Raw materials inventory analysis with Bayes-fishbone and safety stock in PT. XYZ

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Abstract. Inventory control in a production process needs an optimal management to prevent production delay and be able to meet its recruitment. Its condition is affected by the quantity and time accuracy which hold impact of the production process. This study aimed to know whether the inventory in PT. XYZ, a detergent manufacturing company in Tangerang city, was in optimal condition and what are the affected elements using the Bayes-fishbone method. Bayes-fishbone method will show the biggest to the smallest causes of a problem through a visual representation. Later it’s discovered the biggest factor of stock out inventory is 33% by the returned goods material and misfit quantity, 25% by miscommunication with supplier, 17% by bad weather causes lateness, 15% by long lead time, and 10% by sluggish machines. Improvement attempt can be done by figuring out the safety stocks. By using the datas of inventory demands and fulfillments with 90% as the safety factor, the result for each safety stocks are 24 kgs for inventory 131010000146000, 2.645 kgs for inventory with code 450020000115000, 512 kgs for 1410400000259000, inventory 1010200000454000 needs 18.999 kgs, 55 kgs for 1480200000456000, 1.352 kgs for 1460200000457000, and 587 kgs for inventory with code 1410100000465000.

1. Introduction
This research aims to identify PT. XYZ’s raw material which face stock out and overstock conditions. The condition of these raw materials is largely determined by the accuracy of the quantity and time of arrival of the raw materials which affect the production of the company. The raw materials are stored in raw material warehouse, where warehouse functions as a place to store raw goods, semi-finished goods, and goods that are ready to be marketed or workers’ tools [1]. Warehouse management is done to produce customer service on time, optimize warehouse capacity, increase inventory accuracy, increase productivity of warehouse workers, and to minimize costs ranging from incoming and outgoing goods [2]. There are several things that need to be considered because it affects the supply of raw materials, such as estimated usage, price of raw materials, costs of inventory, expenditure policies, actual usage, and lead time. If these factors are not well controlled, then there are some inventory problems that can occur such as "overstock" or "out of stock" [3]. Overstock is a condition of excess stock that can cause damage to goods, expiration, shipping errors, as well as additional costs for maintenance and warehouse rental [4]. While out of stock/stock out is a condition of shortage of inventory that results in the production process stops, delays in profits, and can even result in loss of consumers [5]. The company needs to be alert if the raw material experiences the problem and
immediately find out the cause, which raw materials that have problems, so that efforts can be made to overcome them.

2. Method

2.1. Bayes-fishbone
A fishbone diagram is a tool that can help you perform a cause and effect analysis for a problem you are trying to solve [6]. A fishbone diagram to describe various disabilities, causes, and consequences of events [7]. These influential factors are arranged in a list whose structure is in the form of fish bone structure [8]. Bayes method is one of the techniques for analyzing the best decision-making from a number of alternatives with the aim of producing optimal results [9]. Bayes and fishbone diagram methods can be combined to get the final result in the form of the true root cause and common cause variation and their sequence. The Bayes equation used to calculate alternative values is:

\[ \text{Total Value } i = \sum_{j=1}^{m} \text{Value of } ij \times \text{Crit } j \]  

(1)

Where:
Total value = total final value of alternative i
Value of ij = value of alternative i on the criteria j
Criteria j = level of importance (weight) of the criteria j
i = 1,2,3, ..., n; n = number of alternatives
j = 1,2,3, ..., m; m = number of criteria

2.2. Safety stock
Safety stock or buffer stock is a stock that is used to anticipate the uncertainty of demand and lead time. Safety stock is to anticipate inventory shortages at the time of order lead time. For diverse demand conditions and fixed lead times, the formula for calculating safety stock is:

\[ SS = SF \times \sqrt{LT \times SD} \]  

(2)

Where:
SF: Safety Factor
LT Weeks: Lead Time (week)
SD: Standard Deviation

2.3. Min-max method
Min-max method is an inventory control method that sets minimum and maximum inventory levels to prevent shortages or run out of inventory during a reorder period [10]. Calculation of min-max inventory used is as follows:

\[ \text{Min Inventory: } D \times L \times SS \]  

(3)

\[ \text{Max Inventory: } 2 (D \times L) + SS \]  

(4)

Where:
D: Average demand demand
L: Lead Time (week)
SS: Safety Stock

2.4. Bayes criterion
This research uses 5 criterions for the Bayes method, they are lead time, delivery time accuracy, material quality, material amount accuracy, and machine speed. Lead time is the time needed from sending request until the material received from supplier. Delivery time accuracy describes supplier’s ability to deliver the material as the time promised. Material quality is supplier’s ability to produce high quality material that meets company’s standard. Material amount accuracy shows
communication skill between procurement and supplier and machine speed shows its production capacity in a minute.

3. Results and discussion

3.1 Bayes-fishbone diagram

Several factors were found as causes of the company's raw materials to be not optimal through direct observation and interviews with the company. Through the Bayes-fishbone diagram the final result can be seen in the form of the true root cause and common cause variation and their sequence. Combining this diagram with the Bayes-fishbone of the raw material that is not optimal at PT. XYZ are shown in Figure 1.

![Bayes-fishbone diagram](image)

Figure 1. Bayes-fishbone diagram

Analysis by Bayes method will use several criteria that have been determined in previous fishbone diagrams such as lead time, delivery time, material quality, amount accuracy, and machine speed. Whereas Bayes weight is determined based on subjective assessment, taken from the level of trust, belief, experience, and background behind decision making [11]. Based on the determination of the criteria and the quality score of each factors causing the raw material is not optimal, the results of Bayes calculation are as follows:

| Inventory Code | Criteria | Alternative Score | Rank |
|----------------|----------|-------------------|------|
| 1310100000146000 | Lead Time: 8, Delivery Time Accuracy: 7, Material Quality: 6, Material Amount Accuracy: 9, Machine Speed: 9 | 7.52 | 1 |
3.2 Safety stock & min-max inventory

To calculate the safety stock inventory of PT. XYZ which is below the safety level is used a safety factor of 90% in accordance with management's policy in determining the ratio of units supplied to the units requested [12], assuming the supplier delivers raw materials on time according to the agreed lead time. To calculate the safety stock, the standard deviation of raw material demand is needed, which is used in this study the demand data from week 1 to the 12th week from September to November 2019. The following table calculates the standard deviation of raw material demand for 12 weeks at PT. XYZ.

| Week | 1450200000115000 | 1410400000259000 | 1310100000146000 | 1010200000454000 | 14802000000456000 | 1460200000457000 | 1410100000465000 |
|------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 1    | 4148             | 753              | 22               | 66759            | 71               | 3522             | 725              |
| 2    | 4979             | 1265             | 65               | 43119            | 121              | 6036             | 1238             |
| 3    | 4888             | 1211             | 10               | 23528            | 121              | 6053             | 1211             |
| 4    | 5032             | 1674             | 0                | 30464            | 158              | 7893             | 1629             |
| 5    | 2678             | 95               | 0                | 32982            | 3                | 6259             | 63               |
| 6    | 4327             | 1256             | 48               | 31906            | 119              | 5944             | 1224             |
| 7    | 4339             | 1440             | 34               | 21615            | 135              | 6723             | 1395             |
| 8    | 3590             | 1346             | 13               | 28390            | 128              | 6394             | 1314             |
| 9    | 8,321            | 1125             | 42               | 11126            | 113              | 5625             | 1125             |
| 10   | 9210             | 1652             | 21               | 19340            | 154              | 7685             | 1598             |
| 11   | 7200             | 1517             | 6                | 18626            | 148              | 7392             | 1499             |
| 12   | 2863             | 1251             | 0                | 4908             | 125              | 6255             | 1251             |
| D Average | 5131.23         | 1215.4           | 21.75            | 27730.25         | 116              | 6315.09          | 1189.34          |
| SD   | 2066.34          | 430.87           | 21.33            | 16005.34         | 42.3             | 1138.88          | 427.5            |
After the demands’ standard deviations are obtained, the safety stock calculation results of PT. XYZ are shown in Table 3. PT. XYZ also faces the problem of a full warehouse, so that after getting the amount of safety stock for the inventory it would be better to take into account the maximum number of inventory orders as well. The results of the calculation of min-max inventory for the seven raw materials are shown in Table 3 and Figure 2.

**Table 3. Safety stock and min-max inventory table**

| Inventory code | SF 90% | LT days | LT Week | D | Safety Stock | Min Inventory | Max Inventory |
|----------------|--------|---------|---------|---|--------------|---------------|---------------|
| 1450200000115000 | 1.28   | 7       | 1       | 5131.23 | 2645         | 7777          | 18040         |
| 1410400000259000 | 1.28   | 6       | 0.86    | 1215.42 | 512          | 1558          | 3649          |
| 1310100000146000 | 1.28   | 5       | 0.72    | 21.75   | 24           | 40            | 72            |
| 1010200000454000 | 1.28   | 6       | 0.86    | 27730.25 | 18999       | 42848         | 90545         |
| 1480200000456000 | 1.28   | 7       | 1       | 116.34  | 55           | 172           | 405           |
| 1460200000457000 | 1.28   | 6       | 0.86    | 6315.09 | 1352         | 6783          | 17645         |
| 1410100000465000 | 1.28   | 8       | 1.15    | 1189.34 | 587          | 1955          | 4691          |

**Figure 2. Safety stock and min-max inventory graph**
4. CONCLUSION

Through Bayes-fishbone, we see that PT. XYZ’s raw material conditions are not optimal due to several factors. Main factors are based on the 5M1E concept of material, man, method, environment, and machine. According to the weighting of the Bayes method criteria, the order of the causative factors is 33% due to the return of material goods and the amount that is not appropriate, 25% due to poor communication with suppliers, 17% due to logistical obstructions in the weather, 15% due to long lead times, and 10% due to slow engine performance. By using a safety factor of 90%, the safety stock of raw material coded 1310100000146000 is 24 kg, 450200000115000 requires a safety stock of 2,645 kg, raw material 1410400000259000 needs 512 kg, 1010200000454000 needs 18,999,000 kg, 55 kg for 1480200000456000, 1,352 for 1460200000457000, and 587 kg for raw material code 1410100000465000. As an effort to optimize the company's raw materials, the amount of raw material procurement is better to follow the min-max inventory method so that in addition to preventing stock out, the company can also avoid overstocks.

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