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DETERMINE THE APPROPRIATE INVENTORY MODEL IN TANG COMPANY

Steven Margono and Yuliani Dwi Lestari
School of Business and Management
Institut Teknologi Bandung, Indonesia
steven.margono@sbm-itb.ac.id

Abstract. Purpose – The purpose of this paper is to give recommendation in terms of inventory management to Tang Company. So that, production is on time and in the right amount (avoid overstock, shortage). Methodology / Approach – The methodology used for the research is interviewing company's Director and Secretary and collecting company's purchasing and sales data to get company's business and product data. After that, company's type of demand is identified and a new inventory model which suits with the demand characteristic is proposed. Current company's inventory management system is also analyzed and compared with proposed inventory model to see whether the new inventory model gives more benefit to the company. Finally, recommendations will be given to the company with how to implement it to their system and daily operation. Findings – Tang Company's demand and lead time are variable, so probabilistic model is used to determine the safety stock and reorder point. EOQ model is used to maximize order quantity, while Material Requirements Planning technique is used to calculate total cost for proposed inventory management. After both existing and proposed inventory management results are compared, it seems that the company can save a large number of money by implementing the new inventory model. Research Limitation – The limitation of the research is types and colors of material and final product, which are bur polyester benhur, donker, and black; and purchasing data and sales data, which are from 1st January 2014 until 31st December 2014.

Keywords: Inventory Management, Economic Order Quantity, Probabilistic Model, Material Requirements Planning, Textile Industry.

Introduction

Textile industry is one of the important manufacturing sectors in Indonesia, with gross domestic product (GDP) valued at Rp 172.4 billion (US$ 14.4 billion) and accounted more than 7 percent of the country's total exports in 2013 (Global Business Guide Indonesia, 2014). It provided some 1.1 million jobs in 2012, making the industry very important to Indonesia economy as the main work field providers (BPS, 2012).

Indonesia's textile industry still faces a host of internal and external problems, especially in the current economic crisis. These mainly consist of excessive capacity utilization, inefficiency of machinery, planning uncertainties due to exchange rate fluctuations, increasing production costs, irregular supplies of basic materials, and shortages in qualified human resources (EKONID 2001, cited in Kuncoro, 2013). Furthermore, FIAS (2006, in Kuncoro 2013) also has identified one of the key challenges in Indonesia's textile industry, which is low labor productivity and rigid labor market and policies cause accelerated increases in labor costs, and undermine Indonesia's low labor cost advantage.

Tang Company as one of the textile industries in Bandung, is also facing similar issue in terms of inaccuracy inventory management. They faces uncertain demand, such as quantity, color, and type of products, which have caused a mismatch between the customer demand and supply of the company. For example, the company had ordered many low quality material previously on the 2014 national election

period, so it is ready to fulfill the predicted huge orders. Usually many orders that required low quality material come in the national election period, but the orders in 2014 national election were not as many as the usual national election period orders, instead another orders which required different material. The company had already ordered material and processed it, which was not corresponding with the orders. As the result, wrong final product spilled up in the warehouse.

Literature Review

Basic Economic Order Quantity (EOQ) Model

EOQ model is one of independent demand models, which minimizes the total of ordering and holding costs. The total number of orders placed per year will decrease as the quantity ordered increases. Therefore, as the quantity ordered increases, the annual setup or ordering cost will decrease. But as the order quantity increases, the holding cost will also increase due to larger average inventories which are maintained (Heizer & Render, 2011).

$$Q^* = \frac{\sqrt{2DS}}{H}$$

Q* = Optimum number of units per order (EOQ)

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order

H = Holding or carrying cost per unit per year

Reorder Points

Now that how much to order has been decided, we will look at the second inventory question, when to order. Simple inventory models assume that receipt of an order is instantaneous, but the time between placement and receipt of an order (called lead time), or delivery time, can be as short as a few hours or as long as months in the reality. So that, the when-to-order decision is usually expressed in term of a reorder point (ROP). Reorder point is the inventory level at which an order should be placed to replenish the stocked item (Heizer & Render, 2011).

ROP = Demand per day x Lead time for a new order in

$$d = \frac{\text{Annual Demand}}{\text{Number of working days in year}}$$

Probabilistic Models and Safety Stock

All the inventory models which have been discussed so far make the assumption that demand for a product is constant and certain. The following inventory models are applicable statistical models when product or demand or any other variable is not known but can be specified by means of a probability distribution, called probabilistic models.

An important concern of management is to maintain a sufficient service level in the face of uncertain demand. The service level is the accompaniment of the probability of a stock out. One method of reducing the stock outs is to hold extra units in inventory, which is usually referred to as safety stock. It

involves adding a number of units as a buffer to the reorder point. The amount is maintained depend on the cost of incurring a stock out and the cost of holding the extra inventory (Heizer & Render, 2011).

$$\text{ROP} = (\text{d x L}) + \text{ss}$$

d = Daily demand
L = Order lead time, or number of working days it takes to deliver an order
ss = Safety stock

Previously, it is assumed that both an estimate of expected demand during lead times and its standard deviation are available. These formulas cannot be applied when data on lead time demand are not at hand. However, three other probabilistic models are available (Heizer & Render, 2011):

Demand is Variable and Lead Time is Constant

$$\text{ROP} = (\text{Average daily demand x Lead time in days}) + Z\sigma_{dLT}$$

$$\text{where } \sigma_{\text{dLT}} = \text{Standard deviation of demand during lead time} = \sigma_d\sqrt{Lead\ time}$$
$$\text{and } \sigma_d = \text{Standard deviation of demand per day}$$

Demand is Constant and Lead Time is Variable

$$\text{ROP} = (\text{Daily demand x Average lead time in days})$$

$$\text{where } \sigma_{LT} = \text{Standard deviation of lead time in days}$$

Both Demand and Lead Time are Variable

$$\text{ROP} = (\text{Average daily demand x Average lead time}) + Z\sigma_{dLT}$$

$$\text{where } \sigma_d = \text{Standard deviation of demand per day}$$
$$\text{where } \sigma_{LT} = \text{Standard deviation of lead time in days}$$
$$\text{where } \sigma_{dLT} = \sqrt{(Average\ lead\ time\ x\ \sigma_d^2) + (Average\ daily\ demand)^2\ \sigma_{LT}^2}$$

Methodology

Analysis of company's current inventory management is proposed. Literature study, preliminary interview, field observation, and historical data collection are conducted to support the company's current inventory management analysis. In doing the inventory management analysis, the first step is plotting company's weekly period purchasing and selling data using Excel. The second step is collecting company's cost (holding cost, overstock cost, shortage cost, and ordering cost), lead time in ordering material, and company's cycle service level. After all of the data is acquired and seeing the type of demand consistency, the most appropriate inventory model can be calculated.

Recommendation will be also provided in terms of the most optimum new forecasting method, new inventory model for determining number of units per order, reorder point (ROP), amount of safety stock, and how to implement those ideas in company's daily operation. Finally, deep interview with Chief Operating Officer is conducted to validate the findings of inventory management analysis. The company

will make adjustment later in its implementation of new forecasting method and inventory model to their system and daily operation.

Findings

Business Issue

From the interview and field observation, it can be seen that currently the company is utilizing all of their machines as high as possible to overcome the uncertain demand. It means if there is any idle machine, they will use it for making product which is considered as the most salable by the company and stock them in the warehouse. Moreover, the company will order 200 kilogram of polyester yarn to Gemilang if only material's stock in warehouse has already attained the lowest limit. The lowest limit is approximately 4 sacks (100 kilogram), which is the company's safety stock and reorder point. Because the company just does a simple inventory management, overstock and shortage are frequently occurred in a year time. Figure 4.1 shows that shortage is the most often case occurred in the company, while overstock case shows a stable trend as time goes by and much less occurred than shortage.

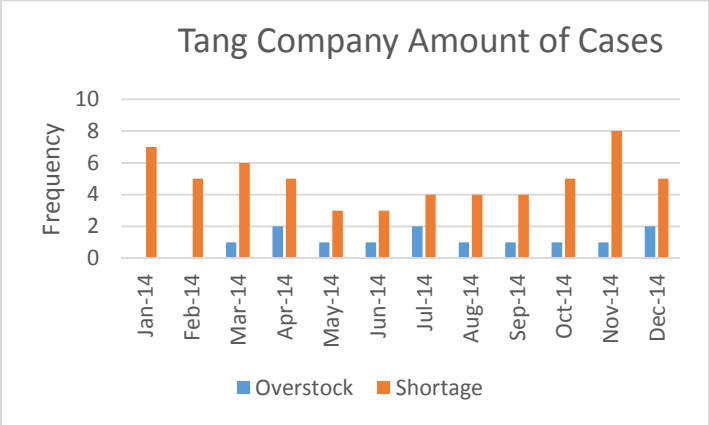

Figure 4.1 Tang Company amount of overstock and shortage cases for bur polyester benhur, donker, and black in 2014

Overstock is assumed as inventory of final product which exceeds company's safety stock in every end of month, and holding cost is assumed as inventory of final product which is equal or lower than company's safety stock in every end of month. According to COO's assumption, these problems are contributed about more than half of total cost for bur polyester benhur, donker, and black, since the shortage cost is assumed 17 times bigger for polyester products. So that, shortage is automatically become the priority problem for the company.

Analysis of Existing Inventory Management

In order to analyze the company's characteristics of existing inventory management, there are several details which are needed to be gathered before, such as number of materials that go into warehouse, number of final products that delivered to customer, and value of all company's costs. Based on historical data, Tang Company total demand per month in 2014 is presented in table 4.1. All of the data are rounded to ease us in observing the table. The demand for three types of company's products are uncertain, which are range from about 100 kilogram per month until 1,500 kilogram per month.

Table 4.1 Tang Company total demand per month in 2014 for bur polyester benhur, donker, and black

Demand (kg)	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
Bur Polyester Benhur	229	261	199	191	258	400	107	274	276	189	158	204
Bur Polyester Donker	632	425	391	355	363	474	386	328	603	677	411	490
Bur Polyester Black	974	1182	1029	887	1563	1119	768	682	1044	1069	1215	1134

The average lead time between ordering and receiving materials for bur polyester benhur, donker, and black are one week with range from half week until one and half weeks. In the matter of cost, currently Tang Company has four types of cost, which are ordering cost, holding cost, overstock cost, and shortage cost. Holding cost and overstock cost for all types of products are the same because they are placed in the same warehouse, which are IDR 3,500 per kilogram per month. On the other hand, the ordering cost and shortage cost are different for several types of products since supplier and amount of materials delivered are different. The ordering cost for bur polyester benhur, donker, and black are IDR 40,000 per kilogram. According to COO's assumption, the shortage cost is adjusted with the ordering cost. For bur polyester benhur, donker, and black, the shortage cost are IDR 60,000 per kilogram.

Holding cost is calculated by multiplying amount of remaining items in every end of month which does not exceed company's safety stock, with the cost of holding cost per kilogram per month. Overstock cost appears when there is remaining items which exceed company's safety stock in every end of month. So that, the overstock cost is calculated by multiplying amount of remaining items in every end of month over company's safety stock with the cost of overstock cost per kilogram per month. Shortage cost appears anytime when the company could not fulfill customer demand. Shortage cost is calculated by multiplying the number of final products which could not be fulfilled by the cost of shortage per kilogram. Last but not least, ordering cost is calculated by amount of materials that go into warehouse anytime by the cost of ordering cost per kilogram.

After all of the data is acquired, existing total cost for the most salable company's products can be calculated by summing all of the company's costs. The calculation result is shown in table 4.2. The holding cost and overstock cost contribute just a very little amount if compared with shortage cost and ordering cost. Both shortage cost and ordering cost contribute for more than 95% of the total cost, which become a major concern contributing for the total cost.

Table 4.2 Tang Company cost calculation based on existing data in 2014

Company's Products	Holding Cost	Overstock Cost	Shortage Cost	Ordering Cost	Total Cost
Bur Polyester Benhur	IDR 2,270,426	IDR 2,095,925	IDR 139,244,520	IDR 101,929,248	IDR 245,540,119
Bur Polyester Donker	IDR 2,402,211	IDR 2,924,350	IDR 119,823,150	IDR 234,726,000	IDR 359,875,711
Bur Polyester Black	IDR 2,086,548	IDR 4,322,269	IDR 210,795,540	IDR 529,414,820	IDR 746,619,177

Analysis of Proposed Inventory Management

The proposed inventory management consists of order guidance and supply process. The order guidance is about maximizing order quantity using Economic Order Quantity (EOQ) model since the company's characteristic is make to stock, whereas the supply process is about determining safety stock and reorder point using probabilistic model since both of company's demand and lead time are variable. At present, Tang Company already has both order guidance and supply process, but still ineffective concerning the existing shortage cost and ordering cost in table 4.2. Therefore, Tang Company is expected to manage better their inventory management at the current condition by improving the order method and supply process.

In order to calculate EOQ model, there are several data needed to be acquired first, which are annual demand, ordering cost per order, and annual holding cost. Annual demand is acquired by summing all final products that delivered to customer. Ordering cost per order is acquired by multiplying ordering cost per kilogram with amount of materials per order in kilogram. Last but not least, annual holding cost is acquired by multiplying holding cost per kilogram per month with 12. After all of data is acquired, the annual demand and ordering cost per order are multiplied with 2, then it is divided by annual holding cost and root squared to calculate the EOQ model.

On the other hand, to calculate the safety stock and reorder point, there are also several data needed to be acquired first, which are average weekly demand, average lead time in week(s), standard deviation of demand per week, standard deviation of lead time in week(s), customer service level (CSL), and Z value. Average weekly demand is calculated using AVERAGE formula in Excel while standard deviation of demand per week is calculated using STDEV formula in Excel. Regarding customer service level, Tang Company has an assumption that its CSL is 85% for all products, which means the probability of stock out is 15%. Even with this CSL, their customers are willing to wait for the delivery of final products because the company guarantees that the delivery will not be more than half week. After CSL is acquired, the Z value can be determined using NORM.S.INV formula in Excel. Moreover, average lead time and standard deviation of lead time between ordering and receiving materials for several types of products are different, since supplier and amount of materials delivered are different. Bur polyester benhur, donker, and black have average lead time of one week and standard deviation of lead time in half week. Finally, the safety stock and reorder point can be determined using all of these data. Safety stock is calculated by multiplying Z value with standard deviation during lead time ($\sigma_d\sqrt{Lead\ time}$). Reorder point is calculated by multiplying average weekly demand with average lead time in week(s) and adding it with the safety stock.

The analysis of proposed inventory management for every product will be discussed more in the following section.

Bur Polyester Benhur

All of data which is needed to calculate the EOQ model is presented in table 4.3. The calculation results 1,023 kilogram for the EOQ model.

Table 4.3 Required data to calculate the EOQ model for bur polyester benhur

Annual Demand	Ordering Cost per Order	Annual Holding Cost
2,747.12 kg	IDR 8,000,000	IDR 42,000

On the other hand, all of data which is needed to calculate the safety stock and reorder point using probabilistic model, is presented in table 4.4. The calculation results 48.61 kilogram for safety stock and 105.85 kilogram for reorder point.

Table 4.4 Required data to calculate the safety stock and reorder point for bur polyester benhur

Average Weekly Demand	Average Lead Time	Standard Deviation of Demand per Week	Standard Deviation of Lead Time	Standard Deviation during Lead Time
57.232 kg	1 week	36.961 kg	0.5 week	46.744

Bur Polyester Donker

All of data which is needed to calculate the EOQ model is presented in table 4.5. The calculation results 1,452.04 kilogram for the EOQ model.

Table 4.5 Required data to calculate the EOQ model for bur polyester donker

Annual Demand	Ordering Cost per Order	Annual Holding Cost
5,534.64 kg	IDR 8,000,000	IDR 42,000

On the other hand, all of data which is needed to calculate the safety stock and reorder point using probabilistic model, is presented in table 4.6. The calculation results 79.61 kilogram for safety stock and 194.91 kilogram for reorder point.

Table 4.6 Required data to calculate the safety stock and reorder point for bur polyester donker

Average Weekly Demand	Average Lead Time	Standard Deviation of Demand per Week	Standard Deviation of Lead Time	Standard Deviation during Lead Time
115.305 kg	1 week	50.356 kg	0.5 week	76.547

Bur Polyester Black

All of data which is needed to calculate the EOQ model is presented in table 4.7. The calculation results 2,196.72 kilogram for the EOQ model.

Table 4.7 Required data to calculate the EOQ model for bur polyester black

Annual Demand	Ordering Cost per Order	Annual Holding Cost
12,667.19 kg	IDR 8,000,000	IDR 42,000

On the other hand, all of data which is needed to calculate the safety stock and reorder point using probabilistic model, is presented in table 4.8. The calculation results 175.76 kilogram for safety stock and 439.66 kilogram for reorder point.

Table 4.8 Required data to calculate the safety stock and reorder point for bur polyester black

Average Weekly Demand	Average Lead Time	Standard Deviation of Demand per Week	Standard Deviation of Lead Time	Standard Deviation during Lead Time
263.9 kg	1 week	105.59 kg	0.5 week	168.997

After the EOQ model, safety stock, and reorder point are determined, total cost for the proposed inventory management can be calculated using Material Requirements Planning (MRP) technique. The proposed inventory management total costs for bur acrylic benhur until collar acrylic black are presented in table 4.9, which consist of holding cost, overstock cost, shortage cost, and ordering cost. Moreover, the detail use of MRP technique is available in Appendix 7.

Table 4.9 Tang Company cost calculation based on proposed inventory management in 2014

Company's Products	Holding Cost	Overstock Cost	Shortage Cost	Ordering Cost	Total Cost
Bur Polyester Benhur	IDR 2,041,620	IDR 21,951,104	-	IDR 122,760,000	IDR 146,752,724
Bur Polyester Donker	IDR 3,343,620	IDR 34,964,024	IDR 12,909,930	IDR 232,326,400	IDR 283,543,974
Bur Polyester Black	IDR 7,381,920	IDR 44,862,624	IDR 3,850,290	IDR 527,212,800	IDR 583,307,634

If the cost calculation from existing inventory management and proposed inventory management are compared, the holding cost and overstock cost seem experienced a huge growth while shortage cost seems extremely decreased. In addition, the total cost for proposed inventory management is also experienced a huge decline since the shortage cost is assumed 25 times bigger than the holding cost and overstock cost for acrylic products, and 17 times bigger for polyester products. So that, Tang Company can save a large number of money by implementing the proposed inventory model. The total saving data is presented in table 4.10.

Table 4.10 Total saving by implementing proposed inventory management

Company's Products	Existing Total Cost	Proposed Total Cost	Total Saving
Bur Polyester Benhur	IDR 245,540,119	IDR 146,752,724	IDR 98,787,395
Bur Polyester Donker	IDR 359,875,711	IDR 283,543,974	IDR 76,331,737
Bur Polyester Black	IDR 746,619,177	IDR 583,307,634	IDR 163,311,543

Conclusion

Analysis of Tang Company existing inventory management is done by gathering number of materials that go into warehouse, number of final products that delivered to customer, and value of all company's costs (holding cost, overstock cost, shortage cost, and ordering cost). The result proves that there is a way to improve the current situation of Tang Company, so proposed inventory management is conducted. The proposed inventory management consists of maximizing order quantity using Economic Order Quantity (EOQ) model and determining safety stock and reorder point using probabilistic model.

After the EOQ model, safety stock, and reorder point are determined, the total cost for proposed inventory management can be calculated using Material Requirements Planning (MRP) technique.

By applying a better method over the current approach in predicting demand and managing inventory for bur acrylic benhur until collar acrylic black, it is expected that Tang Company will have a better plan for their production system.

Recommendation

The following recommendations are provided to Tang Company:

- It is recommended that Tang Company considers applying the proposed inventory model, since it will save a large amount of money for the company.
- In case the proposed inventory model is applied, it is suggested that the company recruits a supervisor who can be trained how to calculate the optimal order quantity, reorder point, and safety stock, and use MRP technique. Besides that, the current situation of writing manually company's purchasing and selling data on notes is needed to be changed. The secretary should transfer all of the secondary data to Excel software and group it into weekly period, in order to ease the processing of data.

The following studies are left for future research:

- As the result of proposed inventory model, Tang Company is expected to carry more inventory and increase their amount of optimal order quantity. It seems that the company needs to improve their quality control as the number of items which they manage are increasing. So that, the topic of the research can be expanded into quality control.
- The amount number of materials which are analysed can be increased since there are only one type of yarn out of eight and three colours out of 128 which are analysed in this research.
- The proposed inventory model in this research can be extended to other region and business areas.

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