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INVENTORY CONTROL MODELS IN THE PRIVATE SECTOR OF NIGERIAN ECONOMY A CASE STUDY OF CUTIX PLC NNEWI, NIGERIA.

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Abstract

This work addressed the issues of Inventory control as regards to private sectors of Nigerian economy using CUTIX PLC Nigeria as a case study. In business organizations, management will be able to control inventory levels, maintain optimum levels of inventories and minimize costs generally if they apply efficient inventory control models in their inventory systems. This work discussed and applied the basic deterministic inventory control models in inventory control system of CUTIX PLC, Nigeria. The work showed that there is need for the company to improve in the areas of economic order quantity for Copper rod, Aluminum rod, PVC Resin and $CaCO_3$. Under the economic batch quantity application when the replenishment is gradual, it was discovered that the economic batch quantity for 1.5 mm^2 single core cable is 1373 coils but the company applies what they called minimum run. The minimum run for 1.5 mm^2 single core cable is 300 coils. It was also discovered that the reorder levels for Aluminum rod, Copper rod and PVC Resin were 50, 53 and 31 tons respectively. This work also discovered that the company is operating on service level of 93% with respect to Copper rod provision. Hence, they have 7% chance of stock out during each lead time.

Keywords—Inventory, Model, EOQ, EBQ, Costs, Deterministic, Reorder, CUTIX PLC, Demand.

Preliminaries

Inventory control models are mathematical models that handle inventory problems (inadequate inventory, excess inventory and costs associated with inventory). A business or an industry usually maintains a reasonable inventory of goods to ensure smooth operation. Inventory is a necessary evil. Too little of it causes costly interruptions and too much of it results idle capital [3]. The models are used to determine the inventory level that balances the two extreme costs. An important factor in the formulation and solution of an inventory model is that the demand (per unit time) of an item may be deterministic or probabilistic. This applies to every product or service, from raw materials to finished goods. It covers stock at every stage of production processes, from purchase and delivery, to using and reordering the stock.

Efficient inventory control guarantees the right amount of stock in the right place at the right time. It also ensures that capital is not tied up, and protects production if problems arise with the chain of supply. Also, efficient inventory control minimizes the total cost of inventory and still improves customer services and operational capability.

The nature of inventory problem consists of repeatedly placing and receiving orders of given sizes at set intervals. However, if one goes on to carry inventory without first determining an optimal level of stock of each resource that will minimize total cost of inventory, one will run into problem of having excess or under stock of a particular resource. In this case, money that would have been channeled to some areas of the business will be tied up in unnecessary stock, or one will run out of stock of the resource at some times.

Thus, in keeping inventory, one should ensure that; inventory level of existing items is kept at reasonable level (optimal level), unnecessary items are not added to inventory and, items which have not been used for a long time are removed from the inventory. To achieve this, one has to carry out periodic review of inventory and maintain records for proper stock control administration and management decisions.

For the management of any organization to take any meaningful decision regarding inventory, production processes and even customer orders, it will first carry out analysis with the available inventory data and then take decisions based on the result of the analysis. Hence there is need for the organization to have a trained inventory control officer, who employs the use of good inventory control models to carry out the inventory analysis before decision on inventory is taken.

Inventory control model helps in minimizing the total inventory cost in the case of deterministic demand or expected cost in the case of probabilistic demand [3]. There are two main types of inventory control models:

(1) Deterministic Inventory control models: used when demand and lead time are known and constant. Under this model, inventory is built up at a constant rate to meet a determined or accepted demand.

(2) Probabilistic inventory control models: used to describe the random behavior of demand and lead time with known probability distribution when demand or lead time, or both are not known with certainty. Due to the uncertainties in demand and lead time, stock-out situations may occur. To prevent or minimize the occurrence of stock-out, business organizations always maintain safety or buffer stock [2, 3, 4, 7].

However, this work looked into basic deterministic inventory control models with a view to testing their real application in the CUTIX PLC inventory control system.

Deterministic Inventory Model

An inventory system may be based on periodic review in which new orders are received at the start of each period. Alternatively, the system may be based on continuous review where new orders are placed when the inventory level drops to the re-order point or level. Deterministic inventory model can be static or dynamic. The static models have constant demand over time, while in dynamic models, the demand changes with time. Among the three variations of economic order quantity model with static demand, the simplest of the inventory models involves constant rate demand with instantaneous replenishment and no shortage.

According to [3], it is difficult to develop a general inventory model that accounts for all variations in real systems. Indeed, even if a sufficiently general model can be formulated, it may not be analytically solvable. "Ref. [3]" discussed five deterministic model, most of which deal with a single inventory item. Only one treats the effect on the solution of including several competing items. The model considers the inventory system including n (> 1) items that are competing for a limited storage space. This limitation represents an interaction between the different items and may be included in the model as a constraint. For instance, if y_i is considered to be the amount ordered of the ith item, the storage requirements constraint becomes

$$\sum_{i=1}^{n} a_i y_i \leq A \qquad (1)$$

where A is the maximum storage area available for all items, and a_i is the storage area requirement for ith item. Assume that each item is replenished instantaneously, and there is no quantity discount and no shortage. Let D_i, K_i and h_i be the demand rate per unit time, the setup cost and the holding cost per unit time corresponding to the ith item respectively. The problem thus becomes

$$\min TCU(y_1, y_2, \ldots y_n) = \sum_{i=1}^{n} \left(\frac{K_i D_i}{y_i} + \frac{h_i y_i}{2}\right)$$

$$\text{subject to } \sum_{i=1}^{n} a_i y_i \leq A \qquad (2)$$

$y_i > 0$, ∀i

The general solution, EOQ of this problem is obtained by the Lagrange multipliers method as

$$y_i^* = \sqrt{\frac{2K_i D_i}{h_i - 2\lambda * a_i}} \qquad (3)$$

if the constraint is active, thereby the unconstrained EOQ value

$$y_i^* = \sqrt{\frac{2K_i D_i}{h_i}} \qquad (4)$$

does not satisfy the storage constraint. Otherwise, the constraint is said to be inactive or redundant and may be neglected. In (3), y_i^* is dependent on λ*, the optimal value of λ. The number of order per year is D_i/y_i^* [5, 6, 7, 9].

Inventory Control Model When Replenishment Is Gradual

From [1, 2, 3, 5, 9], when replenishment is gradual, the economic batch quantity was derived to be

$$EBQ = \sqrt{\frac{2KD}{h}\left(\frac{R}{R-U}\right)} \qquad (5)$$

where R = Rate of production, U = Rate of consumption or usage

(R – U) = Rate of accumulation of stock

Some Basic Terminologies And Definitions

Lead Time/Procurement Time/Delivery Lag:

This is the period of time expressed in days, weeks or months between the day order is placed and the day order arrived.

Economic Order Quantity (EOQ): This is the optimal replenishment order size (or lot size) of inventory item(s) which achieve the optimum total (or variable) inventory cost during the given period of time. In other words, it is calculated order quantity which minimizes the balance of cost between inventory carrying (holding) cost and ordering cost.

Economic Batch Quantity (EBQ): This applies to production section when a machine has more than one product to produce. Since the machine cannot produce the different products at the same time, it will produce them in batches. Thus it will first produce an optimum quantity of A, then optimum quantity of B and finally, an optimum quantity of C if there are three products (A,B,C) so that cost of production is minimized. Therefore, each of these optimum batch quantities that minimize cost of production is called economic batch quantity.

Lot-Size Inventory: This is the inventory necessary to meet the average demand during the successive replenishments.

Safety (Buffer) Stock: This is an extra or additional stock of items in reserve that will take care of uncertainties of demand and lead time in order to avoid stock out. It is also called safety (buffer) inventory.

Stock Out: This occurs when the required item is not in stock; we then say there is a stock out on the item.

Minimum Inventory Level (I_{min}): This is the stock level of an item at which any further demands on it will necessitate withdrawals from the buffer stocks of the item, especially when demand of the item is immediate and the item on order has not arrived.

Maximum Inventory Level (I_{max}): This is the level of stock of an item at which no stock is permitted.

Reorder Level (ROL): This is the level of stock at which an order is placed for replenishment. The reorder level depends on the lead time and demand during the lead time.

Reorder Quantity (ROQ): This is the quantity of the item ordered when a new order for replenishment is placed. This becomes EOQ when it minimizes the total cost of inventory.

Order Cycle: This is the period of time between two successive replenishments. This may be determined in these two ways:

a. Continuous Review: Also known as perpetual stock or inventory record. Here, the stock of an item on hand is always updated and known. In this case an order of fixed size is placed every time the inventory level reaches at a pre-specified level called reorder level. This decision rule is referred to as the two-bin system, fixed order size system or Q-system.

b. Periodic Review: Here, orders are placed at equal interval of time, but the order size may vary depending on the inventory at hand plus the order at the time of review. This decision rule is referred to as the fixed order interval system or P-system.

Stock Replenishment: The replenishment of stock may occur instantaneously or gradually. Instantaneous replenishment is possible when the stock is purchased from outside sources (vendors), while gradual replenishment is possible when the firm produces the items itself at a finite production rate.

Thus, the economic order quantity (EOQ) model established in (3) and (4) minimizes the total variable cost of inventory for the case of instantaneous replenishment, while (5) is the EOQ model for the gradual replenishment.

Background of the Study

CUTIX PLC is a cable manufacturing company located at Nnewi. The company makes use of Aluminum rod, Copper rod, PVC Resin, CaCO3, stabilizer, DOP and some other raw materials in its manufacturing processes. Hence we shall look into each of the above mentioned raw materials with a view to obtaining the economic order quantity in each case.

Methodology/Data collection

Data for this work was collected from both primary and secondary sources. The primary data is made up of personal interviews with some key officials of the company, which includes the CEO, Chairman, chief accountant, chief marketing officer, plus some other staff. Further, questionnaire was administered to workers in the company.

From the secondary data, we have some specimens of CUTIX PLC inventories.

Data presentation

The objective of this work is to analyze the inventory control of CUTIX PLC and examine the efficiency of minimizing their total inventory cost.

The following are data obtained in CUTIX PLC during several visits to the company.

Table 1.

S/N	ITEMS	ANNUAL DEMAND IN TONS	ORDERING COST IN N	CARRYING COST IN N
1	AL Rod	178	3,061,000	155,000
2	Cu Rod	389	4,986,000	205,000
3	PVC Resin	132	1,714,000	100,000
4	CaCo3	144	778, 000	55,000
5	Stabilizer	15	842	60,000
6	DOP	32	2,267,000	130,000

Table 1 displayed the CUTIX PLC demands, ordering costs and carrying costs for various raw materials for a period of one year

Note: AL = Aluminum, Cu = copper.

Table 2.

Product	1.5mm^2 single core cable
Monthly Demand (D)	15,000 coils
Carrying cost of a coil per month (h)	₦ 300
Cost per set up (k)	₦ 6,000
Production Rate (R)	22,000 Coils/month
Rate of sales (U)	15,000 coils/month

Table 2 is CUTIX PLC product, production rate, sales and costs for a period of one month

Table 3.

S/N	ITEM	ANNUAL DEMAND IN TONS	AVERAGE LEAD TIME IN DAYS
1	AL Rod	178	74
2	Cu Rod	389	36
3	PVC Resin	132	62

Table 3 is CUTIX PLC annual demand for various items and respective Lead time in days:

Table 4.

Items	Copper rod
Carrying cost/unit item (₦)	17,083.33
Order quantity (Tons)	25
Shortage cost/ unit (₦)	200
Average monthly demand (Tons)	32.42
Maximum monthly Demand (Tons)	37.29

Table 4 is CUTIX PLC maximum and average demands, order quantity and costs for a period of one month

Application

From Table 1, the economic order quantity (EOQ), y* and the number of order per year, were calculated and discovered to be:

for Aluminum rod

y* ~ 84 tons.

Number of order per year becomes ~ 2 times.

for Copper rod

y* ~ 137.6 tons.

Number of order per year becomes ~ 3 times.

for PVC Resin

y* = 67.2678 ~ 67 tons

Number of order per year becomes ~ 2 times

for $CaCO_3$

y* = 63.827

~ 64 tons

Number of order per year becomes ~ 2 times

for stabilizer

y* ~ 21 tons

Number of order per year becomes ~ 1 time

for DOP

y* ~ 33 tons

Number of order per year becomes ~ 1 time

Note: In all the above application cases, the demand is constant and known, and replenishment is instantaneous.

Inventory Control Model When Replenishment Is Gradual

From Table 2 and equation (5) the economic batch quantity for the 1.5 mm^2 core cable becomes

EBQ ~ 1373 coils

Production time will be

$$\frac{EBQ}{R} = \frac{1373}{22000} = 0.06241 \text{ month}$$

with 22 working days in a month on the average,

0.06241 month = 0.06241x 22days

= 1.373

~ 1.4days

And the optimal production cycle that will meet the monthly demand will be;

= 10.92 ~ 11 cycles

Determination of Reorder Level

From Table 3, the Reorder level (ROL)

= Average demand (d) x Average lead time (LT)

ROL= d x LT.

We now look at the three raw materials and find out what the reorder level in each case will be.

With 264 working days in a year, then the average daily demand and the reorder level in each case will be as follow:

Aluminum Rod (AL Rod)

Average daily demand = $\frac{Annual\ Demand}{264\ days} = \frac{178}{264}$

= 0.674 tons/day

Therefore, the reorder level will be

Recorder level (ROL) = (Average daily demand) x (average lead time)

ROL= d x LT

= 0.674 tons x 74 days

~ 50 tons

Similarly,

Copper Rod (Cu Rod)

Average daily demand ~ 1.473 tons/day

Reorder level (ROL) ~ 53 tons

PVC Resin

Average daily demand = 0.5 tons/day

Reorder Level (ROL) = 31 tons

Determination of Service Level

The service level is given by the relation;

$$S_L = \frac{1 - (carrying\ cost)(order\ quantity)}{(shortage\ cost)(average\ demand)}$$

where S_L stands for service level [6, 7, 8].

Then, the service level with respect to Copper rod provision becomes

= 0.93413275 X 100%

= 93.413275%

~ 93%

Determination of Buffer Stock

The buffer stock is given by the relation;

Buffer stock = Average demand x Average Lead time

= d x LT,

and also when stock out is not required,

the Buffer stock = (maximum demand during lead time) - (Average demand during lead time)

= (d_{max} x LT) – (d_{Ave} x LT)

= (d_{max}– d_{Ave}) x LT

Recall, that the average daily demand for Copper rod = 1.473 tons

average lead time = 36 days

Therefore,

∴ Butter stock for Copper rod

= 1.473 tons/ days x 36days

= 53.028 tons

~ 53 tons

If stock-out is not required in Copper rod, then,

Buffer stock = (d_{max}- d_{Ave}) x LT,

Recall also that the

Average monthly Demand for Copper rod = 32.42 tons

Maximum monthly Demand for Copper rod =37.29 tons

Average lead time for Cu Rod= 36 days

Assuming there are 22 working days in a month on the average, then,

$$\text{Buffer stock} = \frac{(37.29 - 32.42)tons\ x\ 36\ days}{22\ days}$$

= 7.969tons ~ $8\ tons$

It then means that an additional stock of 8 tons of Copper rod should be kept in reserve to take care of variations in demand and lead time during lead time.

Inventory Model Result Obtained and Existing CUTIX PLC Inventory System

Currently the order quantity for Copper rod in CUTIX PLC is average of 25 tons per order and number of orders in a year is 15, while the calculated economic order quantity that will minimize costs is 137.6 tons per order and the number of order in a year will be approximately 3.

The order quantity for Aluminum rod is average of 44 tons per order and the number of order in a year is 5, while the calculated economic order quantity for Aluminum is approximately 84 tons per order and the number of orders in a year will be 2.

The order quantity for PVC Resin is 44 tons per order and number of orders in year is 3, while the calculated economic order quantity is approximately 67 tons per order and the number of orders in a year will be 2.

The order quantity for $CaCO_3$ is 48 tons per order and the number of orders in a year is 3, while the calculated economic order quantity is approximately 64 tons per order and the number of orders in a year will be 2.

The order quantity for stabilizer is 15 tons per order and the number of order in a year is 1, while the calculated economic order quantity for it is approximately 21 tons per order and the number of order in a year will be approximately 1. Thus the order quantity of stabilizer and the calculated economic order quantity are close and the number of orders in both cases is equal.

The order quantity for DOP is 32 tons per order and the number of order in a year is 1, while the calculated economic order quantity for it is approximately 33 tons per order and the number of orders in a year will be approximately 1.

Under the economic batch quantity application when the replenishment is gradual, it was discovered that the company's economic batch quantity for 1.5 mm^2 single core cable is 1373 coils but the company applies what they called minimum run, which is 300 coils of 1.5mm^2 single coils as their batch quantity.

In the case of reorder level model application, it was discovered that the reorder levels for Aluminum rod, Copper rod and PVC Resin were 50 tons, 53 tons and 31 tons respectively whereas the respective reorder levels of the items as CUTIX PLC has it are Aluminum rod = 25tons, Copper rod = 33 tons and PVC Resin = 23 tons.

In service level, it was discovered that the company is operating on service level of 93% with respect to Copper rod provision. Hence, they have 7% chance of stocking out during each lead time.

Summary and Conclusion

Having undertaken critical study of the reflected inventory control models, we conclude that Inventory and its control are very vital in business ventures.

In CUTIX PLC, for instance, the inventories are stock of items like Copper rod, Aluminum rod, PVC Resin, $CaCO_3$, stabilizer, DOP and even stock of stationeries they use in everyday business transactions and operations. Other inventory items in CUTIX PLC include spare parts, production supplies and the work-in-process (popularly called WIP in CUTIX PLC) – those semi-processed products that will still be used in other manufacturing processes within the company as inputs to produce finished goods for sales.

Without adequate supply of these required inventory items, manufacturing operations even business transactions of the company will be affected adversely.

The study of the inventory control models and applications of the models in CUTIX PLC inventory system opened up areas the company needs to improve upon, though the company has been doing well in some areas.

The areas the company needs to improve upon are the areas of economic order quantity for Copper rod, Aluminum rod, PVC Resin and $CaCO_3$, but the order quantities for DOP and stabilizer are very close to the calculated economic order quantity for each of DOP and stabilizer.

Recommendations

1. Any business organization that wants to have a hitch-free operation and minimize costs should consider employment of a well-trained inventory control personnel.
2. The company, CUTIX PLC, used as a case study in this work should ensure that they adopt the technique of economic order quantity, which minimizes inventory costs, in ordering and reordering of all inventory items.
3. The company should also adopt the techniques of reorder level and economic batch quantity and apply them in all their inventory items and manufacturing operations respectively.

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