Estimating Optimum Amount of Stock in The Warehousing Process Using Newsvendor Model

1st Farell Fania
Faculty of Industrial Engineering
Telkom University
Bandung, Indonesia
farellfania@gmail.com

2nd Dida Diah Damayanti
Faculty of Industrial Engineering
Telkom University
Bandung, Indonesia
didadiah@telkomuniversity.ac.id

3rd Seto Sumargo
Faculty of Industrial Engineering
Telkom University
Bandung, Indonesia
setosumargo@telkomuniversity.ac.id

***Abstract* — PT Grow Commerce Indonesia is a technology driven company which focuses on the digital branding of partner brands, mostly local brands. They also help in the warehouse and distribution activities of the partner brand's products. The warehouses that are used by Grow Commerce are the partner brands. The problem faced by PT. Grow Commerce Indonesia is that each year, their warehouse always has overstock left, with increase of quantity each year. The author intends to analyze the problem and design a solution using the Newsvendor Model. The Newsvendor model helps in determining the optimum quantity of products that should be manufactured/ordered to avoid overstocking (supply is more than demand) and or understocking (demand is more than supply) which overall avoids the loss of profit. By analyzing the forecast of demands, the Newsvendor model can calculate the optimum number of stocks to minimize loss of profit.**

***Keywords*— PT. Grow Commerce Indonesia, Overstock, Newsvendor Model**

PRELIMINARY

PT. Grow Commerce Indonesia is a technology-driven commerce company that acquires, operates, and grow great brands at scale. Backed by renowned VCs in Asia, Grow Commerce has extensive track records in scaling brands to their utmost potential. Grow Commerce are on a constant lookout for great brands –offering brand owners a way to sell their business at attractive valuations and with flexible deal structures, allowing them to cash out and achieve their desired financial goals sooner.

However, in recent years, Grow Commerce's warehouse always has some overstock of products left each year and the overstock is increasing each year. The number of products being stored in the warehouse is too much compared to the number of products being transported away from the warehouse (sold). The data of comparison between the inbound and outbound of products in Grow Commerce's warehouse can be seen in figure 1.

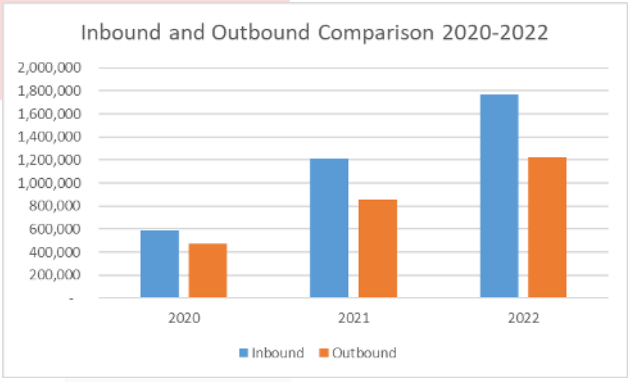

Figure 1
Products Inbound and Outbound Comparison (Source: PT. Grow Commerce Indonesia)

The main cause of the overstock happening is due to the warehouse stocking policy. The company's policy is that the safety stock of a product is three products. So, to stock one product, the company needs to stock four products. The company also wants to apply a deep stocking policy in case the sales of the products sky rocketing. This research will help in establishing a method of stocking policy by establishing a forecasting method by analyzing the trend of past sales which will be used to figure out the optimum number of products that should be stocked to avoid understocking or overstocking to optimize profit using the Newsvendor Model.

I. THEORITICAL REVIEW

A. Warehousing

The warehouse should be seen as a temporary place to store inventory and as a buffer in the supply chain. It works as a static unit - in the main product availability - that matches consumer demand and thus has the main goal of facilitating movement of goods from suppliers to customers, meeting demand in a timely and cost-effective manner. (Van Den Berg, 2013). Warehouses can also be used as a means of supporting supply chains that have added value, in the form of cost savings - operational costs. In other words, with the warehouse costs incurred can be trimmed. But on the other hand, warehouses can also cause quite heavy costs. The two

categories can be managed properly through good warehouse operational business management. With the objective of maximizing utilization, the business processes available of the warehouse are receiving, storage, order picking, and shipping.

B. Newsvendor Model

The newsvendor model is one of the fundamental models for Operations Research and Management Science. Porteus (1990) summarizes the typical newsvendor model for one-period and multi-period cases. The ordering cost and overstocking and understocking costs are considered in the cost function and the unsatisfied demand at the end of one period is either lost or backlogged. The critical ratio that is the optimal probability of not stocking out is the ratio of the unit underage cost to the sum of the unit underage and overage costs. Arrow et al. (1951) gives the first derivation of the optimal inventory level and reorder point as a function of the demand distribution, the cost of making an order, and the overstocking and understocking costs. Arrow and Karlin (1958a,1958b) analyze the optimality of the base stock policy for one stage inventory models with uncertain demand. The optimal inventory level can be determined by examining the derivative of the objective function. Concerning the batch ordering problem of the newsvendor model, Veinott (1965a) shows that a base stock policy, with which the stock is replenished to a certain level, if possible, is still optimal.

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C. Numeric

The Numerical Analysis method is mainly used in Mathematics and Computer Science that creates, analyzes, and implements algorithms for solving numerical problems of continuous Mathematics. Such types of problems generally originate from real-world applications of algebra, geometry, and calculus, and they also involve variables that vary continuously. These problems occur throughout the natural sciences, social sciences, engineering, medicine, and the field of business.

Numerical methods are techniques that are used to approximate Mathematical procedures. We need approximations because we either cannot solve the procedure analytically or because the analytical method is intractable.

Iteration is the process of repeating a mathematical function, using the previous answer as the next input. For example, an iterative function could be as simple as X_(n+1) = X_n+1. In this equation, we would start with a given and then use this to find X_1. We can then continue this process to find as many Xi as we require.

II. METHOD

This research will analyze the past sales of the company and estimate the optimum number of stocks for the company to avoid overstocking and understocking of products. From the stocks estimated, an expected profit will be estimated as well by multiplying the price, manufacturing cost, and salvage value of the products. The stock estimation will be done using the newsvendor model and the profit estimation will be done using the newsvendor model and numeric analysis. Due to the limitation of data, this research will focus on the category of bags as it is on the top 3 of the categories which have the most overstock. To narrow down the scope even further, this final research will focus on the products that are considered as one of the products with high overstock and a product that sells well as a comparison which also have detailed sales data that is compatible with the characteristics of the newsvendor model. The products mentioned are the "Omaiza Quilted Shoulder Bag Beige" and "Taruly Croco Sling Bag Brown". The products mentioned matches the characteristics of the newsvendor model because it is a collection product which is only stocked once. Albeit the product is only stocked once, the pattern of sales of upcoming products will be somewhat similar to the products mentioned given similar conditions. The newsvendor model can estimate the optimum number of stocks for products alike. Also, the products mentioned are stocked in the year 2022 and the sales are still ongoing up until May 2023.

A. Newsvendor Model

The optimum number of stocks using the newsvendor model starts by acquiring the product price, manufacturing cost, and selling price. The products observed are of the bags category. The products with complete data are "Omaiza Quilted Shoulder Bag Beige" and "Taruly Croco Sling Bag Brown", so those products will be observed. The "Omaiza Quilted Shoulder Bag Beige" will be referred to as product 1 and the "Taruly Croco Sling Bag Brown" will be referred to as product 2. The manufacturing cost and selling price and manufacturing cost can be seen in the table below.

TABLE 1
Product Selling Price and Manufacturing Cost

Name	Price	COGS
Omaiza Quilted Shoulder Bag Beige	549,000	218,984
Taruly Croco Sling Bag Brown	499,000	120,000

From the selling price, the salvage value can be obtained by applying discounts. The salvage value of both products can be seen in the table below.

TABLE 2
Product 1 Salvage Value

Omaiza Quilted Shoulder Bag Beige	Discount						
	20%	30%	40%	50%	60%	70%	80%
549,000	439,200	384,300	329,400	274,500	219,600	164,700	109,800

TABLE 3
Product 2 Salvage Value

Taruly Croco Sling Bag Brown	Discount						
	20%	30%	40%	50%	60%	70%	80%
499,000	399,200	349,300	299,400	249,500	199,600	149,700	99,800

The initial forecast and demand for both products are also necessary to continue with the newsvendor model. It is known that the initial forecast for both products is 200 products and 250 products respectively and the demand for both products is 126 products and 228 products respectively.

From the forecasts and demands, we can assume that the forecast for the next stocking will be 150 products and 250 products respectively. After that, the products from the category are listed along with the forecast and demand. There is a total of 401 products. Then, the A/F ratio is determined. To determine the A/F ratio, the following equation is used.

$$\frac{A}{F}\ Ratio\ = \frac{Demand}{Forecast}$$

The product list is then sorted according to the A/F Ratio from smallest to largest. From the list of A/F ratios, the mean (μ) and standard deviation (σ) is calculated by multiplying the average of the A/F ratios and the standard deviation of the A/F ratios to the forecast of the products respectively. Then, the expected actual demand of the products can be calculated by multiplying the A/F ratios of the products to the respective forecast. After the expected actual demand is found, F(Q) which is the probability the outcome of the random variable is Q or lower. Then, the z statistics are calculated which will be used to find the distribution function ($\theta(z)$) to find the optimal order quantity by looking at the standard normal distribution function table. The z statistics are calculated by using the equation below.

$$Z\ = \frac{(Q\ -\ \mu)}{\sigma} \quad (2)$$

After that, the estimated optimum demand can be obtained by first calculating the critical ratio. The critical ratio is the ratio of the overage and underage cost of stocking. The critical ratio consists of the cost of overstocking (Co) and cost of understocking (Cu). The Co is calculated by subtracting the manufacturing cost with the salvage value while the Cu is calculated by subtracting the selling price with the manufacturing cost. The critical ratio can be calculated by using the following equation.

$$F(Q)\ =\ \frac{C_u}{C_o\ +\ C_u} \quad (3)$$

The critical ratio is used to find the optimum number of stocks by referring to the F(Q) using the discrete distribution demand forecast and by referring to the $\theta(z)$ using the normal distribution demand forecast. After the optimum number of stocks is obtained, we calculate the expected lost sales, expected sales, expected leftover inventory, and expected profit.

Expected lost sales is the expected number of products that exceeds the order quantity. To calculate the expected loss sales, use the z-statistic values to determine the $\theta(z)$. Then, find the loss function with the standard normal distribution ($L(z)$) by looking up the $\theta(z)$ values in the standard normal loss function table. After the $L(z)$ values have been obtained, calculate the loss function ($L(Q)$, the expected amount demand exceeds Q) by multiplying the standard deviation with $L(z)$. So, the value of expected loss sales can be calculated using the equation below.

$$L(Q)\ =\ \sigma\ \mathrm{X}\ \mathrm{L(z)} \quad (4)$$

The expected sales is the expected number of sales that will be achieved by using the obtained amount of stocking quantity. The value of expected sales can be calculated by subtracting the expected demand. Assuming that the expected demand is the mean of the demand distribution (μ), we get the following equation.

$$Expected\ Sales\ =\ \mu\ -\ \text{Expected Loss Sales} \quad (5)$$

(1)

The expected leftover inventory is the average amount that demand is less than the order quantity. Leftover inventory is a visibly explicit cost associated with the mismatch of demand and supply. The value of expected leftover inventory can be calculated by using the equation below.

$$Expected\ Leftover\ Inventory\ =\ Q\ -\ Expected\ Sales \quad (6)$$

The expected profit is the estimated amount of profit that will be achieved by using the obtained amount of stocking quantity. The value of the expected profit can be calculated by subtracting the expected sales times by the difference of price and cost with the expected leftover inventory times by the difference of cost and salvage value. Price minus cost is equal to Cu and cost minus salvage value is equal to Co. So, expected profit can be calculated using the equation below.

$$Expected\ Profit\ =\ [(C_u)\ X\ Expected\ Sales]\ -\ [(C_o)\ X\ Expected\ Leftover] \quad (6)$$

B. Numeric Method

The profit estimating using the newsvendor model only applies the normal price and the salvage value which is the lowest price the product could sell (80% discount). Product selling can use many ways to appeal the customers interests so that the product could sell. One of them being the application of discounts to make the price more attractive to the customers. The numeric analysis helps in creating different scenarios of discount application and estimating the sales, product leftover, gross profit, manufacturing cost, and final profit.

III. RESULTS AND DISCUSSION

To estimate the optimum number of stocks and the expected profit, the newsvendor model and numeric methods are used. The calculation is done to help overcome the overstock of products faced by the company by establishing a forecast method suited and applicable to the company's situation and policy. The optimum amount of stock and profit estimation can be seen in this chapter.

A. Newsvendor Model

Referring to chapter 2, the newsvendor model starts by listing the products and calculating the A/F ratio.

TABLE 4
Demand Forecast Ratio

Demand Forecast Ratio				
Product	Forecast	Demand	Error	A/F
Omaiza Quilted Shoulder Bag Beige	200	126	74	0.63
Taruly Croco Sling Bag Brown	250	228	22	0.91

The next step is to determine the mean (μ) which is the average of the A/F ratio multiplied by the demand. The A/F ratio average can be calculated by adding all A/F ratios and dividing it with the number of A/F ratios. Then, it is known that the average of the A/F ratios is 0,58. To find the mean of the actual demand, the mean of the A/F ratios is multiplied by the forecast. Therefore, it is known that the mean for product 1 is 0,58 X 150 = 87 products. For product 2, the calculation of the mean is 0,58 X 250 = 145.

The next step is to determine the standard deviation (σ) of the actual demand by multiplying the standard deviation of the A/F ratios with the forecast. To find the standard deviation of the A/F ratios we use the Ms. Excel software with the function =stdev(). Therefore, it is known that the standard deviation of the A/F ratios is 0,061. Then, we multiply the standard deviation of the A/F ratios with the forecast. The standard deviation of the actual demand for product 1 is 0,167 X 150 = 25 and for product 2 is 0,167 X 250 = 42.

After that, the standard normal distribution function is calculated.

TABLE 5
Standard Normal Distribution Function

Standard Normal Distribution Function				
A/F	Q	F(Q)	z	Φ(z)
0.63	95	0.61821	0.30	0.00026668
0.91	228	0.97676	1.99	0.00030436

Next is to calculate the critical ratio. Using the price, manufacturing cost, and salvage value, the critical ratio of both products can be seen in the table below.

TABLE 6
Critical Ratio

Product	Selling Price	Manufacturing Cost	Salvage value	Critical Ratio
Omaiza Quilted Shoulder Bag Beige	549,000	218,984	109,800	0.7514
Taruly Croco Sling Bag Brown	499,000	120,000	99,800	0.9494

From the critical ratio, the estimated number of stocks can be estimated by using the discrete distribution demand forecast and the normal distribution demand forecast. First is by using the discrete distribution function. Refer to the F(Q) value which is closest to the critical ratio.

TABLE 7
Discrete Distribution Forecast Product 1

Q	F(Q)
f(104)	0.7493
Critical Ratio	0.7514
f(104)	0.7550

TABLE 8
Discrete Distribution Forecast Product 2

Q	F(Q)
f(213)	0.9473
Critical Ratio	0.9494
f(215)	0.9535

From the tables above, the nearest F(Q) value to the critical value is as shown. We then use the round up rule to determine the chosen Q. Then, it can be concluded that the chosen Q for product 1 and 2 is 104 and 215 respectively.

Using the normal distribution demand forecast, refer to the θ(z) value that is the closest to the critical ratio.

TABLE 9
Normal Distribution Forecast Product 1

Q	Φ(Z)
Φ(0.67)	0.7493
Critical Ratio	0.7514
Φ(0.68)	0.7550
Q	104

TABLE 10
Normal Distribution Forecast Product 1

Q	Φ(Z)
Φ(1.63)	0.9484
Critical Ratio	0.9494
Φ(1.64)	0.9495
Q	213

From the tables above, the nearest θ(z) value to the critical value is as shown. We then use the round up rule to determine the chosen θ(z) value. From then, we use the standard normal distribution function table to find the value needed. After that, calculate the chosen Q by adding the value from the standard normal distribution function table with the mean and multiply it with the standard deviation. Then, it can be concluded that the chosen Q for product 1 and 2 is 104 and 213 respectively.

Next is to calculate the expected lost sales. The expected lost sales calculation can be seen in the table below.

TABLE 11 E
xpected Lost Sales Product 1

Expected Lost Sales Product 1					
Q	F(Q)	z	Φ(z)	L(z)	L(Q)
104	0.75503	0.69	0.0002825	0.145217	4

TABLE 12
Expected Lost Sales Product 2

Expected Lost Sales Product 2					
Q	F(Q)	z	Φ(z)	L(z)	L(Q)
215	0.95346	1.68	0.0002961	0.019226	1

From the tables above, it can be concluded that the lost sales for product 1 are four products and for product 2 are one product.

Next is calculating the expected sales. The calculation of the expected sales can be seen in the table below.

TABLE 13
Expected Sales Product 1

Expected Sales Product 1		
Q	Expected Loss Sales	Expected Sales
104	4	83

TABLE 14
Expected Sales Product 2

Expected Sales Product 2		
Q	Expected Loss Sales	Expected Sales
215	1	144

From the tables above, it can be concluded that the expected sales of product 1 are 83 products and the expected sales of product 2 are 144 products.

Next is to calculate the expected leftover inventory. The calculation of the expected leftover inventory can be seen in the table below.

TABLE 15
Expected Leftover Product 1

Expected Leftover Inventory Product 1		
Q	Expected Sales	Expected Leftover Inventory
104	83	21

TABLE 16
Expected Leftover Product 2

Expected Leftover Inventory Product 2		
Q	Expected Sales	Expected Leftover Inventory
215	144	71

From the tables above, it can be concluded that the expected leftover for product 1 is 21 products and for product 2 is 71 products.

Next is to calculate the expected profit. The calculation of the expected profit can be seen in the table below.

TABLE 17
Expected Profit Product 1

Expected Profit Product 1			
Q	Expected Sales	Expected Leftover Inventory	Expected Profit
104	83	21	Rp25,219,922

TABLE 18
Expected Profit Product 2

Expected Profit Product 2			
Q	Expected Sales	Expected Leftover Inventory	Expected Profit
215	144	71	Rp53,202,759

From the table above, we can conclude that the expected profit for product 1 is Rp. 25.219.922,00 and for product 2 is Rp. 53.202.759,00.

B. Numeric Method

The numeric method helps in creating different scenarios with different sets of discounts. For the observed products, there are 12 scenarios created with three different quantities. For product 1, the first quantity obtained is from the newsvendor model, Q = 104 products. The second quantity is obtained from the actual sales of the product, Q = 126 products. The third quantity obtained is from the initial forecast for the product, Q = 200 products. For product 2, the first quantity obtained is from the newsvendor model, Q = 215 products. The second quantity is obtained from the actual sales of the product, Q = 228 products. The third quantity obtained is from the initial forecast for the product, Q = 250 products. The scenarios yield different results with different discounts, sales, leftovers, gross profit, product cost, and profit. From the scenarios, the best result for both products can be seen from the table below.

TABLE 19
Numeric Results

Product	Stock Procured	Total Sales	Leftover	Gross Profit	Product Cost	Profit
1	104	96	8	43,151,400	22,774,336	20,377,064
2	215	206	9	43,013,800	25,800,000	17,213,800

From the calculation using the numeric method, we can see that for product 1, the stock procured is 104 products. The total sales are 96 products with eight leftovers. From the sales, the gross profit obtained is Rp. 43.151.400,00. The product procurement cost is Rp. 22.774.336,00, with a final profit obtained of Rp. 20.377.064,00. For product 2, the stock procured is 215 products. The total sales are 206 products with nine leftovers. From the sales, the gross profit obtained is Rp. 43.013.800,00. The product procurement cost is Rp. 25.800.000,00, with a final profit obtained of Rp. 17.213.800,00.

To compare with the existing conditions, the comparison of the design with the existing conditions can be seen in the table below.

TABLE 20
Comparison of Existing Condition with Newsvendor Model of Product 1

Factor	Existing	Newsvendor Model
Stock	200 Products	104 Products
Sales	126 products	83 Products
Leftover Stock	74 products	21 Products
Product Cost	Rp. 43.796.800,00	Rp. 22.774.336,00
Profit	Rp. 2.703.500,00	Rp. 25.219.922,00

TABLE 21
Comparison of Existing Condition with Newsvendor Model of Product 2

Factor	Existing	Newsvendor Model
Stock	250 Products	215 Products
Sales	228 products	144 Products
Leftover Stock	22 products	71 Products
Product Cost	Rp. 30.000.000,00	Rp. 25.800.000,00
Profit	Rp. 16.157.500,00	Rp. 53.202.759,00

TABLE 22
Comparison of Existing Condition with Numeric Method for Product 1

Factor	Existing	Numeric
Stock	200 Products	104 Products
Sales	126 Products	96 Products
Leftover Stock	74 Products	8 Products
Gross Profit	Rp. 46.500.300,00	Rp. 43.151.400,00
Product Cost	Rp. 43.796.800,00	Rp. 22.774.336,00
Profit	Rp. 2.703.500,00	Rp. 20.377.064,00

TABLE 23
Comparison of Existing Condition with Numeric Method for Product 2

Factor	Existing	Numeric
Stock	250 Products	215 Products
Sales	228 Products	206 Products
Leftover Stock	22 Products	9 Products
Gross Profit	Rp. 46.157.500,00	Rp. 43.013.800,00
Product Cost	Rp. 30.000.000,00	Rp. 25.800.000,00
Profit	Rp. 16.157.500,00	Rp. 17.213.800,00

IV. CONCLUSION

From the calculations, it can be concluded that the proposed design yields better results compared to the existing conditions, although the existing condition is better than the proposed design from the gross profit. However, many factors are to be considered when it comes to the real conditions such as marketing, fluctuating demands, changing trends, seasons, massive discounts, events, etc.

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