Inventory Control Analysis Using Economic Order Quantity (EOQ) in the Pekalongan Batik Industry

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**Abstract.** One of the economic sectors that is able to provide a significant increase in Indonesia's economic growth is MSMEs, which operate in the creative industry sector. On the other hand, MSMEs are a business sector that is often faced with uncertainty. One of the batik MSMEs in Pekalongan was forced to face post-disruption effects such as a pandemic, which had an impact on decreasing demand and increasing supply. Therefore, strategies are needed to remain competitive in the market, one of which is inventory management. The EOQ model is used in this research to minimize raw material inventory costs by determining the economical order quantity (Q) in one of the Pekalongan batik industries. The results of this research provide a concrete reference for MSMEs to plan their supply of fabric raw materials, starting from determining order frequency, reorder points, and safety stock. The optimal order quantity for MSME raw materials is 10,189 meters, with an order frequency of 35 times in the planning horizon. The safety stock level that must be prepared is 3,988 meters, and the reorder point is 6,362 meters to meet demand during lead time. Through the proposed inventory planning, MSMEs can save inventory costs and allocate resources for other purposes.

**Keyword:** Creative industry, MSMEs, inventory, EOQ.

1. Introduction

The creative industry is one of the pillars of the Indonesian industry, which has succeeded in contributing to the greatest increase in national economic growth. The growth of the economic sector by the creative industry itself is quite significant, with an increase of 19.45% from 2016 to 2018 [1]. Pekalongan is a creative city that is the centre of Indonesian batik; not only the batik industry is developing here, but also the development of textile industry and fashion industries. Almost in every corner of the city of Pekalongan, there are creative industry centers for Micro, Small, and Medium Enterprises (MSMEs), especially textiles and fashion.

MSMEs are one line of business that often faces economic uncertainty compared to other large industries [2]. his situation means that MSMEs must be adaptive by carrying out efficiency to reduce losses due to disruption and uncertainty, one example of which is the COVID-19 pandemic that has occurred. This post-disruption effect then had an impact on decreasing demand and increasing supply chain inventories [3], including for MSMEs operating in the fashion and batik sectors in Pekalongan. High inventory levels will result in holding costs and reduce the possibility of profits obtained by a company [4]. The majority of inventory problems are caused by ineffective forecasting, lack of storage support facilities, and an inefficient inventory control system [5]. Therefore, there is a need for strategies and policies to deal with demand and supply problems to ensure that the MSME business continues to run well.

Uncertain demand requires MSMEs to look for ways to survive market competition through inventory management efforts. Inventory management is important in a business because it is directly related to the good production process. Meanwhile, MSMEs are often considered to have failed to reach the optimal point of demand and supply, which results in excess or shortage of inventory [6]. Some inventory problems that often arise in MSMEs are shortages or excess production, stockouts, delays in raw materials, and differences in inventory records [7]. Therefore, there is a need for inventory management analysis so that MSMEs can survive and even develop in the future.

Inventory investment in small businesses tends to dominate the percentage of the total budget, but control needs to be addressed [8]. Thus, the research area related to the effects of inventory on MSMEs is still popular today, such as in research [9]–[12]. Before the massive disruption caused by the COVID-19 pandemic, the majority of companies rarely considered inventory control techniques to mitigate its impact [13]. The unconsciousness then failed several businesses. Therefore, research in the realm of supply chains and supplies, taking into account the disruption caused by the COVID-19 pandemic, has developed greatly in the last two years. Research [14] identified several operational challenges experienced by manufacturers during the COVID-19 pandemic, one of which was excessive inventory. [15] tries to model inventory in a supply disruption scenario with the objective function of minimizing total costs. It can be concluded that appropriate inventory strategies and policies have a significant impact on financial security during the COVID-19 pandemic [16].

This research aims to carry out inventory control for cost efficiency in batik MSMEs in the city of Pekalongan. The main focus of this research is to determine the optimal order quantity for raw materials. Therefore, the inventory model that will be used in this research is the Economic Order Quantity (EOQ). EOQ is used to control the inventory of products or materials purchased [17], not those produced. EOQ allows MSMEs to determine the optimal amount of raw material purchases by minimizing total ordering and storage costs simultaneously [18]. EOQ will help businesses in planning annual costs related to inventory [19]. The results of this research will provide information to MSMEs regarding the amount of raw material purchased, ordering time, minimum inventory amount, and total inventory costs. Then, these results will be used to evaluate action plans and decision-making in one of the Batik Industry MSMEs in Pekalongan.

1. Methods

This type of research is quantitative research carried out on one of the batik MSMEs in Pekalongan, with the main production being stamped batik cloth. It is known that MSMEs are facing a decline in demand, which causes raw material supplies to increase and pile up due to minimal use. This increase in inventory then has an impact on the emergence of operational costs, such as unexpected inventory, to accommodate uncertain levels of demand. Therefore, this research focuses on controlling the inventory of fabric materials as the main raw material for MSMEs, which has implications for developing optimal inventory strategies in the next period.

This research consists of four main stages, which can be seen in Figure 1. The first step begins with data collection, which consists of demand data, lead time for ordering and delivery of raw materials, purchasing costs, holding costs, and ordering costs. The request period used is April 2021 – December 2022, which is then used as a basis for planning for the following year. This data period was chosen because it is considered to accommodate demand data patterns, which tend to decrease and indicate demand uncertainty. This demand data is then converted into raw material requirements for Mori cloth as a research object. Then, this data is analyzed to determine order quantity, reorder point, and total inventory costs using the Economic Order Quantity (EOQ) approach.



**Figure 1.** Research flowchart

EOQ is one of the basic foundations that is often used in inventory management. EOQ aims to minimize costs related to inventory, such as holding costs and ordering costs [20]. EOQ ensures that a business orders the right quantity but still meets market demand so that there is no idle inventory [19]. The initial stage of calculating EOQ is determining ordering costs and holding costs. Order costs in this study consist of transportation costs for delivering raw materials from suppliers to MSMEs and other order administration costs, such as telephone costs. The ordering fee is fixed and does not depend on the quantity ordered but on the ordering frequency. Meanwhile, storage costs are obtained from costs related to storing each unit of raw material, such as warehouse costs and risks attached to the raw material.

The optimal ordering quantity (Q\*) is obtained from the total cost differential process, which consists of ordering costs and holding costs that are equal to zero. The EOQ formula can be seen in equation (1) below.

 $Q=\sqrt{\frac{2 D S}{h}}$ (1)

With:

D = demand for raw materials/year

S = ordering cost/order

h = holding cost/unit

After finding the optimal quantity of orders (Q\*), order frequency (f), reorder point (R), safety stock (SS), and other information related to inventory can be calculated. Next, the Total Cost (TC) of inventory can be calculated based on equations (2) and (3) below.

 $TC=TOC+THC$ (2)

 $TC=\frac{D}{Q}S+\frac{Q}{2}h$ (3)

With:

TOC = Total Ordering Cost

THC = Total Holding Cost

TOC represents the total ordering cost for each order, with $\frac{D}{Q} $indicating the ordering frequency in a period. Meanwhile, THC is the total holding cost for the average inventory. Average inventory is obtained using the formula $\frac{Q}{2}$.

1. Result and Discussions
	1. Raw Material Requirements

Uncertainty in demand for one of the textile and fashion industries in Pekalongan has an impact on uncertain turnover. This erratic demand is one of the impacts of the COVID-19 pandemic, which has further resulted in a decrease in demand for non-essential products, such as creative and fashion products. This then affects shopping centres, which are empty of visitors and buyers. Figure 2 shows a graph of demand for batik cloth (in pieces) in the period April 2021 – December 2022, which is the basis for the observation period for this research.



**Figure 2.** Demand for batik fabric.

It can be seen in Figure 2 that the demand for batik cloth is very fluctuating. It can be seen that there was a decline in demand in June and July 2021, which is assumed to have occurred due to transportation restrictions due to the implementation of policies limiting community activities as a result of the COVID-19 pandemic. The implementation of this policy then had an impact on the closure of wholesale shops in the Pekalongan area and several shopping centres, such as Solo, Semarang, Yogyakarta, Jakarta, and Purwokerto, which were the main demand centres for these MSMEs. Apart from that, the inability to use digital technology as a marketing medium means that the sales space for MSMEs is narrower than before the COVID-19 pandemic occurred. Demand in the following months began to increase and fluctuate stationaryly.

This dynamic demand has an impact on the need for Mori cloth as the basic material for batik cloth that is sold. Mori cloth is a crucial raw material and is the main ingredient in batik cloth production, so shortages or excesses of this raw material will have a big impact on production delays and high inventory costs. Before the pandemic, MSMEs often did not consider inventory costs comprehensively because of the perception that demand was always stagnant every month. So, ordering raw materials is done intuitively and does not have a significant impact on total production costs. However, the pandemic, which has resulted in a drastic reduction in demand, has resulted in a buildup of inventory in warehouses. The decreased demand has an impact on increasing the overall operational costs of MSMEs by 15% – 25%.

By using EOQ, inventory planning is carried out for Mori cloth to determine the optimal order quantity, order time, and minimum stock available to meet the demand that may arise at any time while minimizing total costs. Therefore, data on demand for batik cloth will be converted into the need for raw materials for Mori cloth in meters. Based on the distribution test, data on the demand and need for Mori cloth meets the assumptions of using EOQ, namely that the data is normally distributed. So, the EOQ method is relevant to use in this research. Table 1 shows the need for raw materials during the period January – December 2022. This period was chosen because Indonesia has entered a new normal period and is expected to last for the following months. Thus, the use of this time period is considered to be able to accommodate demand conditions in the following period. In addition, this latest data was chosen to accommodate the annual data required for data processing using EOQ.

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| **Table 1.** Raw material requirements. |
| Period | Requirements (meter) |
| 1 | 29.834,20 |
| 2 | 29.108,20 |
| 3 | 29.807,80 |
| 4 | 32.876,80 |
| 5 | 27.110,60 |
| 6 | 29.158,80 |
| 7 | 27.464,80 |
| 8 | 31.897,80 |
| 9 | 32.392,80 |
| 10 | 29.339,40 |
| 11 | 31.295,00 |
| 12 | 24.371,60 |
| **Total** | 354.648,80 |
| **Average** | 29.554,07 |

* 1. Inventory Costs

Inventory costs used in this research include ordering costs and holding costs. As previously explained, ordering costs consist of transportation and order administration costs. Meanwhile, holding costs are costs related to procurement to store raw materials in meters. Storage costs in this study were obtained from a certain percentage of the raw material value, namely Rp22,778/meter. This percentage is adjusted to the average interest rate at banks in 2022, namely 5.50% and the cost of depreciation or damage to raw materials during storage of 0.50%. So, the holding costs are 6.00% per year of the total raw material costs. These holding costs are linear as the raw materials stored increase. The details of inventory costs can be seen in Table 2 below.

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| --- |
| **Table 2.** Inventory cost breakdown. |
| Cost | Requirements (meter) |
| Material cost | Rp 22.778,00/meter |
| Ordering cost | Rp 200.000,00/order |
| Holding cost | Rp 968,06/meter |

* 1. Economic Order Quantity

To determine the optimal number of orders for raw materials to obtain inventory costs, EOQ is used with reference to Eq. (1). The inventory costs that have been defined in Table 2 will be the basis for determining the optimal order quantity (Q\*).

$Q^{\*}=\sqrt{\frac{2 D S}{h}}$

$Q^{\*}=\sqrt{\frac{2 \left(354.648,8\right)\left(200.000\right)}{1.366,68}}$

 $Q^{\*}=10.188,16157 ≈10.189 units$

Based on the results of the EOQ or Q\* calculation above, it was found that the optimal order quantity for Mori cloth raw materials is 10,189 meters per order. Based on the Q\* value, the order frequency and total costs related to inventory can be calculated and estimated from the beginning of production planning. They can be seen in Eq. (4). Meanwhile, the total inventory costs that must be incurred by implementing the EOQ strategy can be calculated using Eq. (5).

$Ordering frequency= \frac{D}{Q^{\*}}$ (4)

$$Ordering frequnecy=\frac{354.648,8}{10.189}=35 orders/year$$

$TC=\frac{D}{Q}S+\frac{Q}{2}h$ (5)

$TC=\frac{354.648,8}{10.189}\left(200.000\right)+\frac{10.189}{2}(1.366,68)$

$TC=13.923.956,65$

The optimal ordering frequency to meet all raw material needs is 35 times in one period. Apart from that, the total inventory cost for batik MSMEs is IDR 13,923,956.65. These results will provide opportunities for MSMEs in the batik industry to reduce inventory costs and increase profits, which often fluctuate due to falling demand. The Q\* value allows MSMEs to store as little as possible but still be able to meet demand, thereby minimizing inventory costs. Apart from that, these results will also have an impact on the daily operational conditions of the previously implemented strategy. In MSMEs, the inventory strategy that is often used is ordering whenever raw materials run out. The existing strategy influences the high frequency of orders, which has direct implications for ordering costs. By using EOQ, orders will be placed when raw materials approach the reorder point so that production will run normally and minimize the possibility of production not running because raw materials run out.

* 1. Safety Stock

In order to avoid running out of raw materials when unexpected demand occurs, a safety stock calculation is needed. The existence of safety stock will also help MSMEs minimize delays in receiving ordered raw materials [21]. Safety stock can be calculated from the demand deviation value multiplied by the service level desired by MSMEs. Service level can be interpreted as the level of fulfilment of requests [22]. A high service level will reduce the possibility of stockouts [23]. The service level value used is 95%, which means that MSMEs can fulfil all requests with a probability of 95%. Determination of safety stock (SS) can be done using Eq. (6) below.

 $SS=Zα$ (6)

 $SS=\left(1,65\right)\left(2437,665\right)=3997,77≈3998 units$

Dengan:

Z = Service factor adjusted to the specified service level. The Z value is determined from the normal

 distribution table. A service level of 95% has a Z value in the normal curve area of 1.65.

α = The standard deviation of raw materials is 2437.665

Therefore, to ensure that there are sufficient raw materials, a minimum inventory of 3,998 meters is required.

* 1. Reorder Point

The next analysis in inventory control is to determine when orders for raw materials must be reordered (reorder point). Reorder point (R) is a measure of the amount of inventory that becomes the reorder point so as not to disrupt the production process. The reorder point indicates the inventory level that will be used during lead time (LT). Therefore, determining R will depend on the lead time for ordering raw materials from suppliers. Reorder point can be calculated using Eq. (7) below.

 $R=d LT+SS$ (7)

With:

R = reorder point

d = demand in days

LT = lead time

It is known that the MSME batik industry's lead time is two days, with the average daily requirement for Mori cloth raw materials being 1,182 meters. Therefore, the reorder point for MSMEs in the batik industry is as follows.

 $R=\left(11820\right)\left(2\right)+3998=6362 units$

In general, these results imply that when the inventory has reached 6,362 meters, an order for Q\* = 10,189 meters must be made immediately so that the two-day production lead time can still run. Figure 3 below shows an illustration of Q, R, and SS for inventory control in the Pekalongan batik industry MSMEs.



**Figure 3.** The relationship of Q, R, and SS in Pekalongan Batik MSMEs

Figure 3 shows what the inventory levels should be in one of the MSMEs in the Pekalongan batik industry. Figure 3 also provides concrete information regarding when orders must be placed, the optimal order quantity that can minimize inventory costs and the minimum stock that must be in the warehouse in order to accommodate requests that may arise at any time. So far, MSMEs do not have inventory planning, so ordering and holding are often intuitive on the part of the owner. Thus, the absence of this planning results in overstock or shortage of raw materials. Excessive raw materials will result in high inventory costs. On the other hand, too little inventory results in lost sales opportunities. Every MSME business is required to survive by getting as many customers as possible but can reduce unnecessary costs, one of which is inventory costs.

This inventory planning will help MSMEs minimize inventory costs, considering that MSMEs are often faced with uncertainty in demand and supply. Apart from that, through inventory planning, MSMEs can minimize warehouse costs due to the small amount of inventory and low fabric storage costs, so the risk of shrinkage can decrease. Further implications of the results of this research will direct MSMEs to maximize resources for other purposes. A further impact is that MSMEs can increase profits from what they previously obtained.

1. Conclusions

In inventory management, the EOQ model provides optimal results for overall stock control. EOQ gives MSMEs the opportunity to minimize total additional costs (total incremental costs) beyond the cost of the product itself by optimizing the number of orders. From the results of this research, it is known that the optimal order quantity for the main raw material in one of the batik MSMEs in Pekalongan is 10,189 meters. This order amount results in a total annual inventory cost of IDR 13,923,956.65. Further information regarding inventory planning in MSMEs is the reorder point and safety stock levels, which respectively amount to 6,362 meters and 3,998 meters. During the planning horizon, it is known that orders are placed 35 times to meet requests for one year. These results will provide readiness for MSMEs to prepare resources and make decisions more objectively.

This research uses a simple EOQ model to carry out inventory planning. As is known, the EOQ model is often developed to meet certain assumptions, such as the existence of shortages, the possibility of backorders, and other uncertainties. Therefore, further research should consider these conditions to obtain results that are appropriate for MSMEs, especially during the pandemic, which often experiences uncertainty.

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