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# "Using EOQ model, the most favorable economic order to increase productivity (Case Study: Parto industrial manufacturing company)"

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**ABSTRACT**

Economic point of order has been introduced as an efficient model for production and economic order quantity of products. The aim of this study is determining the economic order quantity (EOQ) and cost reduction in Parto Cable Company. The population in this study includes high consumption raw materials, based on the summary of inventory turnover of main and auxiliary raw materials according to the accounting departments of warehouse in 1392 including 90 items. 25 items out of 90 items have been set aside because of low consumption and the rest includes 65 high consumed items. Economic order quantity was calculated using the classical model of EOQ. Based on the constant demand model and the variable period of delay to get the order, the point of order and precautionary storage were calculated. The research results showed that by optimizing, the total cost is reduced. The order status was changed from an existing system to optimize system. Results of this research can be used in cost reduction and the optimal use of machines and manpower in the mentioned organization and other organizations. Lack of access to needed data is the major limitation of this study.



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## INTRODUCTION

In recent years, problems related to inventory items deteriorated and therefore they are widely studied. In general, inventory problems are the loss, corruption, and safety . . . leading to a reduction in profit [9]. The main concern of each productive organization is minimizing overall costs and increasing profit. The cost of inventories includes four types of purchasing cost, ordering, inventory transportation and shortage. Most of inventory managers should consider an important decision about the balance between the cost of order and the order quantity. If the order is less than the required amount of the organization may lead to loss of market and if organization order is more than organization need, storage costs and corruption of goods will increase. So an appropriate balance is necessary between time of the order and its quantity. This leads to developing an economic model of the order [14]. Shortages of inventory cause the number of clients faced with shortage and its negative impact reduces customer demand. In other words, if the customer knows by ordering to a vendor, with a high likelihood his order will not be delivered on time, he is trying to select different vendors and order them. Probabilities of shortage for a vendor results in reducing order and ordering to others and due to the probability of shortage, demand for his goods decreases [8].

Among the issues that the mentioned plant is faced is that some raw materials are stored in the warehouse for more than one year while the supplementary raw materials for the manufacture of a product no longer exists due to the limited energy supplies and this issue has caused a long interruption in product manufacturing and company officials has done no effective action to this problem assuming having the existing system. So the problem is seen more frequently in the factory, is lack of a scientific system based on production management techniques for the economic order quantity. With regard to the mentioned issues, this study is trying to provide a point of economic order to enhance economic efficiency in the Parto industrial manufacturing company.

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*Research literature:*

*Inventory control:*

Inventory control is a process which guarantees the items will be available by considering time, place, number, quality and cost of operations parts for manufacturing, distribution, sales, and engineering. What are important in the inventory control are: 1- order quantity, 2- order time.

The purpose of inventory control: Studying and maintenance a level of inventory to minimize costs of system and the organization or industrial plant.

Inventory balancing act: an operation to minimize the amount of capital used for inventory, with the ability to transform into capital: in order to ensure that inventory is available for all manufacturing, technical and sales operations, timely and in sufficient quantities. Accumulation of inventory increases the cost of organization or industrial plant and hides problems and maintenance inventory at optimum levels reveals the correctable management problems in organization and production. For example: if the product inventory is high in the warehouse, loss of production won't be sensed due to high inventory in the warehouse, so the solution is not considered as a solution. One of the goals of the organization towards inventory is its reduction. The inventory balance has been shown in figure 1 [13].

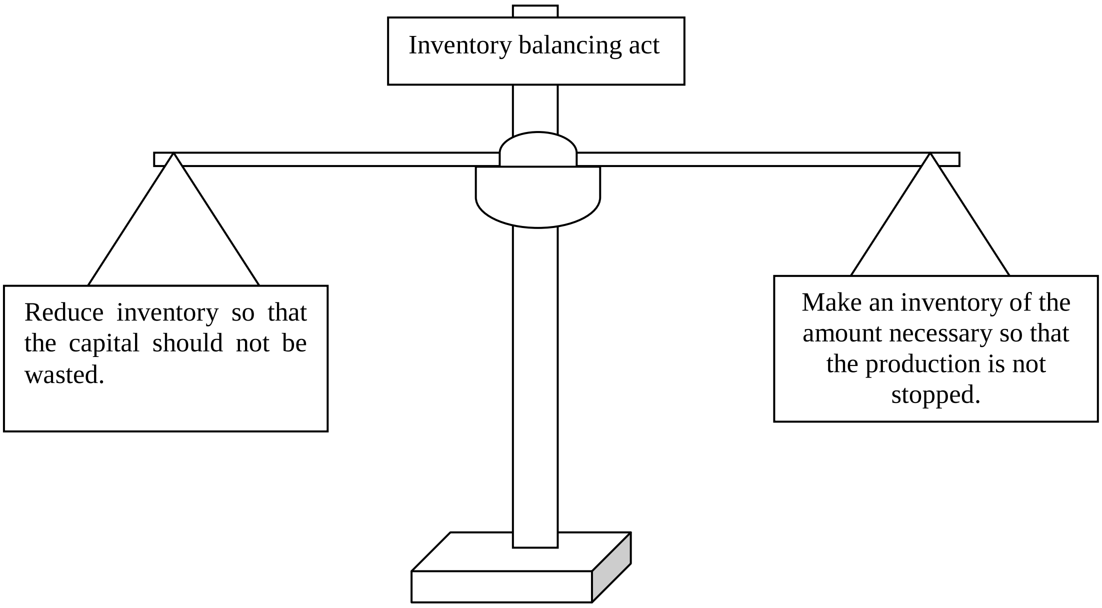


**Fig. 1:** Inventory balance [13].

*Controlling inventory of the warehouse:*

Warehouse is very important in our country's economy, because a significant percentage of the organizations' assets are accumulated in the warehouse inventory, manage warehouses is also difficult and expensive and organizations seek to determine optimal best practice with the minimum cost, in this context, they enjoy the art and science of warehouse management, because time and cost are the basic elements of decision making. To correct Storage systems and designing them appropriately, relying on the knowledge and variety techniques of different disciplines, to remove the waste (waste from too much production, waste from too much purchase of goods, waste from loss of goods and rework, waste resulting from the unnecessary movement in the workplace, waste resulting from faulty processes, waste due to the expecting good supply, waste resulting from transfers, waste resulting from time, waste resulting from the allocation of extra space for merchandise) is necessary**.** One of the main concerns of a manufacturing plant is real-time information of inventories and quick orders of the needed raw material. Storage system is one of the main supporting systems**.** This system creates the balance between supply system and consumer units. Storage system does important actions based on standard criteria for the preservation and storage of goods. Storage system is considered among the most important support processes in all organizations. Despite the fact that industrial and manufacturing centers in developed countries are moving towards production and timely delivery and timely reducing inventories (even zero) ,but besides that, they incur maintenance costs and huge storage costs for the maintenance of strategic and critical materials such as oil or strategic materials not to be deficient in times of crisis [1].

*Inventory control models in terms of full ensuring:*

Inventory control models in full confidence conditions are as follows [16]:

1. The economic order quantity model (EOQ)
2. Fixed Interval Order
3. Quantity Discount Model
4. Production Order Quantity

*EOQ model:*

Classical inventory model of (EOQ) was originally developed in 1915 by Harris. In this model, order was received instantly and there was no shortage of stock and all parameters were considered as definitive. This model was later expanded and developed by other researchers in the definitive, fuzzy and probabilistic environment to be closer to the real world.

Hadley and Whiten in 1963, developed several definitive models and they examined the inventory shortage and so they improved basic model of Harris.

This model is under full confidence conditions and hypotheses of the model are as follows:

1- For each product or commodity the economic order is calculated independently.
2- Annual demand is clear.
3- The sale or consumption rate is constant throughout the year.
4- Each order will be delivered at once.
5- The price is fixed and there is no discount on bulk purchase.

Darwish provided different models of EPQ (classic and also with regard to the legality of the inventory shortage) with the cost of variable preparing and obtained the optimal values by derivative of the objective function.

There have been some studies in the field of the mentioned discussion of the "EPQ model in fuzzy branch": Lee et al. (1998) presented a fuzzy EPQ model that its annual demand and production parameters was a triangular fuzzy number, and the shortage was not allowed in the model.

Das et al. 2004 developed a multi-product inventory model with fuzzy and probable parameters. In this model the inventory shortage was not permitted and Graded Mean Integration Value (GMIV) was used to debug.

Chang et al in 2006 developed a new hybrid fuzzy inventory model including the time between applying the order and delivering of fuzzy random order delivery and also total fuzzy demand.

Islam and Roy in 2006 presented an EPQ model with regard to reliability and flexibility with limited storage space, in this study, a fuzzy geometric programming (FGP) method was used, in this model, an infinite time horizon was considered, and the lack of inventory was not allowed.

Dota and colleagues in 2007 presented a model of hybrid fuzzy and probable visit in which the annual demand parameter was a triangular fuzzy number.

Dey and Chakraborty in 2008 examined issue of single interval with the ability to resell in the probable fuzzy environment.

Roy and colleagues in 2009 presented a product inventory model with reproducing approach for defective goods in the fuzzy environment in which the genetic algorithm was used to solve the model. In this model, the decision variables were the number of cycles in the time horizon, and the time period of collecting vicious cycle. And also the delivery time was overlooked in the model.

Bags and colleagues in 2009 evaluated an EPQ model with random fuzzy demand and considering the reliability and flexibility of the system. In this model, there is no storage inventory, backlog and lost sales there (inventory shortage not allowed) and the preparation time is negligible, GMIV method for removing fuzzy values and fuzzy optimization is used and there is no limit.

Kazemi et al in 2010 developed the economic order model by considering the shortage of delayed order and inventory costs and they used two triangular and trapezoidal fuzzy numbers in their models and compared these models with the exact same model. GMIV method was used for the debugging phase.

Uthayakumar and Valliathal in 2011 presented a model of economy production with corrupt items of Weibull with a fuzzy environment offered by an infinite time horizon. They considered the model cost including startup costs, production, maintenance, and shortage of opportunity related to lost sales in certain sizes with triangular fuzzy numbers. Described optimal policy was proposed by regarding the cost in fuzzy environment.

Hu and colleagues in 2011 examined a model of economy production with corrupt items with fuzzy concepts. They raised two models with fuzzy numbers of L-R.

In one model, the desired coefficient is considered lower than coefficients of production and in other model it is considered more than coefficients of production. Burke in 2011 studied a company in deciding size of many productive groups with uncertainty at the time periods. They defined lack of certainty with triangular fuzzy numbers and optimized the problem by an analytic solution.

In another article, Bjork et al in 2012 examined an effective fuzzy EPQ model with multiple items with bounded production rate. In this model, the order and demand time cycles are defined as triangular fuzzy numbers. To solve the Lagrange multiplier coefficient method is used.

*Constant distance between two orders:*

In some organizations fixed periods of time are set for orders. For example, management decides the orders are made on a quarterly basis. Special feature of this method is to reduce costs of orders. Because the total orders taken together, the total cost is reduced and the benefits of the purchase orders generally are used (pious, 1392).

*The discount on the total purchase:*

To determine the order in conditions that some vendors consider some discounts for customers who do overall shopping, the above model is used [16].

Hypotheses of discount model on the overall purchase are:

1. This model is under complete confidence.
2. All orders will be delivered in one place at the same time.
3. The consumption is uniform and it does not change over time.

*The gradual receiving of goods:*

Hypotheses of this model are similar to the model of EOQ. It means conditions for decision making is perfect and consumption is constant and price is fixed. With the difference that the goods have not been receiving at once but it has had the constant rate and has been gradual. The model for production planning, if the factory parts production and consumption, you can use. Hence its other name is a model of economic production quantity [16].

*Research hypotheses:*

1- Using "EOQ" model, most favorable economic order, an optimal production of production and control inventory, increase yields and reduce the cost of producing the product.

2- Obtaining an optimal level of inventory for production and raw material causes reduction of off time of machines and thus the efficient use of human resources.

*The research method:*

The method of research is theoretical or judging. Mainly information related to this issue was in the form of documents. Type of research based on objective is an applied research. Because research findings are the basis for offer and recommendations for the Production company of Iran Parto and other organizations in order to be used to promote and improve the function.

The population in this study includes high consumption raw materials, based on the summary of inventory turnover of main and auxiliary raw materials according to the accounting departments of warehouse in 1392 including 90 items. 25 items out of 90 items have been set aside because of low consumption and the rest includes 65 high consumption items.

The sampling method in this research has been ABC (Parto) method. 65 items of high consumption raw materials were categorized according to ABC using excel and its results have been shown in table (1). Since then the group a items were selected due to constituting the maximum value of raw material inventory in the warehouse and they are 5 items. According to the experts the materials selected as sample are among the main products to manufacture products and other materials are auxiliary.

**Table 1:** analysis summery of ABC

| group | Items percent | Items value | Percent of Items value |
|---|---|---|---|
| A | 10 | 2100000000000 | 70 |
| B | 30 | 6000000000 | 20 |
| C | 60 | 3000000000 | 10 |

*Data analysis:*

*The current status of the inventory control system in Iran Parto Company:*

65 items of high consumption raw materials were categorized according to ABC using excel and, since then the group a items were selected as statistical sample due to constituting the maximum value of raw material inventory in the warehouse and they are 5 items. According to the experts warehouse is among the main materials to manufacture products and other materials are auxiliary. According to relevant experts the most important materials used in the company is 5 items and applying other items is partial and they have moderating role. The current status of the inventory control system in Iran Parto Company has been shown in table 2. Information about the second row (the annual consumption) obtained using cardex of goods in orders and inventory control and industrial accounting. At fourth row the order cost at each time has been calculated for the mentioned material, and at fifth row maintenance cost of raw material has been calculated and published. At sixth to tenth row total order cost, total maintenance cost and total system cost have been calculated and published.

1. *The current status of the inventory control system in Iran Parto Company (Source: research findings):*

| Number of goods | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Material name | 8mm copper | Granules | PVC materials | Stainless Steel | Painted galvanized iron |
| Annual consumption (kg) | 1200000 | 250000 | 300000 | 170000 | 130000 |
| Ordering cost per order (CO) Rails | 53257525 | 1232575 | 1144628 | 932572 | 872592 |
| Maintenance costs (Ch) | 2752 | 324 | 175 | 145 | 112 |
| Orders per times (kg) | 37500 | 25000 | 20000 | 8500 | 5200 |
| Number of orders per year | 32 | 10 | 15 | 20 | 25 |
| $T_{CO}$ | 1704240800 | 12325750 | 17169420 | 18651440 | 21814800 |
| $T_{CH}$ | 316000000 | 7150000 | 6950000 | 9162500 | 4912000 |
| TC | 2020240800 | 19475750 | 24119420 | 27813940 | 26726800 |

2. *The reliability of the current status of the inventory control system in Iran Parto Company:*

One of the important items in the inventory control system is ensuring the system process. It means when the product is ordered to purchase, how we sure the goods enter the produce process on time. To determine the reliability of the existing system, we use the following formula:

Equation (1)

$$reliability\ of the\ existing\ system = \frac{Number\ of\ times\ of\ the positive\ inventory}{The\ total\ number\ of\ order}$$

The number of positive inventory availability is the number of times that each material is available until the next order and not to faced with a shortage (Shir Mohammadi, 2006).

According to the mentioned method, the reliability of 5 items of row materials described in this study was calculated and the calculated items are presented in the table (3). Statistics of the number of positive inventory availability has been received by referring to the supplies' documents.

For example, the reliability of copper includes:
Number of times of the positive inventory: 20
The total number of order: 32
Degree of reliability= 0.625

**Table 3:** Calculation of reliability percent (Source: research findings)

| Material name | 8mm copper | Granules | PVC materials | Stainless Steel | Painted galvanized iron |
|---|---|---|---|---|---|
| Number of times of the positive inventory | 20 | 6 | 9 | 15 | 18 |
| The ordered number of 92. | 32 | 10 | 15 | 20 | 25 |
| The system reliability (percent) | 62.5 | 60 | 60 | 75 | 72 |

As seen in the above table, inventory system reliability is between 62.5 to 72 percent.

Numerous interviews were performed with officials of inventory of control units, warehouse, supplies and production management in order to determine the reliability of the inventory system. The result of the interviews summarized in tables and other records of the company is that reliability of the system in the current state is 66%.

One of the important items in the inventory control system is ensuring the system process. It means when the product is ordered to purchase, how we sure the goods enter the produce process on time. At first we examine the existing reliability of the system in Parto industrial manufacturing company, and then we present reliability in an optimal condition.

3- *Optimization in confidence level of 95%:*

*Calculating mean and standard deviation of delay time to the order receive:*

Based on the research model in order to calculate mean and standard deviation of delay time to the order receive, The number of days of delay and frequency of occurrence were collected based on the documents in the studied organization, that are seen in table 4, then mean and standard deviation of delay time to the order receive was calculated. The results of the calculations are provided in Table 5.

For example, the mean and SD of delay time to receive order of 8 mm copper is calculated as follows:

Equation 2, mean

$$LT = \frac{\sum_{i=1}^{n} FiXi}{n}$$

$$LT = \frac{(2\times5)+(7\times2)+(3\times3)}{12} = 3$$

Equation 3, standard deviation

$$\sigma lt = \sqrt{\frac{\sum Fi(Xi - X^{-})2}{n}}$$

$$\sigma lt = \sqrt{\frac{\Sigma 3(3-3)2 + 7(2-3)2 + 2(5-3)212}{12}} = 1$$

**Table 4:** Data on the number of days of delay and frequency of occurrence of the material (Source: research findings)

| material | The number of days of delay Xi | Frequency of occurrence Fi | mean LT | SD σ |
|---|---|---|---|---|
| 8mm cooper | 3 | 3 | 3 | 1 |
| | 2 | 7 | | |
| | 5 | 2 | | |
| Granules | 2 | 3 | 2 | 0.5 |
| | 3 | 1 | | |
| PVC materials | 4 | 4 | 4 | 1 |
| | 5 | 2 | | |
| Stainless Steel | 2 | 2 | 3 | 1 |
| | 4 | 3 | | |
| Painted galvanized iron | 2 | 3 | 3 | 1 |
| | 4 | 2 | | |
| | 3 | 2 | | |

*Economic order quantity (EOQ):*

One of the important tasks of managing the warehouse, is to obtain an optimal point of order; That is how much and when to apply a special type of material needed to produce or provide a service to minimizes the warehouse storage costs and the cost of the order and on the other hand not to encounter with shortage of goods, followed by production problems and not suitable for sale, or in other words not to encounter with the cost shortage.

Accordingly, the economic value of the order for the material to be calculated, For example, the economic order quantity of copper is calculated as follows.

For example, the economic order quantity of copper is calculated as follows.

Equation 4, economic order quantity

$$Q* = \text{EOQ} = \sqrt{\frac{2D\underline{C}O}{CH}}$$

$$Q* = EOQ = \sqrt{\frac{2 \times 1200000 \times 53257525}{2752}} = 215512$$

*Maintenance costs ($T_{CO}$) and the cost of the order ($T_{CH}$):*

After calculating the economic point of order, order cost and storage cost is calculated. The results have been shown in Table 5.

For example, order cost and maintenance cost of copper is calculated as follows:

Equation (5), cost of order

$$\text{TCO} = \frac{D}{Q*} \times CO$$

$$TCO = \frac{1200000}{215512} \times 53257525 = 31954515$$

Equation (6), cost of maintenance

$$\text{TCH} = \frac{Q*}{2} \times CH$$

$$TCH = \frac{215512}{2} \times 2752 = 296544512$$

*Economic order frequency (* N), and the most favorable economic gap between the two orders (P):*

After calculating the cost of ordering and storage costs, the economic order frequency (*N) and optimal economic gap between the two orders (P) are calculated. The results have been shown in Table 5.

For example, economic order frequency and the most desirable economic gap between the two orders of copper is calculated as follows.

Equation (7), Economic order frequency (*N)

$$N* = \frac{D}{Q*}$$

$$N* = \frac{1200000}{215512} = 3$$

Equation (8), the most favorable economic gap between the two orders (P)

$$P* = \frac{t}{N*}$$

$$P* = \frac{360}{6} = 60$$

*Re-order point (ROP) and precautionary saving (SS):*

According to the organization experts Re-order point calculation and precautionary storage are based on stable demand model and the variable delay in receiving order at the 95 percent confidence level. The results have been shown in table 5.

For example Re-order point (ROP) and precautionary saving (SS) of cooper are calculated as follows.

Equation 9, Re-order point (ROP) and precautionary saving (SS).

$$ROP = d\bar{LT} + Z\, d\sigma$$

$$ROP = (3334 \times 3) + 1.65 \times 3334 \times 1 = 15503$$

$$SS = Z\, d\sigma$$

$$SS = 1.65 \times 3334 \times 1 = 5501$$

**Table 5:** Results of the optimization at confidence level of 95% (Source: research findings)

| Painted galvanized iron | Stainless Steel | PVC materials | Granules | 8mm copper | material |
|---|---|---|---|---|---|
| 45007 | 46762 | 62645 | 43613 | 215512 | Q* |
| 1684 | 2200 | 4712 | 1964 | 15503 | ROP |
| 598 | 781 | 1376 | 574 | 5501 | SS |
| 3 | 4 | 5 | 6 | 6 | N* |
| 120 | 90 | 72 | 60 | 60 | P* |
| 2617776 | 3730288 | 5723140 | 7395450 | 319545150 | $T_{CO}$ |
| 2520392 | 3390245 | 54814375 | 7065306 | 296544512 | $T_{CH}$ |
| 5138168 | 7120533 | 11204577 | 14460756 | 616089662 | TC* |
| 19.5% | 0.25% | 0.46% | 0.74% | 30% | TC/TC* |
| reduction | reduction | reduction | reduction | reduction | result |

*Results:*

*The first hypothesis:*

One of the most important topics in the field of logistics is inventory control of the materials, components and products. In other words insufficient order increases high cost of production stop and in contrast, supplying over demand due to expensive inventories will cause enormous cost of resting capital.

For an organization, customers and costs reduction is the main key to gain competitive advantage. Scientific models cannot be used for ordering materials in Iran Parto Company and this leads to an accumulation of inventories in warehouses and production costs and results from the storage unit of the company can be seen in Table 2. After using the economic order model (Table 5), suggesting that there have been dramatic changes in the costs of inventory control system. We observed reducing costs after optimizing the amount of requests, the number and fixed orders interval. In this study, we observed significant cost reduction fron 19.5% in the galvanized iron covers up to 74% of the granules and this represents a change in the inventory control system. Thus, according to the results of Table 5, applying "EOQ" model of the most favorable economic order of an optimal production and inventory control increase yields and reduce the cost of production and the research hypothesis is confirmed. Chen et al research (2012), also using stable demand model and variable supply showed that using this model can reduce costs. Harish and Vikara (2014), in their study showed that the method of delivery on time is one of the most important indicators of inventory management that are increased as a result of delivery costs fluctuations. Therefore, in this study, we were able to reduce costs by calculating the mean and standard deviation of latency to get the order. Mojibi and Rezaei Nosrati (2009), in their studies of Mazandaran Wood industries concluded that EOQ model can be used to reduce costs. The results of the study are consistent with other research in the field of reducing costs.

*The second hypothesis:*

The main concern of each productive organization is minimizing overall costs and increasing profit. The cost of inventories includes four types of purchasing cost, ordering, inventory transportation and shortage. Most managers should consider an important decision about the balance between the cost of the order and the order quantity. If the order is less than the required amount of the organization may lead to loss of market and if the orders are more than the organization need, costs of storage and spoilage of goods will increase. The consumption rate and delivery time is not fixed and often are considered as probability, because it may be consumed faster or slower than normal. So as to avoid stopping the company activities some inventory should be considered as supply of reliability to deal with the probable shortages caused by the variable consumption rate and delivery time.

On the other hand, to minimize the cost of storage order costs and maintenance costs may be reduced to a minimum that can be calculated in a commercially viable method. The research results of Iran Parto Company's in order to reduce costs and to calculate order and precautionary storage leads to reduce the unemployment duration and therefore the optimal use of human resources. Because always some caution is in the organization because of the delay caused by custom, thus, according to the results of Rashedi and mohammad research, obtaining an optimal level of inventory for the production and raw material leads to reduce stop duration of machines and so efficient use of human resources and the hypothesis is confirmed. The results of the study are consistent with other research on the optimal use of human resources and the reduction the stop hours of machines.

*Suggestions:*

• Due to the fact that using economic order quantity model may lead to significant cost reduction, it is suggested that the management of the company use the presented suggestion to plan inventory in control system and apply the commands required in this field.

• Based on the results of research the company can choose trusted suppliers in receiving orders to enhance system reliability by preventing the increased costs resulting from the delay.

• By checking the documents of the company, due to high volume of unnecessary material, high cost is necessary to buy and maintain the material including capital stagnation and the loss of material because of heat from the sun and rain and also transforming in storage which leads to decay and loss of product quality. It is proposed based on the model presented in this study, essential materials to be stored.

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