PREDICTION METHODS OF OPTIMAL ORDER QUANTITIES OF INVENTORIES FOR SMALL-SCALE INDUSTRIES IN DEVELOPING COUNTRIES

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ABSTRACT

In this paper, Inventory Control problems of six different small-scale industries were studied using different prediction methods. The effectiveness of each method was measured by the minimum total inventory cost. Results revealed that different prediction methods proved most effective for different industries. Exponential smoothing method proved most effective for clothing and corrugated iron sheet industries; simple moving average for technical service industries; weighted moving average for industries producing simple machines and upholstered furniture; and marginal analysis for fish/meat sales industries.

1.0 INTRODUCTION

Small-scale industrialisation offers a more appropriate alternative to industrialisation strategies than large-scale centralised industries which until recently were favoured by developing countries (Akinkugbe, 1977). However, many structural and/or operational problems militate against the realisation of small-scale industrialisation. These problems include poor inventory control, improper shop layout and technology, and poor production planning and control techniques. For example, improper inventory control can lead to overstocking of inputs and outputs, and large work-in-process thus risking fire, theft, damage, deterioration, increasing insurance charges, storage and service costs. These are costs which, in most cases constitute about 25-45 per cent of the value of the items concerned (Krajewski and Ritzman, 1987). On the other hand, out-of-stock situations can lead to loss of sales and customer goodwill. This gets worse where the supply of inputs and demand for outputs are unstable and irregular.

Inventory is a resource (material) which possesses economic value, stocked up to satisfy some eventual demand (Monks, 1982). According to Austin and Burns (1985), attention should be given to inventory because it can contribute up to 30 per cent of the overall value of the firm. Excessive inventories represent tied up capital in non-income earning assets.

Economic Order Quantity model (EOQ) has been widely applied as a solution to inventory problems (Ajuju, 1988). In this model, the order quantity which minimizes the
total cost of procuring and carrying inventory is determined on the assumption that demand is constant and known with certainty; lots are supplied when ordered; there is no uncertainty in lead times or supply; and stock is withdrawn continuously at a constant rate.

Large-scale industries may feel comfortable with this model but it is of no practical use to small-scale enterprises in developing countries where uncertainties in demand, supply and lead times are prevalent.

OBJECTIVES OF THE STUDY

The objective of this paper is to demonstrate techniques for determining the optimum order quantities for specific small-scale industries, where supply, demand and lead times are uncertain.

The applicable techniques are simple and weighted moving average, exponential smoothing, simulation, and marginal analysis. These techniques are applied to the following six different small-scale enterprises and their actual demands were compared with the predicted values:

1. Anglican Diocese of Owerri Weaving Project (ADOWP) - makers of clothing materials.
2. Guanac Machines, Owerri (GMO) - manufacturers of gari grating machines.
3. King's Furniture Industries, Aba (KFIA) - makes of a brand of upholstered furniture.
5. Fusion Industries, Owerri (FIO) - manufacturers of roofing sheets.
6. Herriot Fish and Meat Store, Owerri (HFMS) - suppliers of beef.

2.0 PREDICTION TECHNIQUES

2.1 Optimal Order Quantity (Qopt).

This is the order quantity for which total inventory cost is a minimum. It is a value generally regarded as the point at which the cost of ordered items equates the cost of carrying inventory (Maynard, 1971).

2.2 Simple Moving Average (S.M.A.)

In mathematical terms, a simple moving average \( (A_{t+1}) \) for an arbitrary period \( (t+1) \) based on history through time \( t \) would be

\[
\text{Moving Average} = \frac{\text{Demand in previous n periods}}{n}
\]

2.3 Weighted Moving Average (WMA)

The weighted moving average \( A_t \) is given as

Where:

2.4 Demand

This section gives the demand values and how it fluctuates immediately to show the nature of such data.

Where:

2.5 Simulation

According to experimental design considered, simulation was done. Thus, demand fluctuates due to environmental factors. Further, Nelson (1988) states that simulation technique is

2.6 Marginal Analysis

The objective is to find the sequence of action, for the forecast of the largest demand calculation. The marginal cost is the marginal increase (decrease) in the total cost (or revenue), the change in profit from a small change in activity level. A marginal analysis is used to determine the economic order quantity (EOQ) and the total inventory cost (TIC) of the item purchased monthly.
Weighted Moving Average = \frac{\text{Weight for period } n \times \text{Demand in period } n}{\text{Weights}} \quad (2)

Where weights are used to place more emphasis on most recent values.

2.4 Exponential Smoothing.

This method makes use of past historical data to predict future demand. Average of past values are assumed as forecast for the current. A fraction of the difference between immediate demands and forecast is added to (or subtracted from) the previous forecast such that

New forecast = Old Forecast + \alpha(\text{New demand - Old Forecast}) \quad (3)

Where \( \alpha \) is a weighting factor.

2.5 Simulation.

According to Austin and Burns (1985), simulation is a methodology for conducting experiment using models of the real system. The expediency for using simulation is considered here because demand necessary for inventory control is dependent on time. Thus, data relationship and variables are not constant over a given period - a dynamic environment. Keen (1978) believes that simulation is the most widely used managerial computer based technique in decision making. Studies by Mayor (1970) and Shannon (1988) suggest that simulation and statistical methods are the most widely used managerial techniques employed in industries.

2.6 Marginal Analysis:

The concept of Marginal Analysis is based on the idea of considering the net consequences of taking an action. The term "marginal" refers to the situation of taking the last action. However, the presence of probabilities in demand requires that the consequences of the last action be weighted by appropriate probabilities (Buffa, 1986). This is done by calculating and comparing the expected value of losses and gain that emerges from the marginal action. This requires the calculation of expected net gain comparing the expected marginal gain (if the last unit is sold) with the expected marginal loss (if the last unit is not sold), the optimal cumulative probability (P*) of selling the last unit emerges.

3.0 DATA ANALYSIS AND DISCUSSION.

Historical data were collected from the six small-scale industries whose inventory problems are being investigated. Consistent with objectives of this study, four relevant quantities necessary for analysis of results obtained are computed. They include optimal order quantities (OOQ), Holding costs, stockout (penalty) costs and Total Inventory Cost (TIC) of each small-scale industry. These values were obtained on four quarterly or monthly basis of each year under consideration.
3.1 Prediction Quantities.

These are secondary values computed from actual demands and shown in columns 5, 6, 7 and 8 of Tables 1 - VI. If these values are known, then the remaining three values (holding, stockout and total inventory costs) can be determined easily.

Demand is predicted by methods earlier outlined. In forecasting, simple moving and weighted moving averages including exponential smoothing methods were used. Other appropriate predicting methods are marginal Analysis (MA) and simulation. Predictions with marginal Analysis method require knowledge of demand of the previous year. For example, to predict for 1988 (Table 1), the actual demand for 1987 was used. For 1989, actual quantities demanded in 1987 and 1988 were used. In like manner, values for 1990 and 1991 were also determined.

3.2 Holding/Stockout Cost.

Differences between actual and predicted values of demand account for stored (holding) and stockout quantities. Costs generated by these two quantities are determined as follows:

Holding cost is found by making use of the formula

$$\textit{H}(Q) = Y \textit{h}$$  

... (4)

Where $\textit{H}(Q)$ is the holding cost, $Y$ the average inventory quantity and $h$, the holding cost per unit, per period.

A summing holding and penalty costs are twenty-five percent of the cost price, Stockout cost is evaluated by the equation below

$$\textit{Stockout cost} = \textit{Expected stockout} \times \textit{Penalty}$$  

... (5)

3.3 Total Inventory Costs (TIC).

These values represent the total cost of running inventories in each small-scale industry over a stipulated period (Table VII). Mathematically, it is the sum of all holding and stockout costs.

4.0 DISCUSSION.

Table VII contains summary of total inventory costs for methods used for prediction in each small-scale industry. It is necessary to observe that the main focus of this table is the least inventory costs (LIC) recorded for a particular industry. In all, weighted moving average and exponential smoothing methods were more applicable than others. These methods accounted for the lowest costs in Gussac machines and kings Furniture Industries and also in Fausan Industries and Anglican Diocese of Owerri Weaving Project.

Next to the most applicable were simple moving average and marginal analysis methods. The former favoured predictions in Juddaco International while the latter suited predictions in Herriots Fish/Meat/Stores.
In monetary terms, LIC with WMA in Gusaie machines and Kings Furniture Industries were four thousand and three hundred naira (N4,300.00) and six thousand naira (N6,000.00) respectively. With ES method, LIC of Nineteen thousand, eight hundred and forty-four naira (N19,844.00) and eight hundred and one thousand, six hundred and eight naira (801,608.00) were recorded respectively for Anglican Diocese of Gwerri Weaving Project and Fanson Industries. SMA method accounted for one thousand, three hundred and fifty-eight naira (N1,358.00) as LIC in Juddaco International. The lowest inventory cost for the entire six industries was recorded in Herricks Fish/meat Store by applying the Marginal Analysis method. The amount was four hundred and ninety-eight naira (N498.00) only.

Predictions using simulation method are not applicable in most of the industries investigated. Where they are applicable (Fanson Industries and Herricks Fish/meat Store), computed inventory costs are outrageously high in comparison with values derived with other methods. Hence, its adoption lacks economic justification. From the data, it is evident that the economic order quantity concept is not appropriate for these small-scale industries.

5.0 RECOMMENDATIONS AND CONCLUSION.

In conclusion therefore, this paper has shown that inventory costs - a crucial and important determinant of the overall cost of goods and services, may be greatly reduced in small-scale industries if the appropriate control methods (models) are applied. Furthermore, it has been observed that not all inventory control models developed for use can be profitably applied in small-scale industries. The way out, therefore, is to ascertain the efficacy of the models before they are adopted for use. Once adopted in a particular type of small-scale industry, similar industries can then apply them profitably.

Exponential smoothing is most appropriate for clothing and corrugated iron sheet industries while simple moving average suits technical service industries. Weighted moving average gave the least inventory cost (LIC) for industries producing simple machines and upholstered furniture and marginal analysis proved best for fish/meat sales industries.

REFERENCES


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