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Strategy of Optimization Inventory: Case Study in Private Manufacturing in Construction Field Company in Indonesia

Lim Sanny and Monica Felicia
Bina Nusantara University, Jakarta, Indonesia

Abstract: The purpose of this study is to improve the effectiveness and efficiency of inventory management and find the alternative that can minimize the cost of inventory. The research methods used are Forecasting method to calculate the data from company, Economic Order Quantity (EOQ) to optimize the cost and quantity of raw materials and Decision trees to analyze the best alternative solution for company. The study is descriptive research and cross-sectional secondary data. The results show that the Forecasting method is necessary to determine inventory and using EOQ model that can reduce the inventory cost. Therefore, this study concludes that in order to manage inventory effectively and efficiently and minimize cost, EOQ model is needed to obtain reasonable quantities for its raw materials.

Key words: Raw materials, forecasting, inventory, EOQ, decision trees

INTRODUCTION

Indonesia as a developing country, is required to continue to develop and improve so Indonesia can compete with the other countries in the world. The real example is the improvements in government systems, economic growth, infrastructure developments, property and many more. With this growth, it is possible for Indonesia to more expand in infrastructure and property sector. In Jakarta, the infrastructure and property developments are continuing. Four infrastructure development plans have been incorporated into Peraturan Daerah Rencana Pembangunan jangka Menengah Daerah (Perda RPJMD) DKI Jakarta for the period 2013-2017 which is recently passed by DPRD DKI Jakarta (Bappenas, 2013). The four infrastructures are Mass Rapid Transit (MRT), monorail, Giant Sea Wall (GWS) or giant sea dam and deep tunnel or tunnels multifunction.

There are also other infrastructures in Jakarta which are in the process now. A public housing development in 2004-2012 rose sharply to 266 twin blocks (Astutik, 2013) which is the realization of the plan in previous years that have not been implemented. This development is still ongoing until now. The government wants to accelerate the infrastructure development in Jakarta. So, there is acceleration of infrastructure development in Jakarta through partnership Government-Private scheme. Not only government but also private companies have mega building projects for this year. With many projects that will be implemented, it gives great opportunity for players in the properties and construction industry, especially for private companies.

Company is a private manufacturing unit that produces precast concrete fence, precast u-ditch, precast box culvert, precast cover u-ditch and many more. The main product of is precast u-ditch. In the beginning, this company is handling private construction projects, for example, installing fences and installing culverts in housing and roads. They expand the scope not only projects in Jakarta but also outside the city. Company has handled the project on the toll road in Jakarta which is installing the potted plants along the road. Now, the company has other projects with the government. This is a positive market prospect, so the company gradually will increase in the production and sales. The company has an inventory system to keep their finished goods and raw materials. They also have safety stock of finished goods and raw materials in the warehouse. In this company, raw materials are ordered when the level of inventory becomes low or the employee's result of checking in the warehouse according to their sight and stock card. This shows that company does not have ineffective and inefficient inventory systems. This system can cause overstocking or under stocking inventory which will lead to high costs or delay the production. With high demand growth, the company should have effective and efficient inventory system, so it can meet the demand of customer, especially with the acceleration of infrastructure program from the government, whom demand is required in rapid process.

With the growing of infrastructure sector, it will have an impact on increasing demand. To be able to compete the market, a business should implement a strategy that

Corresponding Author: Lim Sanny, Bina Nusantara University, Jakarta, Indonesia

can face the market challenges. One of the strategies that can be done is managing the inventories. Mwansele *et al.* (2011) said that poor inventory management may result in under-stocking, overstocking as well as high inventory total cost. By managing inventories, many industries or firms, whether manufacturing or purchasing, can help to keep the firm's production to run smoothly, optimize the inventories, determine the reorder point and minimize the total inventory cost. Inventory is important and crucial to many companies. According to Heizer and Render (2011), a company can reduce costs by reducing inventory but production may stop and customers become dissatisfied when the product is out of stock. The objective of inventory management is to strike a balance between inventory investment and customer service.

This study analyzes the precast u-ditch product because this product produces more than others and it is also the main product of the company. The raw materials of precast u-ditch are iron, cement, sand and split. Therefore, this study needs to be done to predict the next demand in the future. As mentioned before, the company already cooperates with the government. The government projects have a tight schedule and deadline. So, the company must be able to meet the demand, especially with the tight competition among other companies. The company must have good efficiency in terms of inventory management and cost of inventory, in order to prevent scarcity of raw materials. The studied product is a precast u-ditch, this product is used for ditch construction underground for buildings or roads. The phenomenon which is appointed is the circumstances where the use of result of demand forecasting and inventory data can support the implementation of Economic Order Quantity (EOQ) model and the level of reorder point. Anytime, the company has repetitive purchasing or planning of an item, EOQ should be considered. Obvious applications for EOQ are purchase-to-stock distributors and make-to-stock manufacturers. However, make-to-order manufacturers should also consider EOQ when they have multiple orders or release dates for the same items and when planning components and sub-assemblies (Sarjono, 2012). The company can determine how much material should be ordered, when should be ordered and the amount of total cost of inventory. Also using of Decision Trees analysis that can help to determine the alternative solutions and make the best possible solutions for the company to minimize cost and control the raw materials inventory management (Schroeder, 2007).

Inventory management is needed in any business. The proper inventory control technique can help to determine the sustainability in the business process (Haribhai-Pitamber and Dhurup, 2014). Inventory is a stock or store of goods (Stevenson, 2011). Naturally, many of the items a firm carries in inventory relate to the kind of business it engages in and it is pivotal in an effective and efficient organization (Adeyemi and Salami, 2010). On the other hand, Mwansele *et al.* (2011) stated that inventories are idle stocks of goods stored and waiting to be used. A firm can reduce costs by reducing inventory (Heizer and Render, 2011). Production may stop and customer becomes dissatisfied when an item is out of stock. So, The objective of inventory management is to strike a balance between inventory investment and customer service. A low cost-cost strategy cannot be achieved without good inventory management. Render *et al.* (2011) stressed that inventory is one of the most expensive and important assets of many companies, representing as much as 50% of total invested capital. So, there are basic components of an inventory planning and control system. The planning phase is concerned primarily with what inventory is to be stocked and how it is to be acquired (whether it is to be manufactured or purchased). This information is then used in forecasting demand for the inventory and in controlling inventory levels (Sarjono, 2012). The feedback loop in providing a way of revising the plan and forecast based on experience and observation.

Forecasting is the art and science of predicting the future events (Heizer and Render, 2011) and forecasting has been used to predict the uncertain nature of business trends in an effort to help managers make better decisions and plans (Hanke and Wichern, 2005). Forecasting is necessary because all the organizations operate in an atmosphere of uncertainty but decisions must be made today that affect the future of the organization (Render *et al*., 2011). Every day, managers make decisions without knowing what will happen in the future. Inventory is ordered though no one knows what sales will be, new equipment is purchased though no one knows the demand for products and investments are made though no one knows what profits will be (Matthew *et al*., 2013).

The overall accuracy of any forecasting model can be determined by comparing the forecasted values with the actual or observed values (Heizer and Render, 2011):

Forecast error = Actual value-Forecast value

There are three of the most popular measurers which are Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percent Error (MAPE) (Ali *et al*., 2012):

- **Mean Absolute Deviation (MAD):**

This value is computed by taking the sum of the absolute values of individual forecast error (deviations) and dividing by the number of periods of data (n):

$$MAD = \frac{\sum|Actual - Forecast|}{n}$$

- **Mean Squared Error (MSE):**

The average of the squared differences between the forecasted and observed values:

$$MSE = \frac{\sum(Forecast\ errors)^2}{n}$$

- **Mean Absolute Percent Error (MAPE):**

This is computed as the average of the absolute difference between the forecasted and actual values, expressed as a percentage of the actual value:

$$MAPE = \frac{\sum_{i=1}^{n} 100\left|Actual_i - Forecast_i\right| / Actual_i}{n}$$

The Economic Order Quantity (EOQ) is one of the oldest and most commonly known inventory control techniques (Render *et al*., 2011). There are some assumptions in EOQ techniques such as demand is known and constant, the lead time, the receipt of inventory is instantaneous, the purchase cost per unit is constant throughout the year, the only variable costs are the cost of placing an order ordering cost and the cost of holding or storing inventory over time and orders are placed so that stockouts or shortages could be avoided completely (Russell and Taylor, 2011). With EOQ model, the optimal order quantity will occur at a point where the total setup cost is equal to the total holding cost (Harbour, 2014). This fact is developed for equations that solve directly for Q* (Heizer and Render, 2011). The necessary steps starts from developing an expression for setup or ordering cost, developing an expression for holding cost, Set setup (order) cost equal to holding cost, then solve the equation for the optimal order quantity (Piasecki, 2012):

- Annual setup cost = (No. of orders placed per year) ×(Setup or order cost per order)

$$= \left(\frac{\text{Annual demand}}{\text{No. of units in each order}}\right)(\text{Setup or order cost per order})$$
$$= \left(\frac{D}{Q}\right)(S)$$
$$= \frac{D}{Q}S$$

- Annual holding cost = (Average inventory level)× (Holding cost per unit per year)

$$= \left(\frac{\text{Order quantity}}{2}\right)(\text{Holding cost per unit per year})$$
$$= \left(\frac{Q}{2}\right)(H)$$
$$= \frac{Q}{2}H$$

- Optimal order quantity is found when annual setup (order) cost equals annual holding cost, namely:

$$\frac{D}{Q}S = \frac{Q}{2}H$$

- To solve Q^*, simply cross-multiply terms and isolate Q on the left of the equal sign

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

It can also determine the expected number of orders placed during the year (N) and the expected time between orders (T), as follows:

$$\text{Expected no. of orders} = N = \frac{\text{Demand}}{\text{Order quantity}} = \frac{D}{Q^*}$$

$$\text{Expected time between orders} = T = \frac{\text{No. of working days per year}}{N}$$

The total annual variable inventory cost is the sum of setup a holding cost:

Total annual cost = Setup (order) cost+Holding cost

In terms of the variables in the model, it can express the Total Cost (TC) as:

$$TC = \frac{D}{Q}S + \frac{Q}{2}H$$

The reorder point (ROP) determines when to order inventory (Render *et al*., 2011). Heizer and Render (2011) stressed further that a firm will place an order when the inventory level for that particular item reaches to zero and it will receive the ordered items immediately. However, 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. Thus, the when-to-order decision is usually expressed in terms of a reorder point (ROP), the inventory level at which an order should be placed. It is found by multiplying the daily demand times by the lead time in days. The ROP is given as:

$$ROP = (\text{Demand per day}) \times (\text{Lead time for a new order in days}) = d \times L$$

This equation for ROP assumes that demand during lead time and lead time itself is constant. When this is not the case, extra stock, often called safety stock, should be added. The demand per day, d, is found by dividing the annual demand, D, by the number of working days in a year:

$$d = \frac{D}{\text{No. of working days in an year}}$$

Heizer and Render (2011) stated that to achieve the goals of organizations, managers must understand how decisions are made and know which decision-making tools are used. A good decision is based on logic and considers all available data and possible alternatives. It also follows these six steps:

- Clearly define the problem and the factors that influence it
- Develop specific and measurable objectives
- Develop a model that is a relationship between objectives and variables
- Evaluate each alternative solution based on its merits and drawbacks
- Select the best alternative
- Implement the decision and set a timetable for completion

MATERIALS AND METHODS

This study is an applied study which has been purposed to know and to be able to improve and develop the systems to be better, effectively, efficiently. This type of study is called descriptive study. The horizon time used is cross-sectional which is data that are gathered just once, over periods of months. This study uses data from November 2011 until October 2013. There are two sources of research data which are primary and secondary data. Primary data refers to information obtained first-hand by the researcher on the variables of interest or the specific purpose of the study. Secondary data refer to information gathered by someone other than the researcher conducting the current study. This study uses secondary data which are gathered from the company.

The data processing is done by using QM for Windows software to calculate Forecasting, Economic Order Quantity (EOQ) and Decision Trees Analysis. This study focus on the raw materials of u-ditch product. The analysis is used to know the forecasted demand of raw materials, the optimum and economical quantity when to order, the reorder point, the total cost of inventory and the alternative solutions for inventory management.

RESULTS AND DISCUSSION

Figure 1 shows raw material graph, so it can describe and compare the demand data from November 2011-October 2013. The model of the graph is line chart which is divided into four categories in order to display the trends over time of each raw materials.

Figure 1 shows that there are four lines with different changes in twelve months data. It shows that in the first month which is November 2011, the demand is high, then the line is decreasing. After that, the line gradually increasing and then decreasing again. It can be assumed that there is increasing demand for raw materials in every month at the end of the year.

The results and comparison table of the raw materials demand forecasting results on November 2012-October 2013 by using six forecasting methods which are calculated by QM for Windows software. By using a comparison table, the method which has the smallest MAD and MSE will be suggested to be used by company. The MAD and MSE show the error level of that method.

Iron forecasting: The results obtained from processing the data (Table 1) show that Weighted Moving Averages

Table 1: Comparison of iron forecasting results

Methods	MAD	MSE	Forecast
LR	88.5476	12,880.740	152.9849
MA	81.2222	12,412.060	223.0000
WMA	69.0000	8,418.708	214.0000
ES	102.8771	22,523.490	228.9956
ESWT	112.2751	23,087.760	164.7260
Naive	97.2727	21,138.540	203.0000

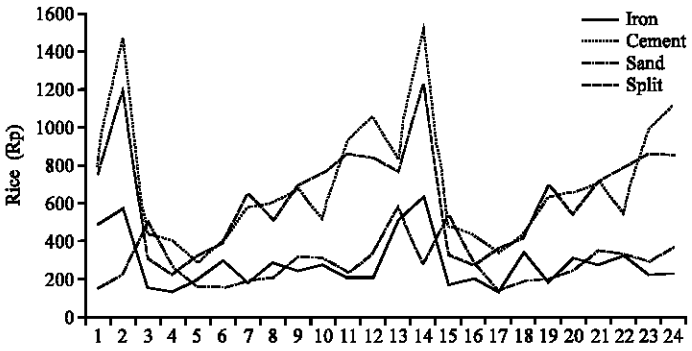

Fig. 1: Raw material graph

Table 2: Comparison of cement forecasting results

Methods	MAD	MSE	Forecast
LR	253.5489	103,099.00	702.6421
MA	258.0160	90,761.02	831.3566
WMA	225.9455	65,388.18	906.8870
ES	299.1411	130,690.80	788.6809
ESWT	338.4887	154,158.90	780.8475
Naive	266.6354	162,342.80	1,051.7300

Table 3: Comparison of sand forecasting results

Methods	MAD	MSE	Forecast
LR	71.2773	9,017.726	280.6122
MA	76.2693	9,054.232	293.5867
WMA	76.2464	7,975.414	299.9680
ES	82.7189	14,127.500	276.6154
ESWT	93.7180	15,302.890	302.0667
Naive	92.5864	15,746.820	332.8300

have the smallest MAD = 69 and MSE = 8,418.708 with the next period forecast is 214 units. The smaller the MAD and MSE show that the model is more accurate to forecast. So, it has been suggested to company to use Weighted Moving Averages to predict the demand of iron in the next period.

Cement forecasting: The comparison (Table 2) shows the results obtained from processing the data show that Weighted Moving Averages have the smallest MAD = 225.9455 and MSE = 65,388.18 with the next period forecast is 906.887 units. The smaller the MAD and MSE show that the model is more accurate to forecast. So, the company is suggested to use Weighted Moving Averages to predict the demand of cement in the next period.

Sand forecasting: The comparison (Table 3) shows that Weighted Moving Averages have the smallest MAD = 76.2464 and MSE =7,975.414 with the next period forecast is 299.968 units. The smaller the MAD and MSE show that the model is more accurate to forecast. So, the company is suggested to use Weighted Moving Averages to predict the demand of sand in the next period.

Table 4: Comparison of split forecasting results

Methods	MAD	MSE	Forecast
LR	21.9558	70,432.81	720.9753
MA	205.8856	62,169.47	818.1634
WMA	162.9333	42,673.38	827.3680
ES	252.9984	91,266.81	737.3680
ESWT	289.1715	109,748.60	754.8392
Naive	211.9109	102,054.80	835.8000

Split forecasting: The results of Split Forecasting (Table 4) shows that Weighted Moving Averages have the smallest MAD = 162.9333 and MSE = 42,673.38 with the next period forecast is 827.368 units. The smaller the MAD and MSE show that the model is more accurate to forecast. So, the company is suggested to use Weighted Moving Averages to predict the demand of split in the next period.

Based on forecasting method for four product, the forecasting results are used for prediction of the demand and for Economic Order Quantity in Inventory Management, as said by Matthew *et al.* (2013) in their study which explains businesses using a variety of forecast and the accuracy result of demand forecast will significantly improve inventory management. It also approves the previous study conducted by Kot *et al.* (2011) stating that the more accurate demand forecasting, the more efficient decisions for the planned production, lower inventory levels and cost of maintaining inventory.

The inventory of raw materials according to actual data November 2012-October 2013, with several data raw materials that are used in this study are iron, cement, sand and split (Table 5).

	Iron	Cement	Sand	Split
EOQ model	Rp594,612,100.00	Rp8,345,052,000.00	Rp990,782,200.00	Rp1,045,236,000.00
Current system	Rp655,755,000.00	Rp9,046,563,500.00	Rp1,009,170,000.00	Rp1,107,433,000.00

Fig. 2: Total cost of inventory chart

Table 5: Raw materials actual data November 2012-October 2013

Raw materials	Iron	Cement	Sand	Split
Demand	3,497 rod	8,649.716 t	3,781.57 kg	7,864.1 kg
Price (Rp)	165,000.00 rod	956,916.00 t	258,500.00 kg	130,000.00 kg
Ordering cost (C_o) (Rp)	2,250,000.00	2,700,000.00	800,000.00	2,300,000.00
Carrying or holding cost (C_h) (Rp)	19,700.00	99,000.00	29,000.00	14,500.00
Lead time	14 days	1 day	2 days	8 days
Number of working days	360 days	360 days	360 days	360 days
Safety stock	500 rod	1,200 t	550 kg	1,150 kg

Company (2013)

The result of split, sand, cement and iron inventory according to QM for Windows calculation, it can be concluded that in order for the amount of ce the total inventory cost for each raw materials. It will show the comparison between EOQ model and the current inventory system according to demand data November 2012-October 2013. So, company can know the gap between using EOQ model and the current system (Fig. 2).

Figure 2 shows that there is a gap between the current system and EOQ model of actual data November 2012-October 2013 for each raw materials. The EOQ model has smaller total cost rather than the current system. This is the result of:

- Company can reduces the total cost of iron as much as Rp 61,142,900.00 and save 9.324% from the current total cost
- The total cost of cement reduces as much as Rp 701,511,500.00 and save 7.754% from the current total cost
- The total cost of sand reduce sas much as Rp 18,387,800.00 and save 1.822% from the current total cost
- The total cost of split reduces as much as Rp 62,197,000.00 and save 5.616% from the current total cost

All of the raw materials that are calculated by EOQ model have smaller total cost than the current system. The biggest percentage reduced is iron material. So, the company can use EOQ model in order to get minimal total cost of inventory. It will help company to save more money or the money can be allocated for other purposes.

Based on the analysis results using Economic Order Quantity, it approves the previous study conducted by Mwansele *et al*. (2011), stating that Economic Order Quantity model with the aid of some judgment by the management, will decrease holding costs and ordering costs. The use of EOQ model will help to know the exact amount of raw materials to order and when to place new orders for each raw material. It also approves the other research by Adeyemi and Salami (2010) which states that inventory management is compulsory for the continuity and survival of any goal focused manufacturing organization. Inventory management has become highly developed to meet the rising challenges.

Decision trees: The analysis of Decision trees in this study is done by using QM for Windows software to determine the best alternative which method has minimal inventory total costs for company. The result, according to QM for Windows software, shows that the best alternative is Forecasting to control inventory. The node value is 213,988,200 which is the smallest value among the others. The smallest node value shows that it has the minimal costs rather than the others (Fig. 3).

Figure 4 reflects the decision to conduct forecasting analysis. There is 50:50 chance that company conduct forecasting. The conditional probabilities are also 50:50 between EOQ condition and non-EOQ condition. Because the Expected Monetary Value (EMV) of conducting forecasting is Rp 5,484,845,000 and non-forecasting

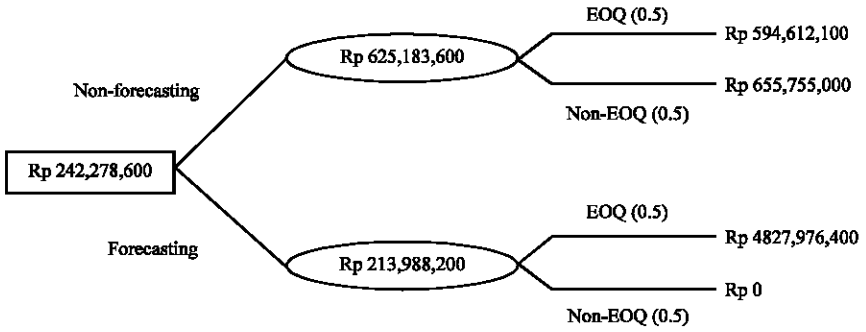

Fig. 3: Iron decision trees

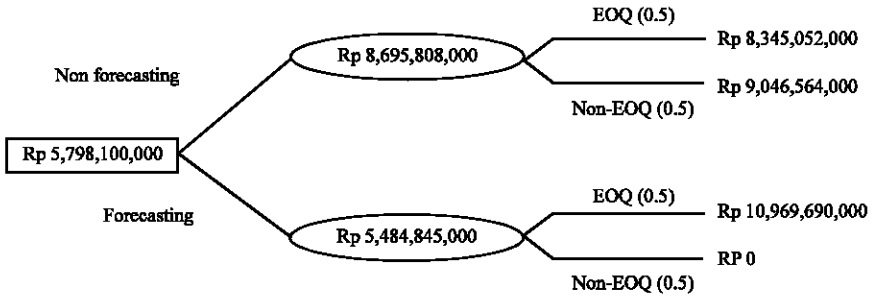

Fig. 4: Cement decision trees

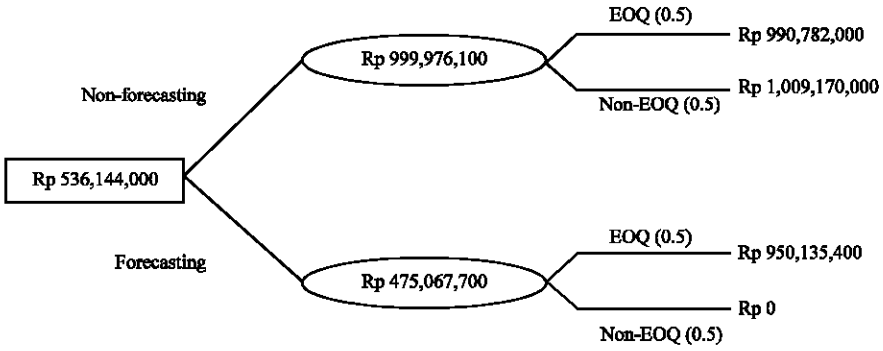

Fig. 5: Sand decision trees

is Rp 8,695,808,000. The best choice is conducting forecasting. So, company should use forecasting to minimize the total cost and control their inventory management, especially in cement inventory.

Figure 5 reflects the decision to conduct forecasting analysis. The Expected Monetary Value (EMV) of conducting forecasting is Rp 475,067,700 and non-forecasting is Rp 999,976,100. The best choice is conducting forecasting. So, PT. Multi Anugerah Swadaya should use forecasting to minimize the total cost and control their inventory management, especially in sand inventory.

Figure 6 reflects the decision to conduct forecasting analysis for split. The Expected Monetary Value (EMV) of conducting forecasting is Rp 662,691,000 and non-forecasting is Rp 1,076,334,000. The best choice is conducting forecasting. So, PT. Multi Anugerah Swadaya should use forecasting to minimize the total cost and control their inventory management, especially in split inventory.

The result of forecasting is used to know the next prediction about something in order to make suitable decisions based on the result. This research uses six forecasting methods based on time series analysis. After

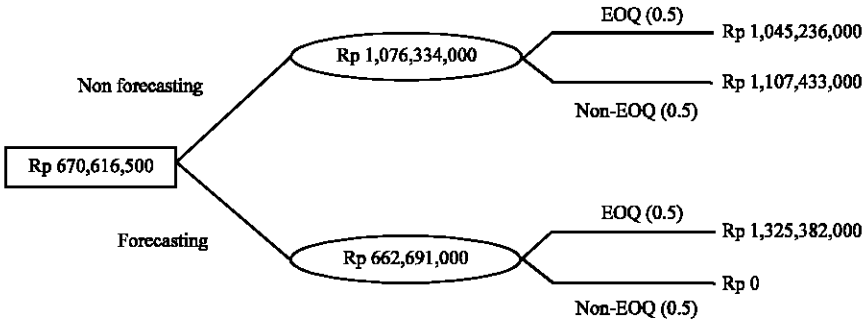

Fig. 6: Split decision trees

forecast the raw materials demand, there are several results. The results show that the smallest error among six methods are Weighted Moving Averages. Weighted Moving Averages have the smallest MAD and MSE. The MAD and MSE show the error level of forecasting (Russell and Taylor, 2011). The other methods can also be used to forecast but the result has high error level.

The next iron demand using Weighted Moving Averages is 214 rods in November 2012 and have smallest error MAD is 69 and MSE is 8,418.708. The next cement demand using Weighted Moving Averages is 906.887 in November 2012 kgs. The MAD is 225.9455 and MSE is 65,388.18. However, the next sand demand is 299.968 kgs in November 2012 and have smallest error MAD is 76.2464 and MSE is 7,975.414. This result uses Weighted Moving Averages method. The last raw material is split. The next split demand is 827.368 kgs in November 2012 and the smallest error MAD is 162.9333 and MSE is 42,673.38. The forecasting result also shows that the demand of iron and sand for next one year are decreasing compare to the actual demand data.

Then, inventory control is calculated by using Economic Order Quantity (EOQ) model to determine the optimal and economical of raw materials inventory. This research will calculate EOQ of actual demand and forecasted demand of raw materials. The result of EOQ and the current system in company can be compared to each other. The EOQ of forecasted demand will help company to compare the results by using forecasting and non-forecasting analysis. So, the company can know the advantages and disadvantages of each system. The result shows that there is a gap between the current system and EOQ model of November 2012 to October 2013 for each raw materials. The EOQ model has smaller total cost rather than the current system. Company can save 9.324% of iron total cost and 7.754% of cement total cost by using EOQ model. Besides that, there is also cost reducing in sand inventory as much as 1.822% and split inventory as much as 5.616%. So, EOQ model helps company to reduce their total cost of raw materials as much as 1.8-9.3%. This cost reduction happens only in iron, cement, sand and split inventory. It can change if there are other factors that affect them which are beyond the scope of this study.

Furthermore, Decision trees analysis will determine the best alternative whether Forecasting and EOQ are necessary to be used and it will minimize the cost of raw materials inventory. The results of the analysis are inventory management of iron, cement, sand and split inventory should use Forecasting method and EOQ model. So, company can manage their inventory management efficiently and effectively. Its approves the previous study conducted by Ali *et al.* (2012) which state that decision trees analysis will determine the best alternative solution for company.

CONCLUSION

There is increasing demand of cement and split. Whereas, the demand for iron and sand are decreasing. Reduction of iron and sand demand has remained unknown, because this research objective is not finding out about the causes. So, the company needs to do further research to determine the causes of the declining. The raw materials inventory management system in company is not efficient. The results show that after conducting EOQ model, the total inventory cost is reduced. So, the company can use the EOQ model in their inventory management systems in order to minimize the total inventory cost. By doing this, the company can save more money or allocated for other purposes and also increase profits.

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