

Designing A Multi-item Product Inventory Policy to Reduce Stockouts on CV VLJ

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ABSTRACT

CV VLJ is a distributor of mineral water and bottled water in Cilegon area, Indonesia selling various water brands and is supplied by four suppliers. CV VLJ often runs out of goods in the warehouse when consumers want to buy the goods they are looking for. As a result, consumers are disappointed and buy it at other distributors. This leads to lost sales. Therefore, this study aims to reduce the loss of sales and minimize the total inventory cost at each supplier. The determination of the order quantity and period is calculated using the EOQ, POQ, EOQ multi-item and multi-item EOI methods. The inventory total cost and lost sales can be calculated through the inventory table simulation. Based on the simulation results, sales losses can decrease by 88-99% for all four suppliers and total costs decrease by an average of around 33% compared to actual conditions.

ABSTRAK

CV VLJ adalah distributor air mineral dan air kemasan di daerah Cilegon, Indonesia yang menjual berbagai macam merek air dan disuplai oleh empat supplier. CV VLJ seringkali mengalami kehabisan barang di gudang ketika konsumen ingin membeli barang yang dicari. Akibatnya konsumen kecewa dan membelinya di distributor lain. Hal ini menyebabkan kehilangan penjualan. Oleh karena itu, penelitian ini bertujuan untuk mengurangi kehilangan penjualan tersebut dan meminimalkan total biaya inventori pada setiap supplier. Penentuan jumlah dan periode pemesanan dihitung menggunakan metode EOQ, POQ, EOQ multi-item, dan EOI multi-item. Total biaya inventori dan kehilangan penjualan dapat dihitung melalui simulasi table persediaan. Berdasarkan hasil simulasi, kehilangan penjualan dapat menurun sebesar 88-99% pada keempat supplier dan total biaya menurun rata-rata sekitar 33% dibandingkan dengan kondisi aktual.

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INTRODUCTION

Inventory has an important role in a business industry. Inventory has a contribution of 20% – 60% of the total assets owned and if the value is converted in cash, it can increase profits

and smooth the cash flow of the industry (Arnold et al., 2008). Inventory availability determines the sustainability of a production or business process. An excess or shortage of inventory can lead to a buildup of goods or, in fact, a loss of sales (Dania et al., 2019). In addition, inventory is a benchmark for the success of a business industry (O'Neill & Sanni, 2018). Therefore, it is important to manage inventory so that the value of the inventory can pay back (Benton et al., 2014).

In inventory management itself, managers must decide what items to stock, how much they are, and how large they can meet consumer needs (Benton, 2014). Actually, efforts to manage this inventory have been carried out since the 1980s which helps to reduce operational costs (Gallego-Garcia, 2021), but until now there are still many challenges. One of them is how to maintain inventory so that it remains sufficient to meet consumer needs without incurring high costs (O'Neill & Sanni, 2018). These various types of costs really have to be considered when a manager wants to decide what amount should be ordered (Bhunia & Shaik, 2014).

Studies are also conducted to find out the optimal number of orders that can minimize the total cost of inventory. The most commonly used inventory model is the Q model, such as the classic EOQ. This EOQ method is an effective method to optimize the total cost of inventory by obtaining the optimal number of orders (Sule & Oshi, 2022). Daud & Nuraini (2017) and Wijaya et al (2016) used classical EOQ to solve the single-item problem by comparing the total inventory cost of the Q model with the actual condition in the industry studied. Not only the cost of ordering and holding is considered as the cost of inventory, but the cost of shortage is also taken into consideration in deciding whether the Q obtained is suitable for use (Daud & Nuraini, 2017). This Q model can also be simulated using Monte Carlo simulation with the function of maximizing profits (Harahap & Nurjayadi, 2016). The simple development of the Q model by paying attention to the purchase price of the product (Nurdin et al, 2015) and the expiration date of the product (Rikardo et al, 2015) is used to determine the number of orders. An even more complex inventory problem is when the items you want to order are more than one. This classic EOQ is used to solve these problems (Sanjaya & Purnawati, 2021; Putra & Rahyuda, 2019). Driven by this multi-item products, the multi-item EOQ method is preferred to solve it (Masyitoh et al., 2016) which can also be supplemented by comparing using the multi-item EOI method (Syarif & Kusuma, 2021).

In addition to the Q model, some industries can also order goods with a fixed period, such as once every two weeks, once a month, and so on. This model is known as the P. Putro et al (2016) model using the periodic review (P) model to obtain the optimal order period for several items by minimizing the total cost of inventory. Likewise with the studies conducted by Sukamto (2017), Arisandhy et al (2021), and Heriansyah (2018).

CV VLJ is a distributor of mineral water and bottled water that often experiences stockouts on the products it sells. The owner who plays a role in determining how many quantities to order still uses intuition to determine his decision. The impact is that when consumers come to buy, often the store cannot meet the consumers so that consumers go to buy at other stores. This research helps owners to determine the order quantity or the order period by minimizing total inventory costs and shortage costs.

RESEARCH METHODS

This study uses EOQ, POQ, multi-item EOQ, and multi-item EOI methods which will later be compared with the actual condition of the store which in previous studies mentioned above only one P or Q model was used to propose the solution. In addition, the order cost calculated in this study was not like in previous studies which were calculated per order. The order cost in this case study is in unit (cartons) so that the results obtained need to be iterated. After that, the results of the calculation using the methods will be simulated using the inventory table.

EOQ (Economic Order Quantity)

By reducing the total order and holding costs, the EOQ method provides a strategy for inventory control (Heizer & Render, 2015). Order costs, holding costs, and the average quantity

of demands in units of time are some factors that influence the EOQ technique. The following formula can be used to calculate the holding costs:

$$\begin{aligned} h &= V \times \%Br \\ h &= \text{holding costs} \\ V &= \text{purchase price} \\ \%Br &= \text{a percentage of interest rate from Bank Indonesia} \end{aligned} \quad (1)$$

From these variables, the EOQ value can be determined using the following formula:

$$\begin{aligned} \text{EOQ} &= \sqrt{\frac{2DK}{h}} \\ \text{EOQ} &= \text{Economic Order Quantity} \\ D &= \text{demand average} \\ K &= \text{order costs} \\ h &= \text{holding costs} \end{aligned} \quad (2)$$

Calculating the reorder point is the next step after figuring out the optimal order quantity. The goal is to know when to reorder in order to keep the product available. The lead time and average demand are the two variables that influence the reorder point computation. The formula for the reorder point is thus:

$$\begin{aligned} \text{ROP} &= D \times L \\ \text{ROP} &= \text{reorder point} \\ D &= \text{demand average} \\ L &= \text{lead time} \end{aligned} \quad (3)$$

POQ (Periodic Order Quantity)

POQ is a method used to determine the amount of an ordered quantity in a unit of time, where the calculation results are integers (Lukmana and Yulianti, 2015). Several variables affect the calculation of the POQ method, namely demand, order costs, and holding costs, with the calculation formula as follows:

$$\begin{aligned} \text{POQ} &= \sqrt{\frac{2K}{Dh}} \\ \text{POQ} &= \text{periodic order quantity} \\ D &= \text{demand average} \\ K &= \text{order costs} \\ h &= \text{holding costs} \end{aligned} \quad (4)$$

In the POQ method, the order quantity (Q) can be found using the following formula:

$$Q = \frac{D}{\text{POQ}} \quad (5)$$

EOQ Multi-item and EOI Multi-item

The methods for determining the optimal order quantity for many products at the same supplier are the EOQ and EOI multi-item methods. The following formula, which is used in conjunction with the multi-items EOQ approach, is used to calculate the number of order frequencies in a given period of time:

$$Q = \frac{D}{m} \quad (6)$$

$$M = \sqrt{\frac{\sum_{i=1}^n h_i D_i}{2 \sum_{i=1}^n K_i}} \quad (7)$$

Q = the optimum order quantity
 D = demand average
 m = order frequency
 h = holding costs
 K = order costs

As for the EOI method, the calculation is based on the magnitude of the interval between orders in a certain period, with the following formula:

$$T = \sqrt{\frac{2K}{\sum_{i=1}^n h_i D_i}} \quad (8)$$

$$Q = D \times T \quad (9)$$

T = order interval
 K = order costs
 h = holding costs
 Q = the optimum order quantity
 D = demand average

RESULTS AND DISCUSSION

CV VLJ is one of the distributors of mineral water and flavored drinks from various brands in Cilegon, Indonesia. Products sold by CV VLJ include Aqua, Vit, Gunung, Teh Gelas, Coca-Cola, and others. This business currently has a number of suppliers and customers, some of them are not only in Cilegon, but also in Serang regency and Serang city.

The suppliers of products in CV VLJ are HTS, SLA, PCI Jaya, and Nita Jaya suppliers. HTS supplier only supplies one SKU, namely Lapan Tiga. There are three Gunung SKUs in all, and SLA supplier exclusively provide those Gunung products. There are a total of 18 SKUs supplied by Nita Jaya supplier: Pulpny Orange, Teh Gelas, Floridina, Good Day, Indomilk, Frisian Flag, Milkku, Kopikap, Cincau, Ultra Milk, Vit, Le Minerale, and Crystalin. Meanwhile, 40 SKUs are supplied by PCI Jaya supplier to Teh Botol Sosro, Fruitea, Teh Pucuk, Teh Kotak, Teh Javana, and others.

One of the issues that many businesses, including CV VLJ, experience is inventory. The unrecorded number of good sales to customers, the unrecorded number of good purchases to suppliers, and the failure to check the inventory when opening and closing the warehouse are some of the issues that lead to inventory discrepancies, or the inventory that does not match the current warehouse inventory on CV VLJ. If this issue persists, it may result in losses for the owner as well as lost sales, which frequently happens when goods are unavailable when shipping is scheduled.

For suppliers who only provide one product, like HTS, solutions can be found utilizing the POQ and EOQ single-item single supplier approaches. EOQ multi-item single supplier, EOI multi-item single supplier, and POQ can be used by SLA, PCI Jaya, and Nita Jaya who supply multiple products.

EOQ Single-item Single Supplier

The calculation of EOQ single item single supplier is used for products originating from one supplier. In CV Viva Lama Jaya, products from one supplier are Lapan Tiga, with the following demand details:

Table 1. Lapan Tiga Sales Overview (cartons)

SKU	Dec	Jan	Feb	Mar	Apr	May	Total	Average
Lapan Tiga 220ml x 48	435	257	298	601	548	237	2376	396

The amount of purchase price of Lapan Tiga products is Rp 10,500.00, with several other costs, namely:

1. Order costs

The order costs of Lapan Tiga products consist of loading-unloading and transportation costs. The product's exact number is still unknown, however labour costs are fixed at Rp 200.00 per carton for loading-unloading activities. The following computation is used to determine the cost of loading-unloading Lapan Tiga products that is Rp 200Q:

$$\text{Loading-unloading cost} = \text{Rp } 200 \times Q = \text{Rp } 200Q$$

In addition, in one pick-up of goods, the transportation costs needed are Rp 350,000.00 with details, toll fees of Rp 100,000.00, gasoline of Rp 200,000.00, and driver's meal of Rp 50,000.00.

2. Holding costs

The purchase price multiplied by the Bank Indonesia interest rate, or BI rate, equals holding costs. In September 2021, the BI rate was 3.5%. the holding costs of Lapan Tiga products are then as follows:

$$\begin{aligned} \text{Holding costs} &= \text{Rp } 10,500.00 \times (3.5\%/12) \times Q \\ &= \text{Rp } 30,625Q \end{aligned}$$

After knowing the amount of related costs, the calculation of Q for Lapan Tiga products is:

$$\begin{aligned} \text{EOQ} &= \sqrt{\frac{2DK}{h}} \\ &= \sqrt{\frac{2 \times 396 \times (350,000 + (200 \times Q))}{\left(\frac{3.5\%}{12} \times Q \times 10,500\right)}} \\ &= \sqrt{\frac{792 \times (350,000 + 200Q)}{(30,625Q)}} \end{aligned}$$

Using this equation, further iterations will be performed until the EOQn result equals EOQn+1. Assume Q = 1 with D = 396 cartons/month for the first iteration. After 11 iterations, the results of EOQ in the 11th iteration are the same as the 10th iteration, which is 217 cartons. Thus, the optimum quantity is 217 cartons. So that the calculation of the ROP value can be done with the following formula:

$$\begin{aligned} D &= 396 \text{ cartons} \\ L &= 0.033 \text{ month} \\ \text{ROP} &= D \times L \\ &= 396 \times 0.033 \\ &= 13 \text{ cartons} \end{aligned}$$

The optimal order quantity for each order was determined to be 217 cartons, with a reorder point at the level of 13 cartons, based on the EOQ calculation for Lapan Tiga products.

POQ

The Q value and the total number of order frequencies will be calculated using the POQ method. The following formula is used to get the P value for the AQ 220 product:

$$\begin{aligned} \text{POQ} &= \sqrt{\frac{2K}{Dh}} \\ &= \sqrt{\frac{2 \times 6.826}{28 \times \left(\frac{3.5\%}{12} \times Q \times 27.500\right)}} \end{aligned}$$

$$= \sqrt{\frac{13.652}{2.245Q}}$$

The amount of order costs at each supplier certainly has a different value, depending on the details and policies of each supplier. The order cost is determined by the amount of petrol used (transportation costs) at PCI Jaya and Nita Jaya suppliers, whereas SLA suppliers derive their cost from toll road fees, driver meal fees, and loading-unloading porter wages.

After getting the equation for the POQ method, the next step is to iterate to get the optimal POQ result. POQ is said to be optimal when the result of P_n is equal to P_{n+1} . The first iteration POQ result is the same as the 0th iteration, or one time, according to the computation results. Therefore, once a month is the ideal ordering frequency for AQ 220ml products. The calculation of Q in the POQ method uses the following equation.

$$Q = \frac{28}{1} = 28 \text{ cartons}$$

The optimum order quantity for AQ 220ml items was determined to be 28 cartons based on POQ calculations. Once order every month for each of the number order frequencies. There are some goods, though, that come with just one carton of takeaway. This is because there were either no sales at all or just one carton of the product sold in a month. One such product is Fruitea, with the following sales table:

Table 2. Fruitea Sales Overview (cartons)

SKU	Dec	Jan	Feb	Mar	Apr	May	Total	Average
Fruitea 500ml x 12	0	0	0	1	0	0	1	1

Based on the sales data and the calculation of the POQ of Fruitea products, the optimum order quantity of 1 carton is obtained for each order with a total order frequency of 10 times per month.

EOQ Multi-item Single Supplier

The calculation of order frequency in the EOQ multi-item single supplier on AQ 220ml is as follows:

$$\begin{aligned}
 m &= \sqrt{\frac{\sum_{i=1}^n h_i D_i}{2 \sum_{i=1}^n K_i}} \\
 &= \sqrt{\frac{71.741 \times Q}{2 \times 6.826}} \\
 &= \sqrt{\frac{71.741Q}{13.652}}
 \end{aligned}$$

This equation can be repeated at the value of m until the optimal value is reached at that value, or until $n+1$ is the result of the iteration.

Following three iterations, the Q of 220ml AQ is calculated as follows, with the third iteration's result equal to m from the second iteration, resulting in an optimum ordering frequency of six times.

$$Q = \frac{D}{m} = \frac{28}{6} \approx 5$$

Based on the calculation of EOQ multi-item that has been done, the optimum order frequency in 1 month is 6 times, with the optimum order quantity for each order of 5 cartons.

EOI Multi-item Single Supplier

The last method used in determining the optimum order is EOI multi-item single supplier. The calculation using this method to find the ordering interval at AQ 220ML is as follows:

$$\begin{aligned}
 T &= \sqrt{\frac{2k}{\sum_{i=1}^n h_i D_i}} \\
 &= \sqrt{\frac{2 \times 6.826}{71.741 \times Q}} \\
 &= \sqrt{\frac{13.652}{71.741Q}}
 \end{aligned}$$

If the iteration n equals $n+1$, then this equation can be repeated at the value of T until the optimum value is reached at that value.

Following four iterations, T 's result in the fourth iteration is 0.195 months, the same as it was in the third. Thus, it can be concluded from the computations that the best order quantity for AQ 220ml items is five cartons each purchase, with a buy interval of four days or 0.195 months.

As mentioned in the research methods section, the next step is to conduct a simulation using the inventory table for the 62 products that have been calculated using the methods above. This simulation is useful for finding out what the total inventory cost (order cost & holding cost), shortage cost, and inventory level at the end of the period are. The simulation was carried out for six months in days.

The chosen solution proposal is one that can reduce the likelihood of lost sales. Furthermore, the strategy yields the lowest total inventory cost. Two cost components—order and holding costs—are taken into account when calculating the total inventory cost in this case study. Lost sales events are referred to here as shortage costs. Losing sales on CV VLJ is impacted by frequent shortages of items. Since there is no backorder system in place, customers will shop at other stores. Here, the profit that supposed to be earned is used to calculate the lost sales.

The Proposed Solution

Based on the calculations that have been made, the following is a comparison table between the total inventory cost and the lost sales in the proposed methods with the actual condition that occur in CV VLJ.

Table 3. Cost Comparison on Supplier SLA

SKU	Lost Sales	Total Inventory Cost
POQ	Rp 105,000.00	Rp 47,284,529.00
EOQ multi-item	Rp 3,224,000.00	Rp 87,561,756.00
EOI multi-item	Rp 5,240,000.00	Rp 126,246,080.00
Actual	Rp 17,115,000.00	Rp 126,688,017.00

As can be seen in Table 3, SLA supplier supplies a wide range of products so that they use the multi-item EOQ and multi-item EOI methods (Masyitoh et al., 2016 & Syarif & Kusuma, 2021). In addition, the P model used is the P model (Lukmana & Yulianti, 2015) which can determine the optimal order period. The results of these three methods are able to reduce the total cost of inventory and lost sales from the actual condition (Arnold et al., 2008). However, when compared to POQ, it results in the smallest lost sales and total inventory costs. Therefore, the chosen method is POQ with a total cost of Rp 47,389,529.00, which is about 67% lower than the total actual cost and is able to reduce lost sales by 99% of the actual condition.

Table 4. Cost Comparison on Supplier HTS

SKU	Lost Sales	Total Inventory Cost
EOQ	Rp 22,500.00	Rp 3,953,852.00
POQ	Rp 0.00	Rp 2,649,131.00
Actual	Rp 1,354,500.00	Rp 3,487,314.00

In table 4, i.e. HTS supplier, the P model that is still used is POQ which helps to determine the optimal order period (Lukmana & Yulianti, 2015). However, the Q model used is EOQ because this supplier only supplies one type of product (Lapan Tiga). This EOQ method will be more accurate if the product supplied is single-item (Arnold et al., 2008). Compared to actual conditions, these two methods can both reduce the total cost of inventory and lost sales. However, the POQ method results in a lower total inventory cost than the EOQ method with no lost sales. Here, with an order period every 15 days. Therefore, POQ approach is chosen. Table 4 illustrates that 98% of the actual condition is reduced in lost sales when using the POQ approach, which has a total cost of Rp 2,649,131.00, or around 45% less than the total actual cost.

Table 5. Cost Comparison on Supplier PCI Jaya

SKU	Lost Sales	Total Inventory Cost
POQ	Rp 337,000.00	Rp 8,825,578.00
EOQ multi-item	Rp 1,231,500.00	Rp 8,549,126.00
EOI multi-item	Rp 1,751,500.00	Rp 8,549,126.00
Actual	Rp 4,226,500.00	Rp 5,517,220.00

Next is PCI Jaya supplier which supplies various products. Similar to SLA supplier, the P model used is POQ and the Q model used is multi-item EOQ and multi-item EOI as can be seen in Table 5. When compared to actual conditions, the total inventory cost for these three methods is larger, which is about eight million. This can happen because, in actual conditions, the number of goods stored in the warehouse is more adequate. The availability of goods in small quantities causes small storage costs, but has the potential to cause shortages or lost sales (Benton, 2014). This can be seen in the actual sales loss condition is greater than the POQ, multi-item EOQ, and multi-item EOI methods. Meanwhile, when comparing the three methods, the POQ method that has the lowest lost sales with a total cost, Rp 9,162,578.00, (total inventory cost and lost sales) is approximately 6% less than the actual cost. This approach can also reduce lost sales by 92% of the actual condition.

Table 6. Cost Comparison on Supplier Nita Jaya

SKU	Lost Sales	Total Inventory Cost
POQ	Rp 19,000.00	Rp 5,952,052.00
EOQ multi-item	Rp 51,000.00	Rp 2,217,905.00
EOI multi-item	Rp 89,500.00	Rp 1,924,077.00
Actual	Rp 742,500.00	Rp 1,388,026.00

From the Table 6 shows the results of calculations at Nita Jaya supplier which also supply several types of products. The P and Q models used are the same as SLA and PCI Jaya suppliers. The total cost of inventory in actual conditions is smaller than the proposed methods. However, lost sales in actual conditions have the largest amount. The same thing was also found in the discussion of the PCI Jaya supplier. Taking into account the lost sales produced, the POQ method has the smallest number of lost sales, but the total inventory cost is large because the inventory accumulates in the warehouse causing storage costs to increase (Dania et al., 2019) which has an impact on the total cost (total inventory cost and lost sales) to be high, Rp 5,971,052.00. This method was also not chosen. The remaining methods are multi-item EOQ and multi-item EOI. The multi-item EOQ method has lower lost sales than the multi-item EOI method, but the total

inventory cost is higher due to the large number of items stacked in the warehouse than the multi-item EOI method. Hence, the multi-item EOI is chosen which can reduce lost sales by 88% of the actual condition, with a total cost of Rp 2,013,577.00, or roughly 6% less than the whole actual cost.

CONCLUSION

These findings suggest that, in general, POQ and EOI multi-item can handle the stockouts happened in the store. Both methods are able to reduce the percentage of product shortages by 88%-99% and the total cost is lower than the actual condition, which is in average 33%. This study has not considered the minimum and maximum storage capacity of the warehouse on CV VLJ. In future research, the warehouse capacity as a constraint might be possible to be considered. This improvement will be able to help owners to store goods by not exceeding the storage capacity of the existing warehouse, in addition to preventing lost sales.

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