic Economic Order Quantity (EOQ) model. The different costs associated with the raw material inventory, that is, ordering costs and holding costs, have also been calculated for fifteen major raw material items of the manufacturing firm. The total variable inventory costs determined by implementation of basic EOQ model have been compared with the existing costs and a net saving of 13.65% have been found in the total variable inventory costs.

KEYWORDS : ABC Analysis, Variable Inventory Cost, EOQ, Ordering Cost, Holding Cost.

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1. INTRODUCTION

Inventory may be described as a comprehensive list of moveable items which aid directly or indirectly in the production of goods for sales. On one hand, Direct Inventory, including raw materials, in-process items and finished goods, forms an integral part of the end product to be sold, whereas on the other hand, Indirect Inventory, including tools, gauges, stationery supplies, etc., does not form an integral part of the end product but is necessary to produce it. Inventory represents an investment in assets in the form of items which are either stocked for sales or in-process of manufacturing or raw materials which are yet to be utilized. Inventory Control or Stock Control refers to in-operation management, logistics and supply chain management, the technological system and the programmed software necessary for managing the inventory.The objective of inventory control is to establish levels of inventory which will serve to minimize the company's cost and maximize its revenues.

The amount of inventory a company should carry is determined by four basic variables: (i) Order quantity; (ii) Lead Time, which is the time span between placing an order and receiving the material; (iii) Safety Stock, needed to mitigate risks of stock-outs by accounting for delays in material supply and sudden increase in demand; (iv) Reorder point, which is the level of inventory that triggers an action to replenish that particular inventory stock.

A company with appropriateinventory management is able to maintain a smooth and efficient production flow and can ensure deliveries of its products against delays. It allows the firm to have a better utilization of man power and machinery and to increase its output.A firm which is not capable of managing its inventory is bound to damage its customer relations.

The scope of inventory management concerns the fine lines between replenishment lead time, carrying costs of inventory, asset management, inventory forecasting, inventory valuation, inventory visibility, future inventory price forecasting, physical inventory, available physical space, quality management, replenishment, returns and defective goods, and demand forecasting. Balancing these competing requirements leads to optimal inventory levels, which is an on-going process as the business needs to shift and react to the wider environment.

2. LITERATURE REVIEW

Harris (1913) laid the foundation of the concept of Economic Order Quantity for the first time. He based the dependency of different costs of inventory, namely holding costs and ordering costs, on the lot size produced per set-up (or the quantity ordered per order) on the assumption that the item under consideration has a continuous and constant demand rate. He recognized a balance between the intangible costs of holding the inventory and the tangible costs of ordering it. According to this model, with increase in order quantity, ordering costs decline whereas holding costs rise and thus, the curve of total variable inventory cost has a minimum point. That is the point where total inventory cost is minimized and the order quantity is most economic.

Taft (1918) developed Economic Production Quantity (EPQ) model; that was an extension of the EOQ Model; as he incorporated a finite production rate to determine the holding inventory cost and thereby eliminating the assumption of instantaneous replenishment. 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. Eynan and Kropp (2003) studied a periodic review system under stochastic demand with variable stock-out costs. The optimal values for cycle length and amount of safety stock are difficult to obtain because one of the First Order Conditions does not have a closed form solution.

According to Dias (2005), there is a growing concern among entrepreneurs to find solutions to reduce inventories without any compromise with production process and without any increase in costs. It is important to measure and monitor the stocks as a function of the system of inventory control. He also believed that ABC Analysis,which is based on Pareto Rule, is the most widely used technique to determine the relative importance of items in inventory as it helps to identify the items which require more attention and an appropriate treatment to these is necessary to establish the sales policies, to set priorities for production planning and to deal with series of other problems which are common to industries. Porras and Dekker (2008) performed an optimization of the inventory system of spare parts. They compare different re-order point methods for effective spare parts inventory control, motivated by a case study at a large oil refinery. Different demand modeling techniques and inventory policies are evaluated using real

data. Adeyemi and Salami (2010) studied the inventory management system of Nigerian bottling industry. The inventory management situation of the Nigeria Bottling Industry**.** They found that the industry through a well-built policy is able to handle its idle stock without incurring unnecessary costs. A basis for inventory planning and control was also provided in this study. Though looking through the inventory policy of the industry, it can be said to be dynamic to some extent but the analysis and findings have revealed the need to remedy some situations in the industry's management of inventory. The study suggests some recommendations to remedy certain defects in the industry inventory policy and if these recommendations are implemented, the industry's inventory management situation will attain a greater height.

Akindipe (2014) highlighted some serious concerns related to inventory management inSmall and Medium Enterprises (SMEs), particularly in developing countries. His findings revealed a noteworthy, positive and strong relationship between different factors like stock level determination, use of skilled human resources, automation in stock control and optimal utilization of production resources. As an outcome, situations of unforseen stock-outs can be averted wherever stock level determination is implemented with models or through automated methods. His recommendations insist that SMEs should build inventory plans and schedules aimed at preventing any delay between requisition time and time of supply. Raphella et al. (2014) established similar conclusions through analysis of a firm manufacturing construction materials. ABC and FSN techniques were employed in the beginning for identification of most important multiple products, followed by the development EOQ Model for each product to find their inventory model equation individually. The study also analysed the then current forcasting model of the company and an inventory ordering model based on Re-order Point was recommended to bring down their product stock-outs and enhance their service level. In the end, it has been observed that an organization suffers halts in production when unavailability of a critical inventory item is encountered. Kumar and Prajapati (2015) implemented basic EOQ model to a firm; manufacturing high-tensile fasteners and cold-forged components. They computed the inventory turn-over ratios and optimized the inventory costs for different items under raw material inventory, in-process inventory as well as finished products of the organization. With a significant reduction in total variable inventory costs, they suggested the

need to shift from conventional methods of procurement to EOQ models of inventory management.

Mishra et al. (2016) derived an EOQ model for a depleting item by considering the demand as a linear function of time with shortages being allowed and partially backlogged. They have determined the cycle time, shortage point and order quantity as a function of time interval under study. They also described the effect of various parameters on the optimal solution by conducting a sensitivity analysis. The model is applicable on items such as paddy, fruits and vegetables with an increasing deterioration rate with time. Gordon and Gupte (2016) demonstrated an overview of the classical EOQ approach to improve the inventory management in modern firms. They discussed the significance of EOQ fundamentals, mainly in public sector organizations of developing economies Asian and Sub-Saharan African countries. Identifying nine vital aspects for the practitioners to implement, they brought to surface the cost-effectiveness of EOQ model through examples and highlighted the need for inventory control to provide optimal service to operationalmanagement function. By also suggesting that large organizations may outsource the task of EOQ modelling and inculcating a shift from manual to computerized inventory management systems to skilled consultancy firms, they provided managers with multiple options to address inventory related problems.

3. INTRODUCTION OF INDUSTRY

This company is one the largest manufacturers and exporters of orthopedic appliances and fracture aids and located in northern part of India. It was conceived at a time when orthopaedic products available to the Indian patient were either of a very low quality or they were very expensive and not affordable if they were imported. It is known for its most acceptable designs, wide range and high quality of products and guarantee/warranty on its products. The company has healthy dealer margins and an active research and product development wing.

The production facility is housed in multiple units, a mini factory concept, for each production process. State of art manufacturing capability with “In house designing and product development sections, Automates for fabric cutting and pasting operations, a stitching and tailoring unit, an efficient painting plant, an eight stage anodizing unit, Silicon moulding section, Thermoforming

section, Assembly line, Packaging department , Quality assurance deptt. etc. Manufacturing is done on lines of 'Toyota Production System' which ensure excellent quality of the produce, lean and faster production, cleaner environment, with low rejection & quick change over's resulting in low manufacturing cost. The company provides high quality health care products at affordable prices to the masses.It exports to about 30 countries like Mexico, Lebanon, France, Morocco, Tunisia, Malaysia, Bangladesh, Nepal, Thailand, UAE, Sudan, Ethiopia, etc. It is currently aiming at a 25% share in the market of Orthopedic appliances in India.

4. IMPLEMENTATION OF ECONOMIC ORDER QUANTITY (EOQ) MODEL

The study was aimed at achieving appropriate stock levels of raw material inventory of the manufacturing firm by implementing the basic Economic Order Quantity (EOQ) model. The EOQ model furnishes with the order quantity which tends to minimize the total variable cost, that is, the sum of holding cost and carrying cost, of managing the inventory.

4.1 Raw material inventory

The total number of items in the raw material inventory of the company, on an average, were approximately 1,100. The raw material inventory stocks are revised on a quarterly basis. It was noticed that the items as well as number of total items in the inventory vary from quarter to quarter.

The assumptions considered for implementing the EOQ model are as follows:

i. The rate of demand is deterministic, known and uniform throughout a quarter, that is, a span of three months.
ii. The lead time for the replenishment of stock is constant for every item.
iii. The prices of raw materials are fixed and the company is not entitled to any quantity discounts.
iv. The ordering cost of each order is constant. It does not change with change in order quantity.
v. The entire order is received all at once instead of being received in parts of a batch.
vi. The optimum value of order quantity is determined for one item at a time.

4.2 Formulae:

Since the company follows a quarterly revision of raw material stock levels, the formulae for basic EOQ model; which involve annual demand rates have been modified to use quarterly demand which is of relevance to the firm:

Economic Order Quantity, $q_0 = \sqrt{\frac{2SC_0}{C_u i}}$

$$\text{Quarterly Ordering Cost} = \frac{S}{q} C_0$$

$$\text{Quarterly Holding (Carrying) Cost} = \frac{1}{2} C_u \, i$$

$$\text{Number of Orders in a quarter} = \frac{S}{q}$$

Where,

S = Quarterly Demand

C_0 = Ordering Cost per order

C_u = Unit Cost of an item

i = Interest Rate on holding the item

q = Order Quantity

4.3 Methodology

The study adopted a deterministic approach to address the inventory problems of an orthoses manufacturing firm. The choice of company was based on the requirement of an industry in the category of Small and medium Enterprises (SMEs) as they are more sensitive to inaccurate inventory control and management.

This section represents a strategic approach adopted to implement EOQ model to the raw material inventory. Initially, the primary data was collected for previous quarters, which included quarterly demand of the items in raw material inventory, price per unit of each item, ordering cost per order, existing order quantity or Existing number of orders per quarter. Inventory control techniques used in the study include ABC analysis, EOQ and Turn-over ratio analysis.

4.4 ABC Analysis

It was contemplated before-hand to classify all the raw material inventory items into three categories, A, B and C on the basis of their usage values as part of an audit of the ABC classification already being used within the company. Considerable deviations were observed in the ABC classification of many items after the audit and the same were notified to the concerned authorities.

First, the annual usage value for each item was computed by multiplying the per unit price by the quarterly use and items were ranked in the descending order of their annual usage values. Then, the total no. of items and their usage values were accumulated and converted into percentages of grand totals.

The plot summary of ABC analysis of raw material inventory is shown in Fig. 1.

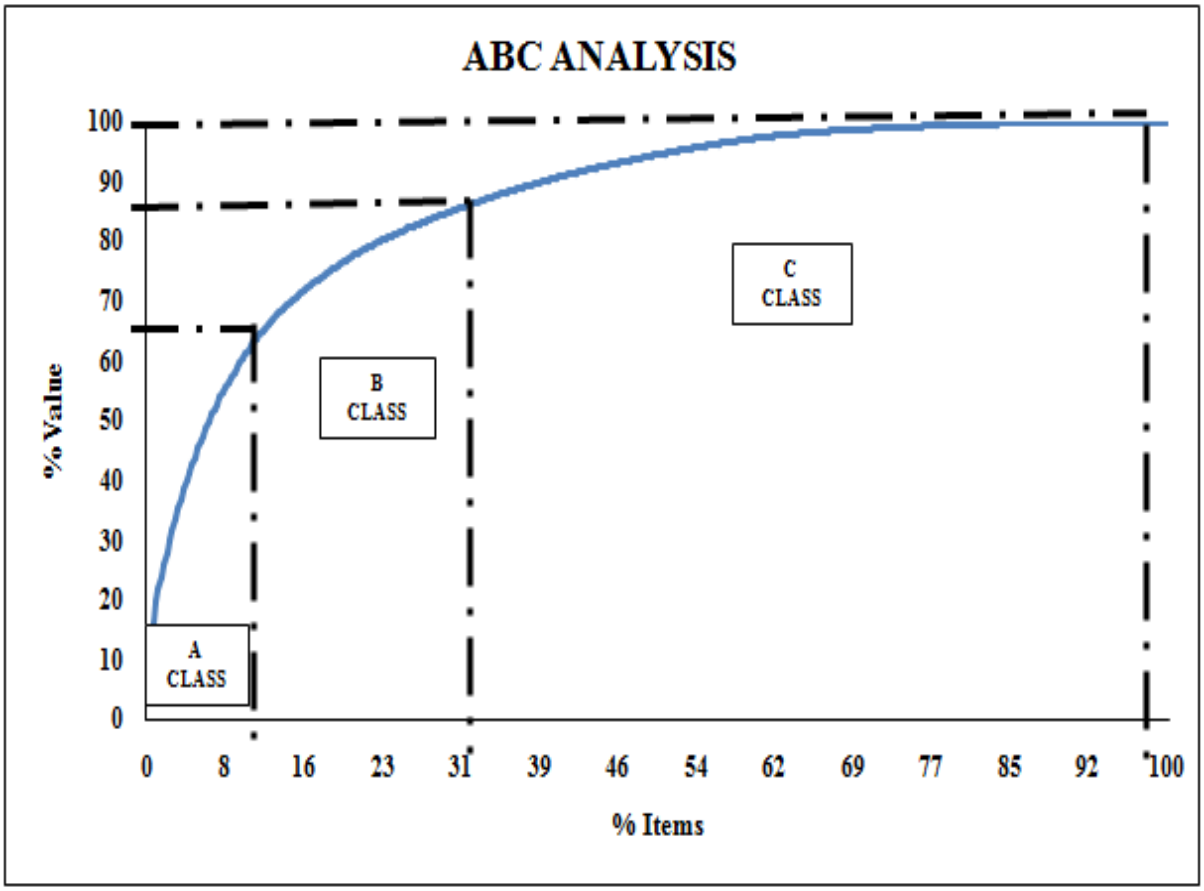

Fig. 1: Plot Summary of ABC analysis of raw material inventory

4.5 EOQ Analysis for raw material inventory items

Fifteen nos. of raw material items have been considered for cost comparisons by using the existing and EOQ methods.

Table 1: Cost Comparison of Raw material items nos. 1, 2, and 3

Parameters	**Raw material 1**		**Raw material 2**		**Raw material 3**	
	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
Unit Cost(In Rs.)	55	55	369	369	21	21
Quarterly Demand	145213	145213	17536	17536	237923	237923
Ordering Cost per Order (in Rs.)	6000	6000	9300	9300	7300	7300
Carrying Cost per unit (in Rs.)	3.41	3.41	23.06	23.06	1.33	1.33
No. of orders	3	6	3	5	3	5
Quantity Ordered	48404	24202	5845	3507	79308	47585
Cycle Time (in days)	30	15	30	18	30	18
Total Ordering Cost(in Rs.)	18000	36000	27900	46500	21900	36500
Total Carrying Cost (in Rs.)	82514	41257	67405	40443	52740	31644
Total Variable Cost (in Rs.)	100514	77257	95305	86943	74640	68144
Saving (in Rs.)	23257		8362		6496	
Saving %	23%		9%		9%	

Table 2: Cost Comparison of raw material item nos. 4, 5 and 6

Parameters	Raw material 4		Raw material 5		Raw material 6	
	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
Unit Cost (In Rs.)	34	34	495	495	254	254
Quarterly Demand	120810	120810	5090	5090	9678	9678
Ordering Cost per Order (in Rs.)	4900	4900	3300	3300	3500	3500
Carrying Cost per unit (in Rs.)	2.13	2.13	30.94	30.94	15.87	15.87
No. of orders	3	5	3	5	3	5
Quantity Ordered	40270	24162	1697	1018	3226	1936
Cycle Time (in days)	30	18	30	18	30	18
Total Ordering Cost (in Rs.)	14700	24500	9900	16500	10500	17500
Total Carrying Cost (in Rs.)	42787	25672	26245	15747	25599	15359
Total Variable Cost (in Rs.)	57487	50172	36145	32247	36099	32859
Saving (in Rs.)	7315		3898		3239	
Saving %	13%		11%		9%	

Table 3: Cost Comparison of raw material item nos. 7, 8 and 9

Parameters	Raw material 7		Raw material 8		Raw material 9	
	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
Unit Cost (In Rs.)	103	103	51	51	31	31
Quarterly Demand	22755	22755	46388	46388	72702	72702

Ordering Cost per Order (in Rs.)	2100	2100	3000	3000	2200	2200
Carrying Cost per unit (in Rs.)	6.44	6.44	3.16	3.16	1.94	1.94
No. of orders	3	6	3	5	3	6
Quantity Ordered	7585	3793	15463	9278	24234	12117
Cycle Time (in days)	30	15	30	18	30	15
Total Ordering Cost (in Rs.)	6300	12600	9000	15000	6600	13200
Total Carrying Cost (in Rs.)	24438	12219	24402	14641	23477	11738
Total Variable Cost (in Rs.)	30738	24819	33402	29641	30077	24938
Saving (in Rs.)	5919		3761		5138	
Saving %	19%		11%		17%	

Table 4: Cost Comparison of Raw material 10,11 and 12

Parameters	**Raw material 10**		**Raw material 11**		**Raw material 12**	
	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
Unit Cost (In Rs.)	1187	1187	210	210	140	140
Quarterly Demand	1805	1805	9666	9666	14220	14220
Ordering Cost per Order (in Rs.)	2700	2700	2800	2800	2200	2200
Carrying Cost per unit (in Rs.)	74.19	74.19	13.13	13.13	8.75	8.75
No. of orders	3	5	3	5	3	5
Quantity Ordered	602	361	3222	1933	4740	2844
Cycle Time (in days)	30	18	30	18	30	18
Total Ordering Cost (in Rs.)	8100	13500	8400	14000	6600	11000
Total Carrying Cost (in Rs.)	22315	13389	21144	12687	20737	12442

Total Variable Cost (in Rs.)	30415	26889	29544	26687	27337	23442
Saving (in Rs.)	3526		2858		3895	
Saving %	12%		10%		14%	

Table 5: Cost Comparison of raw material item nos. 13,14 and 15

Parameters	**Raw material 13**		**Raw material 14**		**Raw material 15**	
	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
Unit Cost (In Rs.)	29	29	159	159	550	550
Quarterly Demand	35732	35732	12119	12119	3256	3256
Ordering Cost per Order (in Rs.)	820	820	2500	2500	1600	1600
Carrying Cost per unit (in Rs.)	1.83	1.83	9.94	9.94	34.38	34.38
No. of orders	3	6	3	5	3	6
Quantity Ordered	11911	5955	4040	2424	1085	543
Cycle Time (in days)	30	15	30	18	30	15
Total Ordering Cost (in Rs.)	2460	4920	7500	12500	4800	9600
Total Carrying Cost (in Rs.)	10891	5445	20072	12043	18654	9327
Total Variable Cost (in Rs.)	13351	10365	27572	24543	23454	18927
Saving (in Rs.)	2985		3029		4527	
Saving %	22%		11%		19%	

4.5 Overall cost comparison and savings in raw material inventory

The Table 6 shows the overall cost comparison and savings in raw material inventories.

Table 6: Overall Cost Comparison in Raw material Inventory

Raw material No.	**Ordering Cost (in Rs.)**		**Carrying Cost (in Rs.)**		**Total Cost (in Rs.)**	
	Existing Method	Recommended Method	Existing Method	Recommended Method	Existing Method	Recommended Method
1	18000	36000	82514	41257	100514	77257
2	27900	46500	67405	40443	95305	86943
3	21900	36500	52740	31644	74640	68144
4	14700	24500	42787	25672	57487	50172
5	9900	16500	26245	15747	36145	32247
6	10500	17500	25599	15359	36099	32859
7	6300	12600	24438	12219	30738	24819
8	9000	15000	24402	14641	33402	29641
9	6600	13200	23477	11738	30077	24938
10	8100	13500	22315	13389	30415	26889
11	8400	14000	21144	12687	29544	26687
12	6600	11000	20737	12442	27337	23442
13	2460	4920	10891	5445	13351	10365
14	7500	12500	20072	12043	27572	24543
15	4800	9600	18654	9327	23454	18927
Total Cost	162660	283820	483420	274053	646080	557873

Net Savings in total variable inventory costs of 15 raw material items = Rs. 88,207

Percentage of Savings in total variable inventory costs of 15 raw material items = 13.65%

5. RESULTS AND DISCUSSION

The results obtained from the implementation of EOQ on 15 raw material items are summarized as follows:

Total initial variable cost	Rs. 6,46,080
Total variable cost with EOQ	Rs. 5,57,873
Total savings	Rs. 88,207
Percentage savings	13.65%

(i) The economic order quantity, no. of orders for various products have been determined as presented above. By providing and recommending the EOQ inventory control model, the results show the improvements in cost reduction.

(ii) The total initial variable cost was Rs. 6,46,080 for 15 items under consideration whereas the total variable cost with Economic Order Quantity (EOQ) model comes out to be Rs. 5,57,873.

(iii) If the industry follows and implements the recommended inventory model, it can reduce the total cost by approximately 14% and this is just for 15 items. The total savings after implementing the EOQ model may be much more for all the items of raw materials.

(iv) Economic Order Quantity model is beneficial in order to reduce the investments in ordering the material and storing it in stock.

(v) The EOQ model helps to identify the cost of extra material that is kept in stock for its requirement within a long time and also takes into consideration the costs incurred every time a new order is placed. In this way, basic EOQ model helps to obtain a balance or say an equilibrium between the two kinds of costs to get the minimum/optimized total variable inventory cost.

(vi) Not just EOQ brings down the cost but also provides time interval after which a new order should be placed for an item. So knowing the number of items to be placed in one order and frequency of orders; make it a lot easier to manage inventory than it is to do so when EOQ model is absent.

6. CONCLUSIONS

There are ever-rising developments in the field of inventory management to tackle the new challenges in the industrial sector. Undoubtedly, inventory is an asset of distinctive characteristics and all the improvements being explored are in resonance with its significance in the financial structure of any company. The manner in which implementation of a cost

optimization technique like Economic Order Quantity can bring about a lot of savings in managing inventory and also help in giving estimate for when to place order is quite exciting and helpful. This has been proved by applying it on 15 items of the company concerned in this project and around 13.65% massive savings justify the value of EOQ Model.

However, there are a few limitations to the basic EOQ Model as the demand is considered constant which might not be the case in industries. There are a few advanced EOQ models too which can help solve these issues. Small businesses require an efficient inventory system to maximize profit. The EOQ model is a commonly used element of a continuous review inventory system. It is based on a formula that calculates the most economical number of items a business should order to minimize costs and maximize value when re-stocking inventory. Small business owners should evaluate the advantages and disadvantages of this inventory model before implementing it.

Storing inventory may be expensive for small business owners. The main advantage of the EOQ model is the customized recommendations provided regarding the most economical number of units per order. The model may suggest buying a larger quantity in fewer orders to take advantage of discount bulk buying and minimizing order costs.

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