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Computer Modelling and Simulation for Inventory Control

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Abstract: This study concerns the role of computer simulation as a device for conducting scientific experiments on inventory control. The stores function utilizes a bulk of physical assets and engages a bulk of financial resources in a manufacturing outfit therefore there is a need for an efficient inventory control. The reason being that inventory control reduces cost of production and thereby facilitates the effective and efficient accomplishment of production objectives of an organization. Some mathematical and statistical models were used to compute the Economic Order Quantity (EOQ). Test data were gotten from a manufacturing company and same were simulated. The results generated were used to predict a real life situation and have been presented and discussed. The language of implementation for the three models is Turbo Pascal due to its capability, generality and flexibility as a scientific programming language.

Key words: Assets, cost, economic order quantity, manufacturing, production, resources

INTRODUCTION

Simulation can be defined as a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behaviour of a business or economic system (or some components thereof) over extended periods of real time while a model can be defined as an object or concept that is used to represent something else. It is readily scaled down and converted to a form that we can comprehend (Neelamkevil, 1987).

Economic order quantity is the level of inventory that minimizes total inventory holding costs and ordering costs. It is one of the oldest classical production scheduling models. The framework used to determine this order quantity is also known as Wilson EOQ Model or Wilson Formula. The model was developed by Harris (1913), but Wilson, a consultant who applied it extensively, is given credit for his in-depth analysis (Hax and Candea, 1984).

The following assumptions are usually made, viz;

- The ordering cost is constant.
- The rate of demand is constant
- The lead time is fixed
- The purchase price of the item is constant, that is, no discount is available
- The replenishment is made instantaneously, that is, the whole batch is delivered at once

Many companies fail each year due to inadequate control of their inventory. Inventory could be classified as raw materials (e.g., components, fuels etc.) used to manufacture products, finished products, ready for final users or Work-in-Progress (WIP) that is, partly finished goods and materials, sub-assemblies etc. held between manufacturing stages.

Inventory problems can arise if too many items are held in inventory either because we increase the inventory level of items with high activity (that is, those that are in high demand) or tend to ignore those with low activity (that is, those with slow use, or low sale) with the attendant result that: money is tied up in unnecessary inventory, valuable space is used unnecessarily and the items may depreciate, deteriorate or even become obsolete (Morrison, 1981).

Inventory problems can also arise if too few items are held in inventory, resulting in loss of profits due to loss of sales and due to loss of goodwill consequent upon the unfilled demands. Stock out (that is, cost due to lack of goods demanded) may result incurring additional manpower and/or costs, actual cost to replenish inventory stock may be excessive because stock must be ordered frequently and the manufacturing plant being shut down as a result of lack of raw materials to work with (Burton, 1980).

Stock represents an investment to the organization. As with any other investment, the cost of holding stock must be related to the benefits to be gained. Hence the following costs are associated with inventory: carrying

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cost or inventory holding cost, ordering costs and stock out costs.

Another important element of inventory control is called reorder point. Businesses need to think ahead and calculate the best time for reordering products. Doing so too soon may cause financial difficulties or running out of space. On the other hand, waiting too long to reorder will result in a shortage and running out of inventory before the next shipment arrives. When figuring out a reorder point, it's necessary to calculate how long it will take the shipment to arrive and the amount of demand for a particular item. The overhead cost, fees and shipping expenses of ordering large versus small quantities should also be looked at (Stanojevic and Laing, 2009).

The accurate calculation of economic order quantity (also referred to as economic batch size) is difficult and it has given rise to many analyses The difficulties arise from the problems concerning the calculation of the carrying cost, since this depends on a number of factors difficult to assess, such as the expected return on invested capital, the total cost of storekeeping, the total cost material controlling, wastage, depreciation, insurance, obsolescence and a number of other factors of varying importance and from the calculation of the ancillary cost (Lockyer, 1983).

Economic Order Quantity (EOQ) is the ordering quantity which minimizes the balance of costs between inventory holding costs and reorder costs.

Stock control usually strikes balance between overstocking and understocking, that is, it eliminates the problems associated with overstocking and understocking (Batty, 1979).

In conclusion, the study focuses on Economic Order Quantity (EOQ) as an inventory tool to prevent a situation whereby more or less than required stocks are ordered and as well to avoid its attendant problems.

METHODOLOGY

The study was conducted at Bowale Industry,Lagos, Lagos State, Nigeria, from November, 2010 to February, 2011. The study was carried out on the organization's production items, in order, to determine when to order and the right quantity to order for each stock item.

Table 1: Results on EOQ model 1

Itemno	Annual Usageamount	Orderingcost	Storagecost	EOQ
1	1000.00	50.00	0 .20	707
2	2624.00	455.00	0.20	3455
3	2150.00	450.00	0.20	3110
4	5234.00	670.00	0.20	5922
5	3500.00	500.00	0.20	4183
6	1000.00	50.00	0.20	707
7	3020.00	450.00	0.20	3686
8	3150.00	560.00	0.20	4200
9	5200.00	875.00	0.20	6745
10	154000.00	5000.00	0.20	87750
11	230000.00	8500.00	0.20	139821
12	3426580.00	50000.00	0.20	1308927

Computer programs were developed for the three models represented as programs EOQ1 (Appendix A), EOQ2 (Appendix B) and EOQ3 (Appendix C), respectively in Turbo Pascal programming language.

In case of EOQ Model 1, the following input parameters were read into the computer namely: stock item number, annual usage amount, ordering cost and storage cost while the economic order quantity for some stock items were generated by computer as shown in Table 1 using the developed computer program (Appendix A).

Similarly, in case of EOQ Model 2, the following input parameters were read into the computer namely: stock item number, annual usage quantity, ordering cost, storage cost and unit cost while the economic order quantity for some stock items were generated by computer as shown in Table 2 using the developed computer program (Appendix B).

Also, in case of EOQ Model 3, the following input parameters were read into the computer namely: stock item number, arrival rate of an order, use or sale rate, annual usage quantity, ordering cost, storage cost and unit cost while the economic order quantity for some stock items were generated by computer as shown in Table 3 using the developed computer program (Appendix C).

Inventory problems are usually concerned with the determination of order quantities and re-order points bearing in mind the associated constraints like delays, stock-outs, lead-time, storage etc. The following costs are usually said to be minimized:

- Carrying costs
- Ordering cost
- Storage cost

Three programs, one for each model, was written to calculate the economic order quantity of some stock/production items using the mathematical models below:

EOQ model: There are a number of variations of the economic order quantity formula, but they all add up to much the same concept (Burton, 1980).

EOQ model 1:

$$EOQ = \sqrt{\frac{2AS}{I}}$$

A = The annual usage, in Naira (₦)
S = The ordering cost, in Naira (₦)
I = The inventory-carrying cost, as a decimal fraction per Naira (₦) average inventory

Table 2: Results on EOQ model

Item no.	Annual usage	Ordering cost	Storage cost	Unit cost	EOQ
1	5600	940.00	0.20	120.00	662
2	3280	582.00	0.20	235.00	285
3	7000	1200.00	0.20	320.00	512
4	5400	1980.00	0.20	328.00	571
5	3520	2600.20	0.20	280.00	572
6	5000	3050.00	0.20	450.00	582
7	6500	4000.00	0.20	530.50	700
8	5400	285.00	0.20	420.00	19
9	8520	1970.00	0.20	325.35	718
10	3450	255.00	0.20	12.40	842
11	7380	3200.00	0.20	527.00	669
12	5900	2000.00	0.20	35.00	1836

Table 3: Results on EOQ model 3

Item no.	Ordering cost	Annual demand	Annual holding cost per unit	U/A	EOQ
1	1200.00	1460	4.00	0.75	1324
2	1000.00	730	3.00	0.50	973
3	1500.00	1095	5.50	0.60	1222
4	650.00	1642	4.20	0.67	1235
5	1750.00	912	6.50	0.67	1215
6	2000.60	1095	3.50	0.33	1370
7	950.75	2190	7.25	0.83	1856
8	2500.65	1460	13.50	0.75	1471
9	3400.15	2555	10.75	0.86	3364
10	4200.25	1095	10.30	0.20	2113
11	3500.85	1643	15.90	0.83	4341
12	5100.40	2920	25.10	0.88	3081

$$\text{EOQ} = \sqrt{\frac{2S}{I}} X \sqrt{A} = K\sqrt{A} \quad (1)$$

$$\text{K} = \sqrt{\frac{2S}{I}} \quad (2)$$

where, k is a constant which is calculated for all items and is then multiplied by the square root of the annual usage in Naira (₦) to determine the Economic Order Quantity (EOQ) for each item. The results obtained after running the Pascal program can be found in Table 1.

EOQ model 2:

$$\text{EOQ} = \sqrt{\frac{2US}{IC}} \quad (3)$$

where
U = Annual usage in pieces
S = Ordering or setup cost, in Naira (₦)
I = Inventory-carrying cost, as a decimal fraction per Naira (₦) of average inventory
C = Unit cost, in Naira (₦) per piece

The results obtained after running the Pascal program can be found in Table 2.

EOQ model 3:

$$\text{EOQ} = \sqrt{\frac{2C_0 D}{C_1(1 - U/A)}} \quad (4)$$

where
A = Arrival rate of an order in unit/day
U = Use or sale rate in unit/day
D = Annual demand /usage
C_0 = Inventory-carrying cost/order
C_1 = Annual inventory holding cost/unit

The results obtained after running the Pascal program can be found in Table 3.

RESULTS AND DISCUSSION

The results of the three models are respectfully presented in tabular form in Table 1, 2 and 3. Each model produced reasonable and workable Economic Order Quantity (EOQ) on selected stock items such that they can be used for production planning and control.

From the Table 1, 2 and 3, it is evident that if the cost in = N = of placing one order (purchasing cost) is large relatively to both the value of annual expenditure in = N = and storage costs expressed as a decimal of the value of stock, we must be dealing with small, inexpensive items and consumption will be low in value while storage costs will be equally small. In this case, EOQ will be eventually large. The reverse will be true of large and expensive items, variability of solution according to the nature of the item is what makes each formula so useful.

It is always useful to know the optimal quantity of items to store in order to minimize expenses. Economic Order Quantity (EOQ) performs analogous functions to inventory control.

Economic Order Quantity (EOQ) is used for material allocation to process, storage and inventory control. The inventory costs are usually minimized while the problems associated with overstocking, stock outs and ordering are drastically eliminated.

Inventory control is the means by which material of the correct quantity and quality is made available as and when required, with due regard to economy in storage cost, ordering costs, purchase prices and working capital. It is possible to adjust continuously the quantity and value of stock held to conform to circumstances at all times.

CONCLUSION

Computer simulation should be seriously considered and favoured as a very important tool for the industry especially, in the area of inventory control. Simulation is a universal and important tool because it promotes automation and the success of industrialization depends largely on it therefore it should not be relegated to the background. Stock control should be embraced by every organization so as to minimize operating costs.

Inventory control usually ensures effective and efficient utilization of assets of an organization, such as, raw materials, components, spare parts, tools, work-in-progress, consumables etc. and also paves way for the creation of valuable and quality product on schedule and at minimum cosIt arrests the situation of overstocking which usually leads to high operating cost and that of understocking which usually leads to loss of sales and goodwill on the part of an organization.

In view of the points enumerated above, the importance of inventory control in a manufacturing outfit is paramount hence it cannot be overemphasized.

APPENDIXES

Appendix A:
EOQ1:

```
Program EOQ1(input,output);
(*A computer program to calculate Economic Order Quantity (EOQ1)*
)
const max = 12;
var itemno, j : integer;
var annualusageamount, orderingcost, storagecost, EOQ: real;
begin
    writeln('Enter the following: itemno, annualusa geamount,
    orderingcost, storagecost');
    writeln('or Press Ctrl + C to stop.');
    for j := 1 to 12 do
    begin
    read(itemno, annualusageamount, orderingcost, storagecost);
    EOQ := sqrt((2 * annualusageamount * orderingcost)/
    (storagecost));
    writeln('Itemno Annualusageamount Orderingcost Storagecost
     EOQ');
    writeln(Itemno:2, Annualusageamount:13:2, Orderingcost:14:2,
    Storagecost:10:2);
    writeln(EOQ:10:2);
       end;
    end.
```

Appendix B:
EOQ2:

```
Program EOQ2(input , output);
(*A computer program to calculate Economic Order Quantity (EOQ2)*
)
const max = 12;
var j, itemno, annualusage: integer;
var orderingcost, storagecost, unitcost, EOQ : real;
begin
    writeln;
    writeln('Enter the value of the following: Itemno, annualusage,
    orderingcost');
    writeln('Enter the value of the following: storagecost, unitcost');
    for j := 1 to 12 do
    begin
          read(itemno, annualusage, orderingcost, storagecost,
          unitcost);
          EOQ := sqrt((2 * annualusage *
          orderingcost)/(storagecost * unitcost));
          writeln('itemno annualusage orderingcost storagecost
          unitcost   EOQ');
          writeln(itemno:2, annualusage:13, orderingcost:14:2,
          storagecost:10:2, unitcost:12:2);
          writeln(EOQ:10:2);
          end;
    end.
```

Appendix C:
EOQ3:

```
Program EOQ3(input,output);
(*A computer program to calculate Economic Order Quantity (EOQ3)*)
const max = 12;
Var itemno, annualdemand, arrivalrate, userate:integer;
Var A,B,orderingcost,annualholdingcostperunit,EOQ:real;
Var j: integer;
begin
    writeln('Enter the following:’);
    writeln(‘itemno,arrivalrate,userrate,annualdemand,orderingcost’);
    writeln(‘annualholdingcostperunit');
    writeln('or press Ctrl + C to stop');
    for j := 1 to 12 do;
    begin
          read(itemno,arrivalrate,userate,annualdemand,orderingc
          ost,annualholdingcostperunit);
          A := (2*orderingcost*annualdemand);
          B := (annualholdingcostperunit*(1-(userate/arrivalrate)));
          EOQ := sqrt(A/B);
          writeln ('itemno arrivalrate userate
          annualholdingcostperunit   EOQ');
          writeln(itemno:2,arrivalrate:14,userate:12,annualdeman
          d:13,orderingcost:10:2);
          writeln(annualholdingcostperunit:10:2,EOQ:10:2);
          end;
    end.
```

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