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Optimization of Plastic Packaging Production Planning Using Economic Production Quantity

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ABSTRACT: Competition in the industrial world demands that companies be more meticulous in determining the optimal production quantity to increase profitability and maintain consumer demand. The aim of this research is to establish the optimal production quantity and minimize total production costs using the Economic Production Quantity (EPQ) method. The EPQ method can be utilized to determine the optimal inventory quantity when a company manufactures its own goods. This study employs secondary data sourced from previous research using different methods. The data used consists of financial records from CV. XYZ spanning from February 2021 to January 2022. By applying the Single-Item Economic Production Quantity (EPQ) method at CV. XYZ, the optimal production quantity for each cycle was determined to be 273 balls, with an optimal number of cycles per year being 44 cycles. In addition, cost savings of 12.3% per year were obtained compared to the production cost before using the EOQ method.

KEYWORDS: industrial competition, economic production quantity, single-item, optimization of production quantity, cost savings

I. INTRODUCTION

The advancement of technology and information has brought significant changes to the industrial landscape in Indonesia. Various types of industries, ranging from home-based businesses to large-scale enterprises, have emerged, leading to increasingly fierce competition. To survive and thrive, companies are required to formulate effective strategies. One crucial approach is to enhance the effectiveness and efficiency of production processes. By reducing production costs, companies can not only increase profits but also meet the growing demands of consumers.

Production is the process of transforming raw materials into finished goods ready for the market [1] . These finished goods are typically stored as inventory before being distributed to consumers. Companies need to determine the right production quantity as it affects production costs, storage costs, and profits. Therefore, optimal production planning is crucial for companies.

Production planning, according to [2], is the process of determining the types and quantities of products to be produced over a specific period. This planning is crucial in management as it allows for the optimal utilization of limited resources to achieve company goals. Therefore, selecting the appropriate method for production planning is essential.

In production planning, determining the production quantity is a crucial aspect to produce the optimal amount of products, avoiding shortages or overages. A company must choose the right method for production quantity planning. Inventory models that can be applied to determine the optimal production quantity include Economic Order Quantity (EOQ), Quantity Discount Model, Production [3] capacity Constraint Model [4], Backordering Model [5], Lead Time Model [6], and Economic Production Quantity (EPQ)[4]. These models share similar assumptions but differ in terms of product source, quantity discounts, backorders, production capacity constraints, or lead time. The selection of the appropriate model depends on the specific characteristics of the inventory system being managed.

EPQ is a mathematical model used in inventory management to determine the optimal quantity of products to be produced in each production cycle in order to minimize total inventory costs. This model considers holding costs and setup costs to achieve an optimal balance. EPQ can be applied when a company carries out internal production. In the EPQ model, the quantity of demand, production rate, holding cost per unit, and ordering or setup costs are all assumed to be constant. Additionally, it is assumed that there are no stockouts. [4].

Research related to the application of EPQ was carried out by [7] to analyze refined sugar products. The results obtained are optimal production quantities, optimal production cycles and time intervals, and by applying the EPQ method, total inventory cost savings of 9% are obtained. [3] have also conducted research by comparing inventory control methods *Economic Order Quantity* (EOQ), *Just In Time* (JIT), *Economic Production Quantity* (EPQ), and *Material Requirement Planning* (MRP) in determining

production costs to maximize profits. The results of this research showed that the EPQ method produced greater profits compared to other methods.

CV. XYZ is an industrial company engaged in plastic printing and manufactures its own goods. CV XYZ is located in Semarang (Central Java, Indonesia). CV. XYZ uses semi-finished raw materials which are processed into plastic packaging. The production results are usually distributed to several areas in Central Java, namely Magelang, Semarang, Boyolali, Purworejo and Temanggung. Before being marketed, the finished plastic packaging will be stored in the warehouse as stock. So that inventory does not pile up in the warehouse, it is necessary to carry out careful production planning. Because CV XYZ is a company that manufactures its own **goods**, so we can use EPQ model.

The aims of this research are to determine: the optimal production quantity and minimum total production costs using the economic production quantity (EPQ) method on CV. XYZ.

II. METHODS

The data used in this research is secondary data from [8]. He was obtained the data from CV XYZ, a company located in Semarang, Indonesia. The data is taken from the period February 2021 to January 2022 which includes: total production and demand in a year, number of working days, storage costs per bale per year, material costs (raw materials) per bale, number of production machines, employee wages per month, number of employees, and working hours per day. The complete data is as follows:

1. Total production and demand in a year.

Data on production and demand for plastic packaging during the time period February 2021 to January 2022 can be seen in Table 1

Table 1. Plastic Sales Data from February 2021 - January 2022

Month	Total		
	Production in bales (P)	Demand in bales (D)	(P – D) in bales
Pebruary 2021	1,493	1,493	470
March 2021	1,842	1,842	921
April 2021	2,141	2,141	1,095
May 2021	2,227	2,227	1,241
June 2021	2,273	2,273	1,290
July 2021	2,324	2,324	1,204
August 2021	2,189	2,189	1,168
September 2021	2,213	2,213	1,267
October 2021	2,290	2,290	1,259
November 2021	2,407	2,407	1,472
December 2021	2,598	2,598	1,588
January 2021	2,798	2,798	1,688
Total	26,795	12,132	14,663

Source: [8]

2. Storage costs (H) are set at 3% of production costs.
3. Material costs (R) are IDR 302,600 / plastic bale.
4. The number of production machines (L) is 5 machines.
5. The amount of employee wages per month (W) is IDR 2,400,000,-
6. The number of employees (E) is 23 people.
7. Many CV XYZ employees work hours.

Within a week CV employees. XYZ works for six days, namely from Monday to Saturday, with the number of working hours in a day (T) being 7 hours.

Since CV XYZ produces its own goods and optimization is only reviewed on one type of production goods, the method applied in this study is the single-item economic production quantity (EPQ). In this model, the amount of production must be greater than the level of demand, with the aim of ensuring that inventory can meet customer needs. Therefore, the company will carry out the production process again before the inventory runs out. The amount of inventory will increase gradually and also decrease gradually due to demand[9].

In this research there are several problem limitations, namely

1. the machine *set-up time* is assumed to be 15 minutes.

2. no depreciation costs for goods
3. not considering the presence of defective products

The data analysis in this research was calculated with Microsoft Excel. The steps used in carrying out data analysis are as follows.

1. Preparing data that was obtained from [8].
2. Calculate the optimal production quantity and optimal total production costs using *single-item economic production quantity* (EPQ) , with steps

a. Calculate employee wages for producing one bale of plastic (B), using the equation

$$B = \frac{W \times M \times E}{N} \quad (1)$$

where B is the employee's wage for producing one bale of plastic (B); W the monthly wage of the employees ; M number of months in a year; E the number of employees; N total production in a year.

b. Calculate production costs per bale per year (V) using the equation

$$V = R + B \quad (2)$$

where R raw material cost per bales.

c. Calculate storage costs per unit per year (H) using the equation

$$H = 3\% \times P \quad (3)$$

d. Calculate the average number of working days in a month ($\bar{A}$), by first determining the number of working days per month for each employee from February 2021 to January 2022, then calculating the average.

e. Calculate set-up costs per production cycle (C) by first calculating employee wages per minute (G) using the equation

$$G = \frac{W}{\bar{A}S} \quad (4)$$

where S is the number of hours worked in one day, which in this case is 7 hours.

Next, set-up cost (C) is calculated using the equation

$$C = GTL \quad (5)$$

where T machine set-up time and L lots of machines.

f. Calculate the optimal production quantity ($Q_p{}^*$) using the equation [4]

$$Q_p{}^* = \sqrt{\frac{2CDp}{H(p-r)}} \quad (6)$$

where D is the number of demand per year; p production rate per day; d demand rate per day.

g. Calculate the optimal number of production cycles in a year (m)using the equation [4]

$$m = \frac{D}{Q_p{}^*} \quad (7)$$

h. Calculate optimal total production costs (TIC^*)[4]

$$TIC^* = VD + \frac{HQ^*(p-r)}{p} \quad (8)$$

3. Calculate production costs without using specific mathematical methods
4. Compare the results of production cost calculations using the EPQ method and without using a particular method.
5. Interpretation of data analysis results.

III. RESULT AND DISCUSION

Based on the data that has been obtained, first we calculate the employee's wages for producing one plastic bale (B), using equation (1)

$$B = \frac{WME}{N} = \frac{(2{,}400{,}0000)(12)(23)}{26{,}795} = IDR\ 24{,}721$$

From these results, the plastic production cost per bale (V) is calculated using equation (2)

$$V = R + B = IDR\ 302{,}600 + IDR\ 24{,}721 = IDR\ 327{,}321$$

Based on these results and considering the large storage costs at CV. XYZ has been set at 3% of production costs, so storage costs per bale (H) can be calculated using equation (3), namely

$$H = 3\% \times V = 3\% \times \text{IDR } 327{,}321 = \text{IDR } 9{,}820$$

The next step is to calculate the average number of working days in a month ($\bar{A}$), by first determining the number of working days per month for each employee from February 2021 to January 2022, then calculating the average, as presented in Table 2.

Table 2. Number of Working Days Each Month of CV XYZ employees from February 2021 to January 2022

Month	Total working days
Pebruary 2021	24
March 2021	27
April 2021	26
May 2021	26
June 2021	26
July 2021	27
August 2021	26
September 2021	26
October 2021	26
November 2021	26
December 2021	27
January 2021	27
Total	314
Average	26

Source: processed data (2024)

Based on Table 2, the average number of working days of CV XYZ employees in a month ($\bar{A}$) is 26 days.

Furthermore, because the average number of working days of CV XYZ employees in a month ($\bar{A}$) is 26 days and the number of working hours of employees in one day (S) is 7 hours, then the employee wages per minute (G) can be calculated using equation (4), it is obtained that

$$G = \frac{W}{\bar{A}S} = \frac{IDR.2,400.000}{(26)(7)} = IDR\ 13,186.813/\text{hour} = \text{IDR } 219.78 / \text{minute}$$

Then, considering the time required to set up the machine (T) is assumed to be 15 minutes, while the number of machines (L) used in making plastic at CV XYZ is 5 machines, then the set-up cost (C) for 5 machines in one production cycle can be calculated using equation (5), namely:

$$C = GTL = \text{IDR } 219.78 \times 15 \times 5 = IDR\ 16,483.5 \approx IDR\ .\ 16,484$$

After obtaining production costs, storage costs and set-up costs , calculations are then carried out using the Single-Item Economic Production Quantity (EPQ) method. Based on previous calculations, the set-up cost $(C)$is IDR 16,484, the number of demand per year $(D)$is 12,132, and the storage cost $(H)$is IDR 9,820.00. From these values, the optimal production quantity is calculated using equation (6). In this case, the daily production rate $d = D = 12,132$ and $p = P = 26,795$, with P = production quantity per year. Thus, it is obtained that

$$Q_p{}^* = \sqrt{\frac{2CDp}{H(p-d)}} = \sqrt{\frac{2(16,484)(12,132)(26,795)}{9.820(26,795-12,132)}} = 272,82 \approx 273$$

This means that the optimal production quantity obtained in one production cycle is 273 plastic bales.

Furthermore, based on Table 1, the annual demand for packaging plastic $(D)$is 12,132 bales and from previous calculations the optimal production quantity for packaging plastic $(Q_p{}^*)$is 273 bales per production cycle. The number of optimal production cycle can be calculated using equation (7), namely

$$m = \frac{D}{Q_p{}^*} = \frac{12,132}{273} = 44$$

The next step is to calculate the optimal total production costs using equation (8). Based on the results of previous calculations, the optimal total production costs are obtained:

$$TIC^* = VD + \frac{HQ_p{}^*(p-d)}{p} = (327,321)(12,132) + \frac{9,820(273)(44)(26,795-12,132)}{26,795} = IDR\ 4,035,608,318$$

Thus, the optimal total production cost per year as a result of calculations using the EPQ method is IDR 4,035,608,318

The next step is to calculate the total production costs of CV XYZ in producing plastic per year without using certain mathematical analysis methods. The total production costs of CV XYZ in one year using this method are shown in Table 3

Table 3. Total Production Costs of CV XYZ per year

Cost	Calculation	Total Cost (IDR)
Employee wages	2,400,000(12)(23)	662,400,000
Material costs	302,600(12,123)	3,671,143,200
Set-up cost	16,484(314)	5,175,976
Storage cost	9,820(26,795)	263,126,900
Total Cost		4,601,846,076

Source: processed data (2024)

Based on Table 3, several costs incurred by CV. XYZ can be seen, namely employee wages, material costs (raw materials), set-up costs, and storage costs. Employee wages in a year are wages given to 23 employees, which is IDR 662,400,000 per year. Material costs are the total material costs required to produce as much as the total demand per year, which is 12,132 bales of plastic packaging. The total material cost is IDR 3,671,143,200. The set-up cost to carry out production for 314 working days is IDR 5,175,819 and the storage cost for a year is IDR 263,116,986. Therefore, the total cost incurred by the company is IDR 4,601,846,076.

According to the previous calculation results, it was obtained that the total optimal production cost per year as a result of the calculation using the EPQ Single Item method is IDR 4,035,605,886, while the total production cost as a result of the calculation without using a specific mathematical method is IDR 4,601,836,005. It is noted that the total optimal production using the EPQ Single Item method is more efficient than without using a specific mathematical method with savings of

$$\frac{IDR\ \ 4{,}601{,}836{,}005\ \ - IDR\ \ 4{,}035{,}605{,}886}{IDR\ \ 4{,}601{,}836{,}005} = \frac{\text{IDR}\ \ 566{,}237{,}758}{IDR\ \ 4{,}601{,}836{,}005} = 12.3\%$$

IV. CONCLUSION

Based on calculations using the Single-Item Economic Production Quantity (EPQ) method at CV. XYZ, the optimal production quantity for each cycle is 273 bales, the optimal number of cycles in one year is 44 cycles and cost savings of 12.3% per year. This applies assuming a set-up time of each machine for 15 minutes, no depreciation costs for goods, and no defective or damaged products.

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