ECONOMIC ORDER QUANTITY: AN APPROACH IN IMPROVING INVENTORY MANAGEMENT

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Abstract
A basic research was conducted at a Routine Maintenance Company in East Coast of Peninsula Malaysia regards to inventory management discipline that focused on one high draw item, which is fluorescent lamp PLL 36 watt. This study was aimed to determine the EOQ, total annual inventory cost, number of orders and expected time between orders. It was found that the EOQ for the item was 518 units per order, at RM 43483.60 of total inventory cost with 6 times of order per year and 52 days of expected time between orders. It was recommended to the company to identify the inventory cost for the current practice and make a comparison with the finding of the study. On top of that the management has to consider specific assumptions before they proceed to the total implementation of EOQ in the future. An ABC analysis should be done to their inventory items in strategizing the company's inventory management system.

Keywords: Economic Order Quantity (EOQ), setup costs, holding costs

1. Introduction

Inventory management is recognized as one of the most important aspects in any field of operations that contributes toward organization's performance. Proper inventory management may lead to cost reduction, availability of the stocks in matching the demand, and gaining advantages over the competitor. Inventory management relates with cost control activity in input-transformation process-output relationship. According to Heizer and Render (2011), the cost to spend on material or inventory indicates about 50% of the revenues of the company that may lead to more than the profit received by the company.

Unmanaged inventories will affect the company's process flow. A good forecasting technique from inventory management activity plays a role to keep the operation flow on

track which may avoid shortages of raw materials. Thus delay of production can be avoided in order to satisfy the customer demand in achieving competitive advantage.
The aims of this paper were to determine the Economic Order Quantity (EOQ) for the fluorescent lamp PLL 36 watt, to calculate the total annual inventory cost, to identify the number of orders, and to identify the expected time between orders. EOQ is treated as an alternative inventory management technique to the Routine Maintenance Company. The study focused on the area of store unit regards to inventory management specifically on the Economic Order Quantity (EOQ) for fluorescent lamp PLL 36 watt that has been used by the clients of the Routine Maintenance Company. It is the most demanded material for illumination purposes by the client thus categorized as fast moving item. In term of price, mutual agreement was made between the client's representative and the Routine Maintenance Company. The item's price has been agreed by both parties for RM 14.45 per unit.

2. Literature Review

Inventory and the Types of Inventory

Inventory comes in many shapes and sizes where the most manufacturing firms have the following types of inventory consist of raw materials, components, work-in-process (WIP), finished goods, distribution inventory and maintenance, repair and operational inventory (MRO) (Reid and Sanders, 2002). Inventories can be broken down into four areas, depending on the stage in the manufacturing process which are raw materials, component, work-in-process and finished goods (Stevenson, 2005; Lancioni and Howard, 1993). According to Blanc (2011), the inventories are idle goods waiting for use or sale whereas different company would have different kind of inventory which leads to be a different purpose of using it.
Heizer and Render (2011) identify the purpose of inventories as:-

- to decouple or separate various parts of the production process.
- to decouple the firm from fluctuations in demand and provide a stock of goods that will provide a selection for customers.
- to take advantage of quantity discounts.
- to hedge against inflation.

The EOQ

According to Reid and Sanders (2002), the economic order quantity model (EOQ) has been around since the early 1900s and remains useful for determining order quantities. Stevenson (2005) stated that EOQ model is an approach to determine how much to order. Bergvall and Bjorkman (2007) stated that EOQ is the lot size that minimizes total inventory holding and ordering costs. Schwarz (2008) defined the EOQ as the cost minimizing order quantity. These are aligned to Dervitsiotis (1981), Monks (1996), Lucey (1992), and Schroeder (2000) in Adeyemi and Salami (2010) which defined EOQ as the ordering quantity which minimizes the balance of cost between inventory holding costs and re-orders cost.
Piasecki (2001) stated EOQ using accounting formula that determines the point at which the combination of order costs and inventory carrying costs are the least. The result is the most cost-effective quantity to order. Finkin (1993) was strongly believe that the most

rational way regards to ordering quantity is to use EOQ. The EOQ provides the minimum cost from both manufacturing or purchasing and carrying cost point of view.

Leenders, Johnson, Flynn and Fearon (2006) indicate carrying and ordering costs as:

> Carrying, holding, or possession costs include handling charges; the cost of storage facilities or warehouse rentals; the cost of equipment to handle inventory; storage, labor, and operating costs; insurance premiums; breakage; pilferage; obsolescence; taxes; and investment or opportunity cost. Ordering or purchase costs include the managerial, clerical, material, telephone, mailing, fax, e-mail, accounting, transportation, inspection, and receiving costs associated with a purchase or production order. (p. 158-159).

How EOQ Models Work

Stevenson (2005) has brief about how EOQ model works by giving some figure in graph to view the flow of EOQ relevance approach.

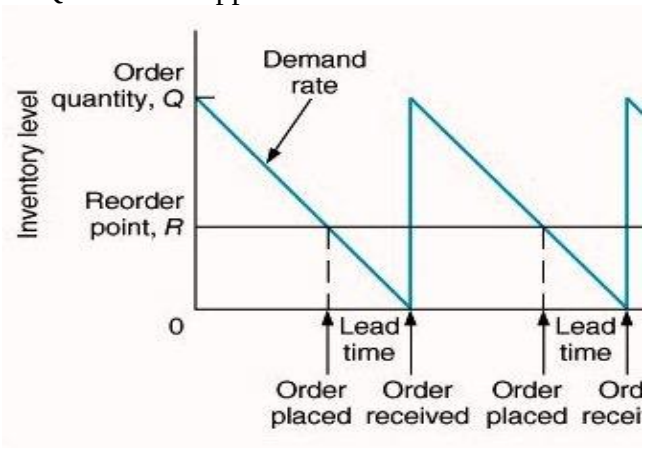

Figure 1: Flow of EOQ relevance approach

Figure 1 shows that a cycle begins with receipt of an order of Q units, which are draw or being used at constant rate overtime. When the quantity on hand is just sufficient to satisfy demand during lead time, an order for Q units is submitted to the supplier because it assumed that both the usage rate and the lead do not vary, the order will be received at the precise instant that the inventory on hand falls to zero. Thus orders are timed to avoid both excess stock and stock outs.

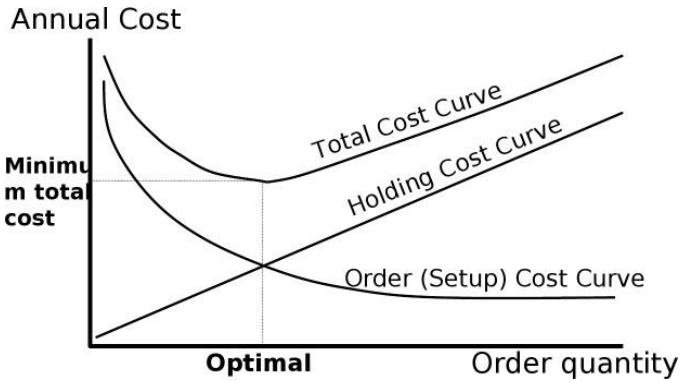

Figure 2: Holding cost, ordering cost and total cost curve

The optimal order quantity reflects a balance between carrying cost and ordering cost. As order size varies, one type of cost will increase while the other decreases. For example, if the order size is relatively small, the average inventory will be low, resulting in low carrying cost. However, a small order size will necessitate frequent order, which will drive up annual ordering cost. Conversely, ordering large quantities at infrequent intervals can hold down annual ordering costs, but that would result in higher average inventory levels and therefore increased carrying cost (Stevenson, 2005).

3. Research Methods

The preliminary information was gathered from an interview session and the secondary data from the store and administration report of the Routine Maintenance Company. The study applies the formula of EOQ as stated by Heizer and Render (2008). The flow chart was used in assessing the ordering process.

EOQ Variables

Heizer and Render (2008) has come out the following variables in order to determine setup and holding costs to solve the EOQ:-

Q = Number of units per order
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

The equations can be developed to solve directly for Q* by following the steps below;

1) Find the annual setup cost

$$(D / Q) * S$$

2) Find the annual holding cost

$$(Q / 2) * H$$

3) Solve the Q*

$$\sqrt{\frac{2DS}{H}}$$

In order to execute the EOQ model, some EOQ assumption must be complied. One of the assumptions is the demand for an item is known, reasonably constant, and independent of decision for other items (Heizer and Render, 2008). Thus, the average monthly usage was used as a basis in projecting the annual demand (see Table 1).

4. Data Analysis and Finding

Determining Annual Demand

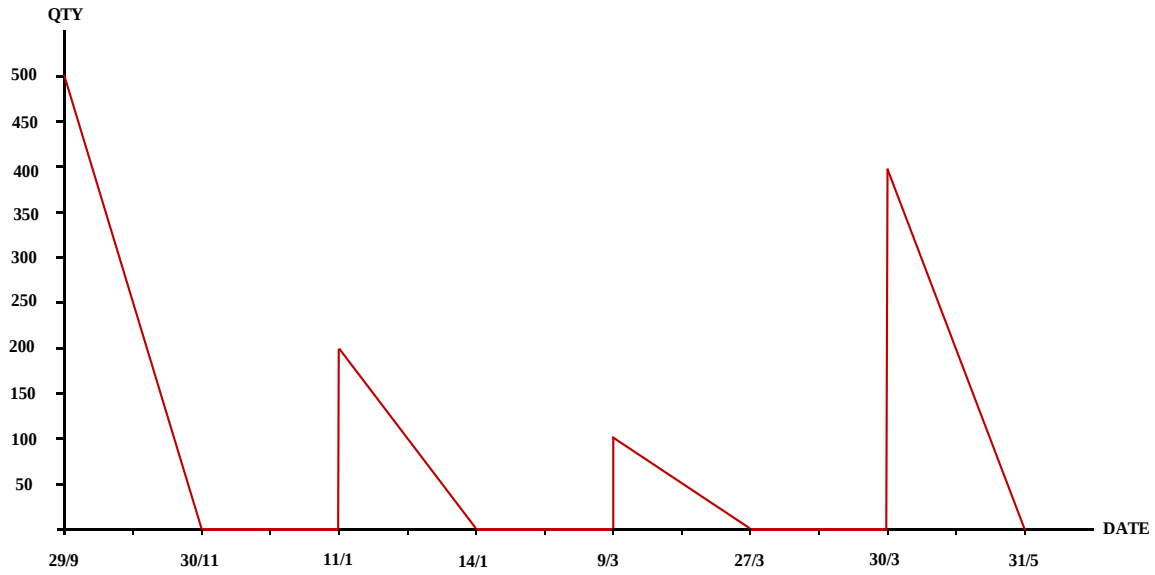

Figure 3: Fluorescent lamp PLL 36 watt order over time (2012)

Figure 3 shows the orders over time for fluorescent lamp from the 29th September 2011 until 31th May 2012. The data was taken from the bin card store that has been updated from time to time for any ingoing and outgoing activity. It was found that the shortages of the item happened on 30th November 2011 until 11th January 2012. The shortages continued on 14th January until 9th March and on 27th March until 30th March 2012. The company experience inconsistent number of orders for each ordering cycle. First time of orders indicates a purchase of 500 units, second time indicates 200 units, third time was 100 units and the latest for the date of 30th March 2012 was 400 units. The inconsistent quantity of the item at each ordering cycle happened due to lack of rigorous forecasting technique used.

Table 1: Fluorescent lamp PLL 36 watt issued out from Oct 2011-Apr2012

Month	Quantity issued by technician staff (unit)
October 2011	265
November 2011	235
January 2012	200
March 2012	117
April 2012	383
TOTAL	1200

Table 1 shows the quantity issued for the item in October 2011, November 2011, January 2012, March 2012, and April 2012. The grand total for the item over the five months was 1200 units. The average usage per month can be identified by dividing the total of 1200 units with five months. Thus the average usage per month was 240 units. To find the

annual demand, the average usage of 240 units per month was multiply by 12 months and the annual demand was 2880 units.

Determining the Ordering Cost

Figure 4 shows the process in determining the ordering cost for this study began with reviewing the ordering process activities. There were 8 activities involved in making a purchase order. Variables that should be considered for ordering process were; person in charge with the estimation labor hour for doing the task and the equipment/tools used. The calculation for ordering cost started with identifying costs related to ordering process and its labor cost. For the labor cost, the estimated of 26 working days was identified (standard calculation for employee salary given by the company). Detailed calculations were presented on Table 2 and Table 3.

TITLE :	ORDERING PROCESS FLOW			
NO.	ACTIVITY	PROCESS FLOW	PIC	TIME
1	Identify stock below par level and do Reorder Advice (ROA)		Storekeeper	2 minutes
2	Setup Request For Quotation, receive and select quotation from vendor, fill the PR form		Technical Executive	25 minutes
3	Checking selected vendor and budget.		Manager	2 minutes
4	Process the quotation, setup Purchase Request in the system		Clerk	5 minutes
5	Checking Purchase Request and approve		Operation Manager Regional General Manager	2 minutes 2 minutes
6	Establish Purchase Order, print and fax		Clerk	5 minutes
7	Item receive, inspect and counting stocking, update into system		Storekeeper	30 minutes
8	Identification Delivery Order, fax to vendor and HQ		Clerk	3 minutes

Figure 4: Flow chart of ordering process

Table 2: Working calculation for labor costs and related items

Items / Person in charge	Calculation	Total
Item		
1. A4 Paper cost RM 19.42 = 10 ream (450 pcs/ream)	10 ream x 450 pcs = 4500 pcs RM 19.42/ 4500 pcs = **RM 0.004**	**RM 0.004/piece**
2. HP LaserJet 2055d Toner cost RM 253 = 2300 pages	RM 253 / 2300 pages = **RM 0.11**	**RM 0.11/piece**
3. Ribbon Amano Fax Toner KX FA83E cost RM 123.60 = 2500 pages	RM 123.60 / 2300 pages = **RM 0.049 @ RM 0.05**	**RM 0.05/page**
4. Faxing cost TM fax rate: 150km – over = RM 0.90/minute	1 fax x RM 0.90 = **RM 0.90**	**RM 0.90/activity**
5. Purchase Request Form cost RM 5.60 = 1 pad (50 pcs)	RM 5.60 / 50 pcs = **RM 0.112**	**RM 0.112/piece**
6. Transportation cost charged by Vendor (KVC Industrial Supplier SdnBhd) RM 150.00	Each delivery = **RM 150.00**	**RM 150.00/order**
Person in Charge		
1. Storekeeper RM 1000	RM 1000 / 26 days = RM 38.462/day RM 38.462 / 8 hours = RM 4.80775 @ RM 4.81/ hour RM 4.81 / 60 minutes = **RM 0.08/minute**	**RM 0.08/minute**
2. Clerk RM 900	RM 900 / 26 days = RM 34.61/day RM 34.61 / 8 hours = RM 4.33/ hour RM 4.33 / 60 minutes = **RM 0.07/minute**	**RM 0.07/minute**

3. **Technician Executive** RM 2600	RM 2600 / 26 days = RM 100/day RM 100 / 8 hours = RM 12.50/hour RM 12.50 / 60 minutes = **RM0.208/minute**	**RM 0.208/minute**
4. **Facility Engineering Management Service (FEMS) Manager** RM 5200	RM 5200 / 26 days = RM 200/day RM 200 / 8 hours = RM 25/hour RM 25 / 60 minutes = **RM 0.42/minute**	**RM 0.42/minute**
5. **Operation Manager** RM 4500	RM 4500 / 26 days = RM 173.08/day RM 173.08 / 8 hours = RM 21.64/hour RM 21.64 / 60 minutes = **RM 0.36/minute**	**RM 0.36/minute**
6. **Regional General Manager** RM 8000	RM 8000 / 26 days = RM 307.69/day RM 307.69 / 8 hours = RM 38.46/hour RM 38.46 / 60 minutes = **RM 0.64/minute**	**RM 0.64/minute**

Table 3: Working calculation for ordering cost

Activity	Calculation	Total
1. **Activity 1** Job description: Identify stock below par level and do Reorder Advice (ROA) Person in charge: Storekeeper Estimate time: 2 minutes Item used: A4 paper and printer	1. **Activity 1** Labor cost RM 0.08 x 2 minutes = **RM 0.16** Print cost RM 0.11 + RM 0.004 = **RM 0.114**	**RM 0.16** **RM 0.114**
2. **Activity 2** Job description: Setup Request For Quotation (RFQ), receive and select quotation from vendor and fill the Purchase Request (PR) form Person in charge: Technician Executive (T.E) Estimate time: 25 minutes Item used: A4 paper, printer, fax and PR form.	2. **Activity 2** Labor cost RM 0.208 x 25 minutes = **RM 5.20** Print cost RM 0.114 x 3 pieces = **RM 0.342** Faxing cost RM 0.90 x 3 pages = **RM 2.70** Fax printing RM 0.05 x 3 pages = **RM**	**RM 5.20** **RM 0.342** **RM 2.70** **RM 0.15**

	0.15 Purchase Request form RM 0.112 x 1 piece = **RM 0.112**	**RM 0.112**
3. **Activity 3** Job description: Checking selected vendor and budget. Person in charge: FEMS manager Estimate time: 2 minutes	3. **Activity 3** Labor cost RM 0.42 x 2 minutes = **RM 0.84**	**RM 0.84**
4. **Activity 4** Job description: Process the quotation; setup Purchase Request in the system. Person in charge: Clerk Estimate time: 5 minutes	4. **Activity 4** Labor cost RM 0.07 x 5 minutes = **RM 0.35**	**RM 0.35**
5. **Activity 5** Job description: Checking Purchase Request (PR) and approve. Person in charge: Operation Manager (O.M), Regional General Manager (RGM) Estimate time: 2 minutes/ person	5. **Activity 5** Labor cost RM 0.36 x 2 minutes = **RM 0.72** RM 0.64 x 2 minutes = **RM 1.28**	**RM 0.72** **RM 1.28**
6. **Activity 6** Job description: Establish Purchase Order (PO), print and fax. Person in charge: Clerk Estimate time: 5 minutes Item used: printer and fax	6. **Activity 6** Labor cost RM 0.07 x 5 minutes = **RM 0.35** Print cost RM 0.114 x 1 pages = **RM 0.114** Faxing cost RM 0.90 x 1 pages = **RM 0.90**	**RM 0.35** **RM 0.114** **RM 0.90**
7. **Activity 7** Job description: Receiving, inspecting and counting, update stock status in the system. Person in charge:	7. **Activity 7** Labor cost RM 0.08 x 30 minutes = **RM 2.40** Transportation cost **RM 150.00**	**RM 2.40** **RM 150.00**

Storekeeper Estimate time: 30 minutes		
8. **Activity 8** Job description: identification, fax Delivery Order (DO) to vendor and headquarter. Person in charge: Clerk Estimate time: 3 minutes Item used: fax	8. **Activity 8** Labor cost RM 0.07 x 3 minutes = **RM 0.21** Faxing cost RM 0.90 x 2 pages = **RM 1.80**	**RM 0.21** **RM 1.80**
TOTAL		**RM 167.74**

Determining the Holding Cost

According to Lambert and Mentzer (1993), most of the company reported inventory carrying cost percentages in the range of 20 percent to 25 percent of value item. The total of 35 over 45 respondent use 25 percent of the value item to estimate the inventory carrying cost for their own company. Timme and Williams (2003) believe that by using 25 percent of total carrying cost is much accurate than 15 percent. Heizer and Render (20011) stated that an overall inventory carrying cost of less than 15 percent is very unlikely, but the carrying cost can exceed 40 percent especially in high-tech and fashion industries. Hence, to calculate the holding cost for fluorescent lamp PLL 36watt, the assumption of 25 percent of value item has been used for this study.

Fluorescent lamp PLL 36watt price = RM 14.45/unit
Holding cost percentage = 25%
RM 14.45 x 25% = RM 3.61 per unit per year

Finding the EOQ for Fluorescent Lamp PLL 36 watt

After obtaining annual demand, ordering cost and holding cost the calculation of EOQ was executed using formula as stated by Heizer and Render (2011). Variables used in computing the optimal order quantity (EOQ) presented below:-

Annual demand (D) = 2880 units
Ordering cost (S) = RM 167.74
Holding cost (H) = RM 3.61

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

$$= \frac{\sqrt{2(2880)(167.74)}}{3.61}$$

$$= \frac{\sqrt{966182.4}}{3.61}$$

$$= 517.34 \approx 518 \text{ units}$$

Total Inventory Cost

Annual setup/ordering cost

(Number of orders placed per year) X (Setup or order cost per order)

$$= \frac{\text{Annual demand}}{\text{Number of units in each year}} \times \text{Setup or order cost per order}$$

$$= \frac{2880 \text{ units}}{518 \text{ units}} \times \text{RM167.74}$$

$$= 5.56 \times \text{RM167.74}$$

$$= \text{RM } 932.61$$

Annual holding/carrying cost

(Average inventory level) X (Holding cost per unit per year)

$$= \frac{\text{Order quantity}}{2} \times \text{Holding cost per unit per year}$$

$$= \frac{Q}{2} \times H$$

$$= \frac{518 \text{ units}}{2} \times \text{RM3.61}$$

$$= \text{RM } 934.99$$

Total Annual Inventory Cost

(Annual setup cost/ordering cost) + (Annual holding cost/carrying cost) + (Price x Annual demand)

= RM 932.61 + RM 934.99 + (RM 14.45 x 2880 units) = RM 43483.60

Finding the Expected Number of Orders (N)

$$N = \frac{\text{Demand}}{\text{Order Quantity}}$$

$$= \frac{2880 \text{ units}}{518 \text{ units}}$$

$$= 5.56 \sim 6 \text{ orders per year}$$

The Expected Time Between Orders (T)

$$T = \frac{\text{Number of working days per year}}{\text{Expected number of orders}}$$

$$= \frac{312 \text{ days}}{6 \text{ orders}}$$

$$= 52 \text{ days}$$

5. Conclusion and Recommendation

The study was successfully analyzed the prospect of implementing the Economic Order Quantity (EOQ) at a Routine Maintenance Company fluorescent lamp PLL 36 watt. Four research objectives were achieved; (1) to determine the EOQ for the fluorescent lamp PLL 36 watt, this quantity is the best amount to order for each time of ordering as it holds down the ordering and holding cost simultaneously. The EOQ for fluorescent lamp PLL

36 watt was 518 units per order. (2) to calculate the total annual inventory cost; in order to achieve this objective, the ordering cost and holding were computed. The total annual inventory cost was RM 43483.60. (3) the expected number of order for the item which was 6 orders per year. (4) the expected time between orders was 52 days.

The current inventory management practice for this item is an assumption approach. It results into inconsistent amount of quantity per order. The researchers would suggest to the top management to identify the total inventory cost for the current approach and do the comparison with the calculated cost using EOQ (finding of the study). This will help the organization to avoid excessive cost and to get the optimal order quantity for constant quantity of orders. On top of that the management should give special consideration in updating the inventory records and to the cost associated with their inventories. In this case, the researchers found that the management does not have concrete values/assumptions on ordering and holding cost.

Several assumptions must be fulfilled before the company can proceed with total implementation of EOQ (Heizer and Render, 2011) which are; demand for an item is known, reasonably constant, and independent of decision for other items; Lead time – that is, the time between placement and receipt of the order – is known and consistent; Receipt of inventory is instantaneous and complete. In other words, the inventory from an order arrives in one batch at one time; quantity discounts are not possible; the only variable costs are the cost of setting up or placing an order (setup or ordering cost) and the cost of holding or storing inventory over time (holding or carrying cost); stock outs (shortages) can be completely avoided if orders are placed at the right time.

The company is recommended to revise all inventory items and categorize the items whether they are slow or fast moving item with their RM contribution and group these items into ABC categories. ABC analysis is an inventory application of what is known as the *Pareto principle* that dividing on-hand inventory into three classifications based on annual dollar volume (Heizer and Render, 2011). The ABC analysis could help the management in deciding which parts/items are important to be ready-in-stock or need special controlling activities.

It is expected that the company can get lots of advantages by applying the EOQ techniques in managing their inventories. As mentioned by Stevenson (2005) "the optimal order quantity reflects a balance between carrying cost and holding cost. As order size varies, for the both type of costs (ordering and holding costs), one type of costs (for example the ordering cost) will increase while another one (the holding cost) will decrease. This problem has confusing the management to made decision on how much quantity to order. With the implementation of EOQ, the decision can be made at the right point".

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