



Inventory management of 50 kg packaged cement products with a lot sizing ratio (Case study: XYZ warehouse)

Annisa Sherina Rahmadhani Hasibuan^{a,1}, Wahyuda Wahyuda^a, Farida Djumiati Sitania^a

^aDepartment of Industrial Engineering, Faculty of Engineering, Universitas Mulawarman, Jl. Kuaro, Gn. Kelua, Samarinda Ulu, Samarinda City 75119, East Kalimantan, Indonesia

¹E-mail: annisasrhasibuan@gmail.com

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ABSTRACT

XYZ is a trading and shipping company for building needs. The problem experienced by XYZ warehouse is the high demand for 50 kg packaged Conch cement products without being balanced with good inventory management so that companies often experience shortages and excess supplies which can increase inventory costs. Therefore, good inventory planning and control are needed to make the costs incurred is more optimal. The model used in this study is the economic order quantity (EOQ) model by calculating safety stock and reorder points to avoid demand uncertainty. Before calculating the inventory model, forecasting was done using the moving average six methods as the chosen method with MAD 4,712,852, MSE 37,283,346,809, and MAPE 15.502%. Based on the calculation results, the optimal order quantity was 1,868, safety stock was 185, and reorder point was 1,320. Other than that, the lot-sizing technique was also carried out using the EOQ, LFL, POQ, and Silver Meal methods. Based on the calculation result, the lot-sizing technique that provides a minimum total cost was the LFL method with a total cost of Rp. 1,430,406.61 and savings up to 77.04%, followed by the EOQ method with a total cost of Rp. 1,918,668.55 and savings up to 69.21%. Also, the POQ and Silver Meal method with a total cost of Rp. 2,106,571.61 and savings up to 66.19%.

ABSTRAK

PT. XYZ merupakan perusahaan yang beroperasi dalam sektor perdagangan barang dan jasa pengiriman untuk keperluan bahan bangunan. Permasalahan yang dihadapi Gudang XYZ adalah tingginya permintaan produk Conch cement 50 kg tanpa diimbangi pengelolaan persediaan yang baik sehingga kerap mengalami kekurangan maupun kelebihan persediaan di mana hal tersebut dapat meningkatkan biaya persediaan. Oleh karena itu, dibutuhkan suatu perencanaan dan pengelolaan persediaan yang baik sehingga biaya yang dikeluarkan pun lebih optimal. Model yang dimanfaatkan dalam penelitian ini adalah model economic order quantity (EOQ) dengan memperhitungkan safety stock dan reorder point untuk menghindari ketidakpastian permintaan. Sebelum dilakukan perhitungan model persediaan, terlebih dahulu dilakukan peramalan dengan metode moving average 6 sebagai metode terpilih dengan MAD 4.712,852, MSE 37.283.346,809, MAPE 15,502%. Berdasarkan hasil perhitungan model EOQ, diperoleh Q optimal sebanyak 1.868 sak, safety stock 185 sak, dan reorder point 1.320 sak. Selain itu, dilakukan pula lot sizing dengan metode EOQ, LFL, POQ, dan Silver Meal. Berdasarkan hasil perhitungan, lot sizing yang memberikan total biaya minimum adalah LFL dengan total biaya sebesar Rp. 1.430.406,61 dan penghematan mencapai 77,04%, kemudian diikuti oleh EOQ dengan total biaya sebesar Rp. 1.918.668,55 dan penghematan mencapai 69,21%, dan POQ serta Silver Meal dengan total biaya sebesar Rp. 2.106.571,61 dan penghematan mencapai 66,19%.

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1. Introduction

The increasingly fierce and competitive global competition encourages business actors to improve efficiency in all fields, especially inventory management or management. Inventory management aims to balance investment and customer service [1]. According to Handoko in [2], inventory



management must involve a large investment, an essential managerial function. A company cannot achieve a low-cost strategy without good inventory management. Inventory management has a significant influence on the financial condition of a company. The amount of money invested in inventory formulations is generally found, making inventory the single largest asset a company has. Many companies have inventory value of more than 25% of their total assets, which shows that the value of the stagnant assets is high in inventory [3]. PT. XYZ is a company that operates in the trading sector of goods and shipping services for building materials. Until now, PT. XYZ has three store units spread across the cities of Samarinda and Tenggarong. In meeting its needs, PT. XYZ has a warehouse used to store supplies of cement, iron, plywood, and other materials. The XYZ warehouse is managed by PT ABC, which is part of the XYZ Group and a provider or distributor of Semen Conch for the Samarinda & surrounding areas.

Based on product sales data for 2020, 50 kg Conch cement products have the highest demand, which is 65.85% of the total sales of all items in the XYZ Warehouse. The high demand for 50 kg packaged Conch cement products must be anticipated with good inventory management. The current inventory model for Conch cement packaged in 50 kg is a continuous purchase every day. The model has not run optimally because the company often experiences excess or shortage, thereby increasing inventory costs. After all, it does not pay attention to the optimal order quantity. As a result of the excess inventory, namely the increase in inventory costs, while the lack of inventory is the unfulfilled demand from consumers [2]. If the demand is not met, the company must place an order for the product to the vendor, resulting in delays in the delivery process of the product to the consumer, and the company can even lose customers. In addition, this can result in losses because it increases the costs incurred for reordering and reduces consumers' trust.

Based on these problems, it is necessary to carry out good inventory management so that the costs incurred are more optimal. Efforts to optimize the inventory costs of 50 kg Conch cement products are to use the economic order quantity (EOQ) model. The EOQ model is one of the inventory management techniques that can minimize the total ordering and storage costs. This model is one of the most frequently used inventory management techniques, is relatively easy to do, and can avoid the occurrence of excess or shortage of inventory. In addition, the determination of safety stock (SS) is carried out to protect against uncertainty in demand, supply, and reorder point (ROP). The next step is to determine the order lot size (lot sizing) using the economic order quantity (EOQ), lot for lot (LFL), periodic order quantity (POQ) method, and the silver meal method. This step tries to establish an ordering strategy that minimizes ordering and storage expenses.

The previous research related to inventory management, namely research [4-8]. Research [4] compares optimal inventory policies by considering the minimum total inventory costs. With the same topic, [5-6] discusses the optimal inventory level and frequency of orders for merchandise inventory. Slightly different, [7] examined the optimal Q value and total inventory cost using the EOQ and silver meal methods. Research [8] shows that a company has not carried out optimal inventory management because it only makes purchases based on hunches when goods are running out, so the company must do forecasting and EOQ calculations to plan inventory better. This research will discuss the supply of 50 kg packaged Conch cement products at XYZ Warehouse. This study uses the EOQ method followed by lot-sizing EOQ, LFL, POQ, and Silver Meal to overcome inventory problems. The results of this study are expected to help XYZ warehouse or other warehouses that have the same characteristics and problems. In addition, the company can find out the amount of safety stock (SS), know when to order another product based on the reorder point (ROP), and get the right lot-sizing technique proposal to optimize the total cost of 50 kg packaged Conch cement product.

2. Research Methodology

This study uses primary data and secondary data. Primary data were obtained directly through observation and interviews, as secondary data was obtained indirectly through available intermediary media, such as company documents, books, journals, and so on [9]. The primary data in this research are purchase cost data, order cost data, and storage cost data for 50 kg Conch cement products. The secondary data in this study is data on sales of 50 kg Conch cement products for 15 periods, namely January 2020 - March 2021. The data processing stage consists of many steps, namely forecasting, calculating the optimal Q value, safety stock and reorder point, and lot sizing. EOQ, LFL, POQ, silver meal, and company policy models.

2.1. Forecasting

Inventory forecasting is done first to determine the number of product requests in inventory management. Demand forecasting estimates the demand for products or services within a company. Forecasting can help in decision making so that it requires immediate and accurate information about the actual demand where the focus of attention is on identifying and tracking consumer desires very quickly. Forecasting will include collecting historical data and projecting it into the future in a mathematical model [1]. Forecasting can be done using two approaches, namely quantitative and qualitative. Quantitative forecasting is carried out using statistical methods, while qualitative forecasting is carried out based on the forecaster's opinion [10]. There are seven basic steps in forecasting. This step demonstrates a systematic rule for starting, designing, and implementing forecasting methods which can be seen as follows [1].

- a. Determine the purpose of forecasting
- b. Selecting the product to be forecasted
- c. Determine the forecasting time horizon
- d. Choose a forecasting model
- e. Perform data collection needed in forecasting
- f. Making forecasts, and
- g. Validate and apply forecasting results.

2.2. Economic Order Quantity

The most frequent and relatively easy inventory management technique to do is the Economic Order Quantity (EOQ) model. The inventory model is generally used to minimize total costs by ordering and holding costs. With the EOQ model, the optimal order quantity will appear at a point where the total ordering cost and the total holding cost intersect. This technique is based on the following assumptions [1]:

- a. The number of requests is known, fairly constant, and independent
- b. The waiting time between ordering and receiving is known and constant
- c. Inventories ordered are received immediately and completely completed in one batch at a time

- d. No quantity discount available
- e. Variable costs are only in the form of installation or ordering costs and costs to hold inventory for a certain time
- f. Orders are placed on time to avoid running out of stock

2.3. Safety Supplies

According to Assauri in [11], safety stock is an additional inventory by considering the circumstances that allow shortages or out-of-stock due to unequal demand for a product. Several factors affect the safety stock level that must be carried out, namely the level of sales expected by the company and the waiting time for delivery [12]. Safety stock generally uses acceptable deviation limits, which are 5% higher than forecast and 5% lower than forecast, with a value of 1.65 [13]. A standard deviation calculation is carried out to determine the magnitude of the deviation between the estimated product demand and actual product demand [5].

2.4. Reorder Point

The simple inventory model assumes that orders are received at the same time. In other words, this model assumes the the company will place an order when the product inventory level reaches zero, and the company will receive the ordered products simultaneously. However, there is a time difference between procurement and receipt of orders in practice, which is referred to as lead time. Lead time is required to place an order until the company's warehouse receives the product as inventory [14]. The decision when to place an order is generally expressed by the reorder point, which is the inventory level at which an order must be placed when the inventory has reached that level. The purpose of determining the reorder point is to minimize the danger of an inventory shortage in the business [15].

2.5. Lot Sizing

Lot sizing is a process or technique used in determining the size of the order quantity. The lot size can be the number of production or the amount ordered from the vendor. Things considered in deciding on the lot sizing method are costs incurred due to inventory, namely ordering costs and storage costs. The calculation of the total costs incurred by the lot-sizing technique can be obtained as follows [16]:

$$\text{Total cost} = \text{ordering cost} + \text{holding cost} \quad (1)$$

The lot sizing methods used in this study are as follows:

- a. Economic order quantity method. The economic order quantity (EOQ) method is a lot-sizing method where the quantity ordered is fixed based on the calculation of the optimal order quantity. EOQ can be an appropriate method when demand is relatively consistent. Orders on this method will be made when the amount of inventory can no longer meet the desired needs [1]. In research [8], the application of the EOQ method can provide minimal storage costs, save space, and solve problems that arise from stockpiling. The EOQ method also helps companies determine the optimal order quantity and reorder time.
- b. Lot for lot method. The lot for lot (LFL) method is one of the lot sizing methods that always recalculate the net requirement. In this method, the quantity ordered is only following the net requirement, there is no safety stock, and does not anticipate further orders. This method aims to minimize storage costs so that storage costs can be zero [1]. The advantage of the LFL method is that there is no inventory, so there are no storage costs. The drawback of the LFL method is that if an order suddenly exceeds the estimated number of needs, the company will have difficulty meeting these needs [17]. In research [18], the use of LFL lot-sizing can reduce the total distribution costs incurred by the company. By implementing LFL lot-sizing, the distribution process in the company can run better so that consumer demand can be fulfilled appropriately, both in quantity and time.
- c. Periodic order quantity method. Periodic order quantity (POQ) is a lot-sizing method that orders are placed based on needs during certain intervals. The quantity of each order will be recalculated when the order is released so as not to cause excess inventory [1]. Lot sizing POQ extends the EOQ method for uneven demand [17]. In research [19], lot sizing with the POQ method can save the cost of procuring raw materials and total inventory costs of up to 20% per year.
- d. Silver meal method. According to [17], Edward Silver and Harlan Meal developed the silver meal algorithm. This method determines the dynamic lot size based on the state of least period cost to determine the average inventory cost per period. This method aims to determine the value of the amount that provides the minimum relevant total costs for each period.

3. Result and Discussion

3.1. Forecasting Calculation Analysis

This study used several forecasting methods, namely single exponential smoothing, exponential smoothing with the trend, moving average, and simple linear regression. The exponential smoothing and moving average methods reduce random factors in the forecasting data. In contrast, exponential smoothing with the trend and simple linear regression methods are used to see if there is an element of a trend or trend in the data. The forecasting method chosen is the method that gives the smallest MAD, MSE, and MAPE error values. The following is a comparison of forecasting errors.

Based on Table 1, it can be seen that there is no accurate method. Therefore, in selecting the forecasting method, a comparison is made to the value of the forecasting error [1]. In Table 1, the forecasting method that produces the smallest forecasting error is the moving average of six methods with a MAD error value of 4,712,852, MSE 37,183,346.809, and MAPE 15,502%. The smaller the error value of a forecast, the better the forecast is in predicting the future. Next, forecast verification is carried out to measure forecasting accuracy using a tracking signal. The tracking signal chart for forecasting Conch cement 50 kg using the six moving average methods is shown in Figure 1. The forecasting period is only 12 periods, because the longer the planning horizon, the less accurate it will be.

Figure 1 shows that all tracking signal values are within the control limits, between -4 to +4 for each period. The value shows that six moving methods are considered appropriate in predicting the 50 kg Conch cement forecast. The difference between the actual demand and the demand for forecasting results which is then compared with the MAD value, is acceptable. The results of forecasting sales of 50 kg Conch cement for the next 12

months using the moving average six methods are shown in Table 2. In Table 2, it can be seen the results of forecasting the demand for 50 kg Conch cement which have been carried out using the six moving average methods for the next 12 periods, amounting to 353,940 sacks. Forecasting is not too long, only 12 periods. This process is done because the longer the planning horizon, the less accurate it will be.

Table 1. The results of the comparison of forecasting errors.

Forecasting method	α	β	MAD	MSE	MAPE
Single exponential smoothing	0.45	-	6,325.794	95,051,327.661	23.467%
Exponential smoothing with trend	0.88	0.30	8,222.093	126,815,541.482	29.630%
Moving average 3	-	-	5,908.556	77,938,063	18.725%
Moving average 4	-	-	4,900.795	39,310,541.972	16.604%
Moving average 5	-	-	5,335.200	46,262,650.328	17.847%
Moving average 6	-	-	4,712.852	37,183,346.809	15.502%
Linear regression	-	-	6,131.405	59,392,053.974	51.579%

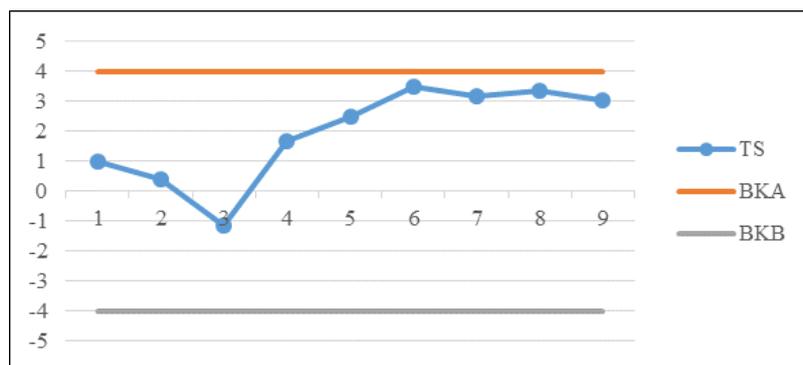


Figure 1. Tracking signal conch cement 50 kg moving average method 6.

Table 2. Forecasting results of 50kg snail cement using the moving average method 6.

Month	Forecasting results	Month	Forecasting results
April 2021	31,258	November 2021	29,345
May 2021	29,672	December 2021	29,290
June 2021	29,460	January 2022	29,262
July 2021	28,750	February 2022	29,347
August 2021	29,211	March 2022	29,370
September 2021	29,357	Σ	353,940
October 2021	29,618	Deviation standard	574,856

3.2. Optimal Order Quantity Analysis

In calculating the optimal order quantity with the EOQ model, it is necessary to detail costs related to 50 kg Conch Cement inventory procurement. The following are detailed data related to 50 kg Conch cement supplies procurement.

- Forecasting the need for 50 kg Conch cement for one year (D), which is 353,940 sacks
- The purchase fee per bag of cement is Rp. 41,000.00/ sack.
- Ordering fee (S) Rp. 4,567.40/ one message.
- Storage fee (H) is 2.26% per bag/year

The calculation of the optimal order quantity for 50 kg Conch cement products can be obtained as follows:

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(353,940)(4,567.40)}{41,000(0.0226)}} = 1.86 \text{ sack} \quad (2)$$

The optimal Q formula calculations show the quantity forecasted for 50kg Conch cement product demand for the next 12 periods using the moving average 6 methods is 353.940 sacks. This value shows the total number of bags of cement needed for the next 12 months, from April 2021 to March 2022,

which is obtained from forecasting with an average movement of 6 months. With this request, it is known that the optimal order quantity is with an ordering cost of Rp. 4,576.40 per one order and a storage cost of 2.26% per sack/year of the purchase cost, which is 1,868 sacks.

3.3. Safety Stock Analysis and Reorder Point

When procuring 50 kg Conch cement supplies, there is a waiting time or lead time until the inventory arrives at the warehouse one day. The quantity of safety stock is determined to anticipate the likelihood of shortages or out-of-stock, either owing to uncertainty in demand, delays in the receipt of orders, or other factors. The calculation of the 50 kg Conch cement safety stock can be obtained as follows:

$$SS = Z\sigma\sqrt{L} = 1.645(574.856)\sqrt{\frac{1}{26}} = 185 \text{ sack} \quad (3)$$

The results based on the safety stock formula show that the safety stock of 50 kg Conch cement products must be provided by the company assuming a service level of 95%, which is 185 sacks. This inventory is carried out to avoid stockouts if the demand during the waiting time exceeds the forecasted demand. The calculation reorder point (ROP) is carried out to determine when the remaining inventory is how much it must be reordered. The calculation of ROP can be obtained as follows:

$$ROP = (d \times L) + SS = \left(\frac{353,940}{26 \times 12} \times 1\right) + 185 = 1,320 \text{ sack} \quad (4)$$

The calculation results using the ROP formula show that when there are 1,320 bags of inventory left in the warehouse, a reorder must be made. Setting the ROP can anticipate the need for inventory during the waiting time. In addition, because the amount of the ROP has been adjusted to the safety stock, it can also be anticipated that demand uncertainty during the waiting time can be anticipated.

3.4. Lot Size Analysis

Several lot-sizing methods are calculated to see the order size planning that can provide the minimum ordering cost and storage cost. The methods used are lot-sizing EOQ, LFL, POQ, Silver Meal, and company policy. After calculating the lot sizing, the method that produces the total ordering and minimum storage costs is chosen. The following is the result of calculating the costs of several lot-sizing methods.

Table 3. Cost of lot sizing calculation.

Lot sizing method	Ordering frequency	Ordering cost	Holding cost	Total cost
EOQ	188	Rp 858,671.20	Rp 1,059,997.35	Rp 1,918,668.55
LFL	309	Rp 1,411,326.60	Rp 19,079.81	Rp 1,430,406.41
POQ	155	Rp 707,947.00	Rp 1,398,624.61	Rp 2,106,571.61
Silver meal	155	Rp 707,947.00	Rp 1,398,624.61	Rp 2,106,571.61
Company policy	178	Rp 812,997.20	Rp 5,418,238.20	Rp 6,231,235.40

Table 3 shows that the LFL lot sizing method has the minimum total cost, Rp. 1,430,406.61. Then followed by the EOQ method, which has a total cost of Rp.1,918,668.55, and the POQ method and silver meal with a similar total cost, Rp. 2,106,571.61. The lot sizing with the company's policy resulted in the largest total cost, which was Rp. 6,231,235.40. Lot sizing with company policy is carried out to compare the proposed lot sizing method, which is calculated. The lot size currently being carried out by the company is 100 tons or 2,000 sacks continuous order, with an order period of 1-2 days, safety stock is 2,000 sacks, and no orders are placed if the inventory in the warehouse has reached $\pm 6,000$ sacks. This model causes inventory accumulation in the warehouse because, based on the forecasting results, the average demand for Conch cement 50 kg per day is only 1,134.423 sacks or rounded up to 1,135 bags. By carrying out the inventory model that the company is currently applying, it will cause storage costs to increase. Table 3 shows the value of storage costs with company policy is very high compared to other lot sizing methods, Rp. 5,418,238.20. The increase in storage costs will also affect total inventory costs.

By applying the EOQ lot sizing method, the message fee is 5.62% higher than the company's policy. The fee happens because the ordering frequency exceeds the company's policy, 188 times the order. However, the cost of saving on the EOQ method is 80.44% lower than the company's policy, so that a total cost savings of Rp. 4,312,566.85 or 69.21% can be made. The storage cost results in a lower value than the company's policy because the EOQ method has considered the optimal order quantity. In addition, in the EOQ method, there is also a safety stock with a quantity of 185 sacks. This amount is less than the safety stock applied by the company, which is 2,000 sacks. This safety stock serves to avoid shortages or out-of-stock, but if the amount is too much, it will cause storage costs to increase.

In the LFL lot sizing method, the message cost is the largest compared to other methods and 73.60% greater than the company policy. However, the LFL method produces the lowest storage cost compared to other methods. It is 99.65% lower than company policy because of the depreciation of holding costs by not storing the remaining inventory from the previous period. The inventory costs come from the cost of repeated orders whose quantity is adjusted to the net needs of each period. The frequency of ordering using the LFL method is 309 times the order. The total cost savings if the company applies the LFL method, which is Rp. 4,800,828.99 or 77.04% of the company's policy.

In the lot sizing POQ method, the lowest cost of ordering is obtained compared to other methods and 12.92% lower than company policy because the frequency of order is less than that made by the company, which is 155 orders. These orders are made periodically with POQ intervals, which are two periods. The order is made based on the need for two periods each time the order. The cost of storage in the POQ method is 74.19% lower than the company's policy because this method is balanced so that there is no excess inventory. The total cost of the POQ method is Rp. 2,106,571.61, with a total cost savings of 66.19%. By applying the silver meal lot sizing method, the cost is similar to that of the POQ lot sizing, which is 12.92% ordering cost and

74.19% lower holding cost compared to company policy. In this method, the order size is carried out at dynamic intervals based on calculations that produce a minimum total cost per period. The total cost of the silver meal method is Rp.2,106,571.61, with a total cost savings of 66.19%.

Overall, the LFL method best determines the demand for 50 kg Conch cement product planning for the next 12 periods. By applying the LFL method, the company can save 77.04% because of demand forecasting, which is quite constant. In addition, the large order size is not an obstacle in placing an order to the vendor because the cost of the expedition is calculated according to the amount of cargo sent. There is a weakness in the LFL method. If the demand that occurs exceeds the results of forecasting calculations carried out, the company cannot directly meet these needs because there is no safety stock. However, the lead time for Conch cement 50 products which are not too long, which is one day, becomes one of the advantages if there is a sudden spike in demand at any time. Because of the short lead time, the growing demand can be satisfied rapidly; cement demand is not an urgent necessity.

4. Conclusion

The results show the most appropriate method for forecasting the demand for 50 kg Conch cement at XYZ Warehouse for the next year is the moving average of six methods with an error value of MAD 4,712,852, MSE 37,283,346.809, MAPE 15,502%, and the results forecast of 353,940 sacks. The optimal order quantity to fulfill this demand is 1,868 sacks. Safety stock to anticipate demand uncertainty during the waiting time, 185 sacks, and orders will be made again when the remaining stock is 1,320 bags.

The proposed lot sizing method that produces the minimum ordering and storage costs is the LFL method, with Rp. 1,430,406.61 and a total cost savings of 77.04%. The LFL method is very good for use in XYZ Warehouse problems because the company can carry out inventories according to net needs each period and reduce inventory costs. The next proposed lot sizing method follows the EOQ method of Rp1,918,668.55 with a total cost savings of 69.21% and the POQ and Silver Meal method Rp2,106,571.61 with a total cost savings of 66.19%.

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