| Author | OFORUM, Cliiford Obiyo  
  PG/MBA/92/17096 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Inventory Management and Manufacturing Companies: A case Study of the Nigerian Cement company Nkalagu</td>
</tr>
<tr>
<td>Faculty</td>
<td>Business Administration</td>
</tr>
<tr>
<td>Department</td>
<td>Accountancy</td>
</tr>
<tr>
<td>Date</td>
<td>May, 1994</td>
</tr>
</tbody>
</table>
| Signature | Digitally signed by Omenuko Sunday Ogbonna  
DN: CN = Omenuko Sunday Ogbonna, C = NG, O = University of Nigeria, OU = Innovation Centre  
Reason: I have reviewed this document  
Date: 2008.11.05 16:00:44 -12'00' |
INVENTORY MANAGEMENT AND MANUFACTURING COMPANIES

A CASE STUDY OF THE NIGERIAN CEMENT COMPANY Nkalagu.

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS DEGREE IN BUSINESS ADMINISTRATION MBA (ACCOUNTANCY)

BY

OFURUM CLIFFORD OBIYO
PG/MBA/92/17096

DEPARTMENT OF ACCOUNTANCY FACULTY OF BUSINESS ADMINISTRATION UNIVERSITY OF NIGERIA, ENUGU CAMPUS.

MAY, 1994
INVENTORY MANAGEMENT AND MANUFACTURING COMPANIES

A CASE STUDY OF THE NIGERIAN CEMENT COMPANY NKALAGU.

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS DEGREE IN BUSINESS ADMINISTRATION MBA (ACCOUNTANCY)

BY

OFURUM CLIFFORD OBIYO
PG/MBA/92/17096

DEPARTMENT OF ACCOUNTANCY FACULTY OF BUSINESS ADMINISTRATION UNIVERSITY OF NIGERIA, ENUGU CAMPUS

MAY, 1994
We, the undersigned, hereby certify that this research project work is carried out by OFURUM CLIFFORD ORIYO, under our supervision and found adequate in quality and scope for the partial fulfillment of the requirement for the award of Masters in Business Administration - MBA (ACCOUNTANCY) of the University of Nigeria, Enugu Campus.

Mrs. U. Mgbum
Head of Department

Date: 7/6/97

Mr. V. U. Ezeugwu
Project Supervisor

Date: 11/8/97
DEDICATION

To God Almighty who made it all possible.
To my Mother, who continued from where my father stopped.
To Obed, my only brother, and finally to my wife, Ifeoma.
ACKNOWLEDGMENT

A project of this nature cannot be adequate without my acknowledging my indebtedness to the numerous people that contributed towards the success of this work.

I am grateful to my supervisor, Mr. V. U. Ezeugwu, for his invaluable assistance and guidance in seeing this work through inspite of all his commitments. In fact Mr. Ezeugwu is a 'father.'

My appreciation also goes to my elder sister; Mrs. P. C. Opara whose advice and contribution made me what I am today. The same thing also goes to Mr. & Mrs George Nkwopara.

I am greatly indebted to all my classmates, whose argument, criticisms and encouragement, contributed in no small measure to the success of this work.

Finally, I wish to acknowledged my uncle, Mr. Theophilus Onyeneke and all the staff of the Nigerian Cement Company, Nkalagu for providing the necessary data needed for this work.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title Page</td>
</tr>
<tr>
<td>Approval Page</td>
</tr>
<tr>
<td>Dedication</td>
</tr>
<tr>
<td>Acknowledgment</td>
</tr>
<tr>
<td>Table of Contents</td>
</tr>
<tr>
<td>Abstract</td>
</tr>
<tr>
<td>List of tables and figures</td>
</tr>
</tbody>
</table>

## CHAPTER ONE

**INTRODUCTION**

1.1 Background of the study | 3
1.2 Statement of problems | 3
1.3 Objectives of the study | 7
1.4 Hypothesis formulations | 12
1.5 Significance of the study | 15
1.6 Scope of the study | 14
1.7 Research Questions | 16
1.8 Definition of terms | 18
References | 22

## CHAPTER TWO

REVIEW OF RELATED LITERATURE | 23
<table>
<thead>
<tr>
<th>Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Historical sketch of inventory problem</td>
</tr>
<tr>
<td>2.2 Specification of an inventory system</td>
</tr>
<tr>
<td>2.3 Importance of Inventory</td>
</tr>
<tr>
<td>2.4 Inventory Management problem</td>
</tr>
<tr>
<td>2.5 The Economic order quantity</td>
</tr>
<tr>
<td>2.6 Evaluation of Economic lot size formula</td>
</tr>
<tr>
<td>2.7 Another Economic lot size formula</td>
</tr>
<tr>
<td>2.8 Quantity discounts</td>
</tr>
<tr>
<td>2.9 Inventory Control under Risk and Uncertainty</td>
</tr>
</tbody>
</table>

| References                                                                 |
|                                                                           |
| CHAPTER THREE                                                            |
| RESEARCH DESIGN METHODOLOGY                                              |
| 3.1 Definition of area and population of study                            |
| 3.2 Procedure for Data collection and analysis                            |
| 3.2.1 Primary sources                                                     |
| 3.2.2 Secondary sources                                                   |
| 3.3 Pilot Survey                                                          |
| 3.4 Sample technique                                                      |
| 3.5 Procedures and Techniques for data analysis                           |
| Appendix 3:1                                                              |

| CHAPTER FOUR                                                             |
| ANALYSIS AND PRESENTATION OF DATA                                        |
| vi                                                                       |
4.1 Data presentation

4.2 Analysis of primary data (Questionnaire)

4.3 Research Question I

4.4 Hypothesis 1

4.5 Hypothesis 2

4.6 Hypothesis 3

4.7 Hypothesis 4

4.8 Hypothesis 5

4.9 Research Question 3

CHAPTER FIVE

SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Summary

5.2 Findings

5.3 Conclusion

5.4 Recommendation

Bibliography

Questionnaire

LIST OF TABLES AND FIGURES

<table>
<thead>
<tr>
<th>Table/Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 2.1</td>
<td>An input - output representation of an inventory system</td>
<td>28</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>Order quantity determinant</td>
<td>30</td>
</tr>
<tr>
<td>Fig. 2.2</td>
<td>Relationship between production level and stock</td>
<td>32</td>
</tr>
<tr>
<td>Fig. 2.3</td>
<td>Multiechelon inventory system</td>
<td>33</td>
</tr>
</tbody>
</table>

vii
Fig. 2.4  Economic order quantity
Fig. 2.5  The maxi-min system of inventory control when delivery occurs over a period of time
Fig. 2.6  Total cost curve generated by two unit prices
Table 3: 1.1  Sources of raw materials
Table 3: 1.2  Materials re-order level
Table 4: 1  Questionnaire response rate
Table 4: 2  Companies and the administration of questionnaire
Table 4: 3  Departments and the distribution of questionnaire
Graph 4: 1  Rough graph
Graph 4: 2  Graph of $Y = -123.17 + 24.07x$
ABSTRACT

The study of inventory management, as it is practised in Nigerian manufacturing firms is a pioneer work. This research project examines the existing practice as regards the ordering of raw materials their conversion to finished goods through the production process and the disposition of the finished goods. A lot of questions, usually asked by inventory/material managers were received and plausible solutions suggested. The study also aimed at determining to what extent the level of raw material purchase was related to the level of production, sales as well as turnover in the Nigerian Cement Company, Nkalagu.

This research project, which followed the scientific pattern of problems solving is divided into five chapters. In the introductory chapter, certain questions and problems usually asked and faced by inventory managers were identified. Hypothesis were formulated as guides to finding solutions to these problems.

Related literatures were reviewed. Literature abounds in the area of inventory management though most of them treated "Classical cases". Sources of literature include textbooks, journals, especially those of the Harvard School of Business and past research projects.

Under the methodology and the research design, five (5) companies were selected though only one: the Nigerian Cement Company, Nkalagu was used for the analysis. The rest were used as dummies just to arrive at general conclusion. Questionnaires were designed and used to collect information. Three hundred and fifty (350) were administered primarily to answer those research questions and hypothesis already raised at the introductory chapter.

Mathematical and statistical tools were used to analyze the data got from those questionnaires. Based on this analysis, the following findings were made:
a. The Economic lot size of the Nigerian Cement Company, Nkalagu should be 1,000 tons, instead of the present 13,000 tonnes.

b. That the company is possibly currently losing N1,733,520.00 (One Million Seven Hundred and Twenty Naira) annually for not buying at the Economic order quantity.

c. That a significant relationship exists between the inventory level and turnover at the Nigerian Cement Company, Nkalagu.

d. That inadequate stock leads to production stoppages and loss of sales.

e. Finally that most inventory managers are aware of the existence of the Economic order quantity but use it with various modifications.

Based on the findings, the following recommendations were made:

a. That the company should endeavour to keep adequate record as a means of control.

b. That materials/inventory managers should take the same entrepreneurial approach that most other company executives do.

c. Further research in this area is equally recommended for research students and companies.
CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

"Inventory represents an important asset and is the largest single item of cost in almost every business, accordingly, the success or failure of a concern may depend largely upon efficient material purchasing, storage, utilization, and accounting."

- C. I. Buyers and G. A. Homes

It is possible to distinguish three different classes of inventory; they are:

1. Pre-production Inventory (raw materials)
2. In-process Inventory (work-in-process) and
3. Finished Goods Inventory.

Pre-production inventory provides a type of insurance for the company; if difficulties in the future supply of raw materials are expected, this inventory will enable production to continue smoothly, if future costs of raw materials are expected to rise, higher stocks might be held as a speculation against the rise in price. Finished goods may also be thought of as an insurance; if orders are received they will be able to be supplied immediately from inventory, hence the customer will not have to wait for delivery. Such insurance and speculative reasons
for holding inventory do have a cost and this cost must be recognized, because it is considered in times of high interest rates. Consequently, good management of inventory is important to the profit minded enterprise.

Investment in stock represents a major asset of most industrial and commercial organization, and it is essential that stocks are managed efficiently so that such investments do not become unnecessarily large. A firm should determine its optimum level of investment in stocks, it must ensure that stocks are sufficient to meet the requirement of production and sales, and secondly, it must avoid holding surplus stock which are unnecessary and which increase the risk of obsolescence. The optimum stock level lies somewhere between these two extremes.

The country is currently passing through a period of cash squeeze where profit is hardly-earned, hence stewardship of resource has become more and more vital. Thus methods must be adopted to ensure that funds invested in inventory are not wasted. For these reasons, more operations research has become directed towards inventory control than toward any other problem in business and industry. Resources invested in inventory are not earning a return for the company. They are on the other hand costing the firm money, both in an opportunity cost sense in that other profitable uses of the funds are forgone, and in the sense that they represent funds which have to be paid for.

Inventory may be defined as being an ideal resource with economic value or as Lewis suggests, "inventory is money temporarily wearing the guise of a casting or a bag of chemicals." It is money on which the company pays, rather than collects interest. Values lessen as physical deterioration progresses, while insurance, storage and other cost accumulate. Inventory is money always in danger of devaluation with forces such as design and customer's preference changes.
constantly in operation.

Management has been defined as the establishment of the environment for group efforts in such a way that individuals will contribute to group objectives with the least amount of such inputs as money, time, efforts, discomfort and materials (Koontz and O'Donnel 1980). It can also be defined as the process of planning, organizing, directing and controlling the efforts of organization members and using all other organizational resources to achieve stated organizational goals. Control involves the development of precise plans/standards/budgets, and the monitoring of performance against them in order to take any needed corrective action in time.

Inventory management is the art and science of achieving the set objectives of procuring the materials at the lowest possible costs, ensuring adequate flow and making the most economical use of such materials in order that the total cost of production is minimized through the creation of such an environment that would enable the individuals contribute to the achievement of the objectives with least amount of such inputs as money, time, material etc. On the other hand, inventory control is the science based art of ensuring that enough inventory is held by an organization to meet economically both its internal and external demand commitments. There can be disadvantages in holding either too much or too little inventory, as such, inventory control is primarily concerned with obtaining the correct
balance or compromise between these two extremes. It is therefore, the quantity that should be held that management is interested in.

An economic lot size equation was developed which minimized the sum of inventory carrying and setup cost where demand was known and constant. Accordingly, industrial engineers, economists and to a large extent mathematicians have contributed to this work. A considerable literature exists on most of the techniques and tools currently used by operations research in the inventory control area, and these were developed in the last few years. This recent development began with the attempt to provide procedures which are applicable in situations in which demand is known with certainty but can only be estimated. One problem that arises when uncertainty of demand is taken into account is that of providing buffer stock to protect against shortages; though recent findings have indicated that conditions under which optimum inventory level can be found is possible.

Since production is very important to any economy, adequate and proper utilization of labor, materials and equipments will then have to be made in order to ensure greater efficiency. In the case of Nigeria which is filled with uncertainties, the manufacturing sector cannot afford wastage especially with regards to materials. Hence, there is need for proper and effective utilization of resources in order to prevent any shortfall in the level of production.
An inventory problem exists when it is necessary to stock physical goods or commodities for the purpose of satisfying demand over a specified period of time. Almost every business organization must stock goods and raw materials to ensure smooth and efficient running of its operations. Decisions regarding how much and when to order are typical inventory problems. Inventory management and control systems ensure that proper and adequate utilization of materials are made and that the optimum level of material investment are determined and maintained. Presently, the Economic order quantity (EOQ) model is the most frequently used model for controlling inventory in most manufacturing companies.

1:2 STATEMENT OF PROBLEMS:
The primary objective of most business organizations include survival and growth, and the maximization of shareholders wealth. To attain these objectives, a level of profit must be earned to allow a company take advantage of business opportunities, undertake research and innovations which will enable growth. The achievement of these objectives make it imperative that positive steps will be taken to minimize the total cost of the business and at the same time maximize revenue generating potentials. One major component of the
operating cost of any manufacturing concern that deserves the attention of top management is the investment in inventories. The inventory figure for many firms is the largest single item in the current asset group.

The biggest question before management is: How big should inventories be? The answer to this question is obvious - they should be just big enough. But what is big enough? This question is made more difficult by the mere fact that generally each individual within a management group tends to answer the question from his own point of view. He fails to recognize costs outside his usual framework. He tends to think of inventories in isolation from other operations. The Sales Manager commonly says that the company must never make a customer wait; the Production Manager says that there must be long manufacturing runs for lower costs and steady employment; the Treasurer says that large inventories are draining off cash which could be used to make profit. Such a situation occurs all the time. The task of all production planning, scheduling, or control functions, in fact, is typically to balance conflicting objectives such as those of minimum purchase or production cost, minimum inventory investment, minimum storage and distribution cost, and maximum services to customers.

An excess inventory consumes a proportion of the company's finance which otherwise could
have been profitably employed in other areas while a situation in which a firm runs out of stock of materials and finished products could be costly in terms of the loss of sales and customers goodwill. The ability of management to effectively manage this issue helps to strike a balance between the cost of holding and ordering its inventory.

Any manufacturing organization needs to effectively manage its inventories. The management of inventory involves determining the basic stock of inventory to hold on hand at any particular point in time, decisions as to whether to buy raw materials in large quantity, the number of times to place orders for materials and the optimum time to place requisition. "Why are we always out of stock?" So goes the complaint of great number of businessmen faced with the dilemmas and frustrations of attempting simultaneously to maintain stable production operations, providing customers with adequate services and keeping investment in stocks and equipments at reasonable levels.

But this is only one of the characteristic problems business managers face in dealing with production planning, scheduling and keeping inventories in hand to meet customers need. Other question - just as perplexing and baffling when managers approach them on the basis of intuition and pencil work done are: How often should we reorder? How should we adjust production, when sales are uncertain? What capacity levels should we set for job-shop
operations? How do we plan production and procurement for seasonal sales? And so on, and so forth. Inventory management further involves how to schedule the departments and machines in order to avoid the risk of having excess in-process inventory. A profit oriented company that can maintain these features of inventory management will accentuate the company’s chances of optimizing profitability and will have to be doing a good job of controlling its inventories and production levels.

Even though a recent invention, the Economic Order Quantity (E.O.Q) model, designed by engineers, accountants and mathematicians has been in existence for sometime now. The model has an objective to determine the inventory quantity a firm should order and carry in order to minimize the cost of carrying and holding stock. But despite this laudable objective of the Economic Order Quantity (EOQ) model, it is still noticeable that most companies in Nigeria are operating annually at losses as a result of the high costs due from poor management of inventories. Consequently, this project will equally be aimed at finding out if actually manufacturing companies apply the inventory management model - EOQ, if they do, why are most of them still run high operating costs especially in the area of inventory management?

Often times, it takes between nine months to one year in the Nigerian Cement Company Nkalagu; from the time customers place order to the time, the orders are filled. A critical analysis of this situation reveals that production is usually far below customers requirement;
hence the need to ration the available output on a pro-rata basis. Is there actually a relationship between production stop-pages/insufficient output and inventory? Synder identified some questions necessary for solving the inventory problem:

* "Why are we out of stock too often?"
* Why do we have too much capital tied up in inventories?
* "Why is our storage costs high?"
* Are we losing business because we don’t have enough inventories?*
* "Why do competitors operate with lower inventory sales ratio?"
* "Why do we have too much ‘dead’ inventory?"

The fact that the statements are voiced so frequently points out the many conflicts of interest which appear in most inventory situations. To resolve these conflicts, we need to resolve uncertainties such as:

- Should we even have inventories?
- "What should the inventories be?"
- "What is the correct inventory level for production?"
- "How do we control inventories?"
- "How do we evaluate performance?"
OBJECTIVES OF THE STUDY:

The objectives of this study are as follows:

1. To examine the basic inventory models (such as the EOQ, safety stock) as operated by the Nigerian Cement Company, Nkalagu; otherwise to find out how much the company is losing for not buying in the Economic Order Quantity (EOQ) lot sizes.

2. To determine whether there is any relationship between the level of inventory and the level of production and customers services.

3. To determine whether there is any relationship between the level of inventory and the level of profitability of the Nigerian Cement Company, Nkalagu.

4. To identify the weakness if any involved in implementing inventory management and control systems in manufacturing companies with special reference to Nigeria Cement Company, Nkalagu.

5. Finally to make recommendations for improvement.

HYPOTHESIS FORMULATION:

Specifically, this section serves as a guide to the research work. With the problems identified and the objective stated, certain assumptions are made which will be tested during the course of the project work. These hypothetical statements are stated in the next page.
1. Most inventory managers do not know about the existence of the Economic Order Quantity (EOQ).

2. A significant number of them do not apply EOQ model in making inventory decisions.

3. Inadequate stock leads to disruption in production and loss of sales.

4. There is no significant relationship between inventory level and turnover in manufacturing companies.

5. Inventory management problems revolve around the determination of the optimum stock level to hold/carry at any point in time.

1:5 SIGNIFICANCE OF STUDY:

Inventory constitutes a large proportion of the operating costs of a business, hence its effective management would enhance the survival and growth of the business while contributing to a satisfactory profit level of operations by minimizing costs. No company can afford to invest its scarce resources in areas of considerable risks and uncertainties. Therefore, the need to study a means of evaluating the profitability of holding inventory and costs involved in doing so can never be over emphasized.

Given the crucial position of the Nigerian Cement Company, Nkalagu, as a profit oriented
concern and its social and economic commitment to the growth of the country, it is therefore of considerable importance that all avenues that will enhance the growth of the company's need to be exploited. It is therefore the hope of the researcher that this study would be found useful by the owners, management of the company and others.

1. This research project would help the management of the Nigerian Cement Company, Nkalagu to identify the most influential variables of inventory management and production. Furthermore, the study will also help the management of the company, to guide against risk of losses through obsolescence.

2. This research project will also be very useful for research students, who may want to extend their studies in the area of inventory management. This work will provide a base of literature to such students.

3. Finally, it is hoped that this study would offer useful suggestions on ways to improve the inventory control system of the company.

1:6 SCOPE OF THE STUDY:

Inventory management is really a very broad area, but this study is limited to manufacturing companies, with special reference to the Nigerian Cement Company, Nkalagu.

The study investigates the general practice of inventory management and control system.
adopted in the Nigerian Cement Company, Nkalagu, the nature, types and other factors which influence the size of inventory and of raw materials in the factory.

It is an analytical survey of the problems of the Nigerian Cement Company, Nkalagu with respect to the application of raw materials management techniques. Practically, the study is based on the analysis of raw materials management of the company for a period of five years (1988 - 1992). Investigations are carried out in this project as to what extent the inventory policies have affected total corporate objective of the firm such as profitability, efficiency e.t.c. In analyzing the data gathered, quantitative techniques are employed to calculate the economic order quantity and re-order point (ROP).

Furthermore, attempts are made to analyses any cost savings or otherwise that resulted from such computations. Efforts are also made to relate the level of inventory to the level of production and sales.

Finally, inventory costs are related to the levels of profit with the aid of basic statistical tools namely correlation and regression analysis.
RESEARCH QUESTIONS:

The research questions for this study are:

1. What is the Economic Order Quantity of the Nigerian Cement Company, Nkalagu?
2. Is the company buying at the Economic Order Quantity?
3. If no to 2 above, how much is the company losing annually for failing to buy at the Economic Order Quantity lot sizes?
4. What basic inventory models are most common to manufacturing companies?
5. Why are most companies always running out of stock?
6. How big should inventory be?
7. Is there any relationship between inventory level and profitability?
8. Finally, do most managers apply various inventory management models?

LIMITATION OF STUDY:

In a study of this nature, a lot of problems are bound to appear. It was left to the researcher to strive to achieve the best he could in spite of these problems. Some of the limiting factors of this research project are:
1. **Inadequate** information was a limiting factor in the sense that the extent the research could go depended on the available data. Most data which the researcher intended using for his analysis were not available as complete records were not kept by the company. Attitudes of some heads of department of the company also place a check on easy accessibility to relevant information.

2. **Finance:** The researcher was forced by lack of money to limit the study to certain periods and to limit the respondent to a certain number. This is the case as a lot of expenses were incurred in typing questionnaires and conducting interviews.

3. **Time:** This research project, being a requirement for the award of MBA degree had time interval allocated to it by the University authority. The allotted time is also the same for other course work and various assignments, hence, there is always a consistent conflict between lecture hours and appointed schedule with company executives. Because of all these constraints, the researcher could not carry out his study as envisaged, hence he strenuously investigated the relevant areas of the study for the period under review.

4. **Illiteracy:** The researcher encountered problems in administering his questionnaires as a result of illiteracy of some respondents. The researcher had to take time to help some of his respondents in completing the questionnaires by asking the question and recording the responses accordingly.
DEFINITION OF TERMS:

1. INVENTORY: According to Pandey, "Inventory is stock of goods and components that make up the product that a manufacturing company is producing for sale".

a. Raw Materials Inventory: Raw materials inventory are those units of production which have been acquired and stored for future production. They are those basic materials that are converted into finished products through the manufacturing process.

b. M.R.O. Inventory: Maintenance, Repairs and Operating supplies are these inventory which are consumed in the production.

c. Work-In-Progress Inventory: These are semi-manufactured products. They represent products that need more work before they become finished products for sale.

d. Inventory of Supplies: Supplies are maintained by firms and include office and plant cleaning, materials (soap and broom) etc. Oil, fuel, light, bulbs, and their like. These materials do not directly enter into the production process.

e. Finished Goods Inventory: These are manufactured goods ready for sale.
2. **Lead or Procurement Time**: The period of time expressed in days, weeks, months, etc. between ordering (either externally or internally) and replenishment i.e. when the goods are available for use.

3. **Demand**: The amount or quantity required for production, usually expressed per week, month or year. Estimates of the rate of demand during the lead time are critical factor in inventory control system.

4. **Economic Order Quantity (EOQ)**: This is a calculated ordering quantity which minimizes the balance of costs between inventory holding and re-order cost.

5. **Physical Stock**: These are numbers of items physically in stock at any given time. The physical quantity of goods on hand can be determined by physical count by the employee of the firm and by maintaining record of all increases and decreases in stock.

6. **Buffer Stock**: The reserve stock held to guard against a stock out due to usage or lead time exceeding the average.

7. **Inventory Carrying Costs**: They are also known as stock holding cost or storage cost. They are real out of pocket costs associated with carrying inventory on hand.
8. **Stock Out Costs:** The stock out costs refer to costs incurred by a firm as a result of running out of some of stock items. They include contribution margin or lost sales, loss of customer goodwill and confidence, and extra purchasing and transportation costs.

9. **Safety Stock:** This can be defined as the extra inventory held as a hedge or protection against possibility of a stock out. In other words, it is a stock allowance to cover errors in forecasting the lead time or the demand during the lead time. By carrying a safety stock, the firm ensures that there is protection against the establishment becoming idle because of shortage of raw materials inventory. Safety stock immunizes the Inventory Control Department against the risk of stock out.

10. **Maximum Stock Level:** The maximum stock level is the level above which stocks should not normally be allowed to rise. It is set by:

    a. The rates of sales of the finished goods.
    b. Lead time.
    c. Re-order level of inventory
    d. Re-order quantity of inventory
    e. The capital available and the opportunity to acquire items at low prices.
    f. The cost of storage and availability of storage space.
    g. The risk of obsolescence and deterioration.
    h. Insurance cost.
11. **Minimum Stock Level:** This is the level below which the stock must not normally fall. If stocks go below the level, then there is the possibility of shortage of supplies which may lead to production stoppage. It is set after considering two factors.

   a. The rate of production of goods during the lead time.
   b. Lead time which is the same thing as the period necessary to obtain delivery of raw materials.

12. **Re-order Quantity:** The re-order quantity is the quantity that a firm orders any time it wants to replenish its stock. It is important for an establishment to know not only the size of inventory to order at a time, but also when the inventory is due for replenishment.

13. **Re-order Level:** The level of stock at which a further replenishment order should be placed. The re-order level is dependent upon the lead time and the demand during the lead time.
REFERENCES:


CHAPTER TWO
REVIEW OF RELATED LITERATURE

INTRODUCTION:
Naturally, no two individuals think alike on an issue, but that firms profitability depends on good inventory management is one issue where there seems to be a unanimous agreement amongst business managers. This is what has happened here, as an attempt is made to review and examine past and present work dealing with the management of inventory and the development of a suitable economic order quantity model for manufacturing companies.

The issue of inventory management has evoked a lot of debates in public discussions, workshops and symposia, both at the local, national and international levels, amongst public institutions and company’s policy makers, organizations as well as academicians. Various efforts have been made by the management of new companies through schemes, incentives etc for the organization of workshops in the area of inventory management.

A survey of most writings in inventory management portrays some common and interesting features. Many of such writings deal largely with the problems associated with inventory management; yet others concentrate on the best model for managing inventory. However,
the experience and knowledge gained from these writings coupled with the analysis of empirical data, will form the basis of this research.

This literature review, relied heavily on textbooks, accounting magazines, some past unpublished works and expert views on important issues that are relevant to the objectives of this study. It is sub-divided under the following headings:

2.1 Historical sketch of inventory problems
2.2 Specification of an inventory system
2.3 Importance of Inventory
2.4 Inventory management problem
2.5 The Economic Order Quantity
2.6 Evaluation of economic lot size formula
2.7 Another economic lot size formula
2.8 Quantity discounts
2.9 Inventory control under risk and uncertainty

2.1 HISTORICAL SKETCH OF INVENTORY PROBLEMS:
Although inventory problems are as old as history itself, it has only been since the turn of the century that any attempts has been made to employ analytical techniques in studying these
The initial impetus for the use of mathematical methods in inventory analysis seems to have been supplied by the simultaneous growth of the manufacturing industries and the various branches of engineering, especially industrial engineering. The real need for analysis was first recognized in industries that had a combination of production scheduling problems and inventory problems i.e. in situations in which items were produced in lots - the cost of set up being fairly high - and then stored at a factory warehouse.

The earliest derivation of what is often called the 'Sample lot size formula' was obtained by Ford Harris of the Westinghouse Corporation in 1915. This same formula has been developed, apparently independently, by many individuals, since then it is often referred to as the 'wisdom formula' since it was also derived by H. Wilson as an integral part of the inventory control scheme which he sold to many organizations. The first full length book to deal with inventory problems was that of F. H. Raymond written while he was at M.I.T. It contains no theory or derivations, and only attempts to explain how various extensions of the simple lot size model can be used in practice.

It was not until after World War II, when the management sciences and operations research emerged, that detailed attention was focused on the stochastic nature of inventory problems. Prior to that, the systems had been treated as if they were deterministic except for a few isolated cases, such as the work of Wilson, where some attempts were made to include
probable considerations. During the war, a useful stochastic model was developed. Shortly thereafter, a stochastic version of the simple lot size model was developed by Whitin\footnote{3}, whose book, published in 1953, was the first book in English which dealt in any detail with stochastic inventory models.

As has been noted above, the original interest in using analytical techniques to solve inventory problems arose in industry where engineers were seeking solutions to practical problems. It is interesting to observe that economists were not the first to take an active interest in inventory problems even though inventories play a crucial role in the study of dynamic economic behavior. The reasons for this lack of interest lies in the fact that economists were concentrating their attention mainly on static equilibrium models. Recently, however, some economists and mathematicians have taken an interest in inventory models. They have not been especially concerned with immediate practical applications; instead they have been interested in the models because of their mathematical properties and economic interpretations. The paper by the economists Arrow, Harris, and Marschak\footnote{4} was one of the first to provide a rigorous mathematical analysis of a simple type of inventory model. It was followed by the often quoted and rather abstract papers by the mathematicians, Dvoretzky, Kiefer, and Wolfowitz\footnote{5}; since then a number of papers by mathematicians have appeared. A recent full length book devoted to the mathematical properties of inventory system is that
of Arrow, Karlin and Scarf. At the present time, work on inventory problems is being carried on at many different levels. At one extreme a considerable amount of work is concerned strictly with practical applications, while at the other extreme, work is being done on the abstract mathematical properties of inventory models without regard to possible practical applications.

2.2 SPECIFICATION OF AN INVENTORY SYSTEM:

According to Kostas, the inventory system is basically an input-output system. In order to arrive at the best inventory policy i.e. the best decision rules for when and how much to order, it is necessary to have a clear picture of the inventory system.
Regardless of the items held in stock, an inventory system requires specification of the components shown in the input-output representation of figure 2.1; these include:

1. The demand pattern for items held in stock (i.e. the system output). The demand side is the most critical yet uncontrollable components, for without demand, there would be no need for maintaining inventory.

2. The replenishment pattern (the system input). The replenishment side represents the controllable component of the physical flow through an inventory system.

3. The operating constraints: Generally, the range of options for making the decisions to operate an inventory system is limited by a number of restrictions relating to limited warehouse, limited budget available for inventory etc. Occasionally, replenishment may be limited by the suppliers policy to certain number of quantities. Unless such constraints are taken into account explicitly it is difficult to arrive at an optimum feasible inventory policy.
4. The decision-making mechanism concerning inventory replenishment. We have seen that demand for the items is necessary in inventory and is usually uncontrollable, being generated externally. Decisions relating to the management of the inventory system must therefore be made with reference to the replenishment side. The decision-making mechanism is designed to respond to (a) when inventory must be replenished \( t \) and (b) how much must be ordered (or produced internally) for each replenishment \( Q \).

These two questions are answered in one of two ways:

a. Replenishment may take place at a fixed time interval \( t = \text{constant} \), by placing orders of variable sizes \( Q = \text{variable} \) to bring inventory to a desired level.

b. Management may order a fixed amount \( Q = \text{variable} \) when inventory drops to a certain re-order level, an event which may happen at variable cycle times \( t = \text{variable} \). Our discussion assumes that for an operating system, the decision of what to hold on stock has already been made.

Kerner supported Kostas when he asserted that the decision rules governing delivery from stock fall into four categories, based upon two criteria:

a. Can order be placed at any time or periodically?

b. Does the order quantity for a given article depend partly upon the economic stock on hand at the time order is placed.
These criteria can be represented in the form of a table as shown in table 2.1. below.

5. The total (or incremental) inventory cost that reflects system performance. The result of operating an inventory system with decision rules is reflected in the total (or incremental) inventory cost, necessary to satisfy forecasted demand under given restrictions.

Table 2.1 ORDER QUANTITY DETERMINANT

<table>
<thead>
<tr>
<th></th>
<th>Order quantity independent of stock at time of ordering</th>
<th>Order quantity dependent on stock at time of ordering.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continued possibility of ordering</strong></td>
<td>(B,Q) - Method</td>
<td>(B,S) - Method</td>
</tr>
<tr>
<td><strong>Periodic possibility of ordering</strong></td>
<td>(S,Q) - Method where the quantity covers consumption for more than one interval.</td>
<td>(s,S) - Method and various variant therefore.</td>
</tr>
<tr>
<td></td>
<td>The 'run-out list' method.</td>
<td>&quot;Periodic replenishment as a special case of the (s,S) method.</td>
</tr>
</tbody>
</table>
Any system of production and inventory control must be based upon a preliminary study of the relationship between the factors: DEMAND - INVENTORY - PRODUCTION. This view is shared by Van and Monhemius. According to them, each of these factors has certain characteristic feature - "Demand is characterized by trend, cyclic movements and random variation. Furthermore, it is in principle impossible to forecast the demand exactly, since in the event such forecast are invariably found to contain some element of error".

Inventory has two important aspects, since it can be used effectively as a buffer to reduce the overall cost of stock holding and production. The production (or supply) process is characterized by the rate of production, the speed with which this is done and by the costs associated with such variations. These characteristics are important in that they have a great deal of influence upon the stock build-up and the service on delivery.

The relationship between production level and stock (finished goods and raw materials) level in fig. 2.2 is derived from a proposition in control theory, where the term proportional control is used for cases of this kind.
Fig. 2.2 Relationship between production level P and stock i for finished goods and raw materials inventory.

From fig 2.2 (a), there is an inverse relationship between production level and finished goods; hence as finished goods inventory increases production level is reduced and vice versa. On the other hand, there is a direct relationship between production level and the raw material inventory; hence as the stock of raw materials increase, production level also increases.

There are great differences between existing inventory systems. According to Whitin, "they differ in sizes and complexity, in the types of items they carry, in the costs associated with operating the system, in the nature of the information available to decision makers at any
given point in time. To him, all these differences can be considered to reflect variation in the structure of the inventory system. These variations can have an important bearing on the type of operating doctrine that should be used in controlling the system. By an operating doctrine, we simply mean the rule which tells us when to order and how much to order.

It is desirable to spell out in somewhat more detail the differences which can exist in inventory system - either real world system or mathematical model hence the echelon structure of inventory system.

Fig. 2.3 MULTI ECHelon INVENTORY SYSTEM
Source: Inventory Management decision - By Whitin

An item may be stocked in an inventory system at only a single physical location, or it may
be stocked at many locations. For example, if the organization under consideration is the U.S Air Force supply system, a spare part for a certain type of aircraft may be stocked at over 100 bases and repairs facilities all over the world. If the organization under study is a single privately owned lumber yard, the entire stock of the organization will be held at this lumber yard.

When there is more than a single stocking point, there exists the possibility for many form of inventory systems, the simplest forms of interaction involves one stocking point which serves as a warehouse for one or more other stocking points. This leads to what is referred to as a multiechelon inventory system - refer to 2.3. The arrows indicate the normal pattern for the flow of goods through the system. This might be referred to as a four echelon system since there are four levels. Each level is called an echelon. In the system, customer demands occur only at the stocking point in level 1. These stocking points have their stocks replenished by shipments from warehouses at level 2, which in turn receives replenishment for their stock from level 3 etc. This is only one type of multiechelon system. In other cases, customer demands might occur at all levels, or stocking points at any level might not only receive shipments from the next highest level but might also get replenishment from any higher level or from the source.
2.3.1 IMPORTANCE OF INVENTORY:

There is a unanimous agreement that inventories play a vital role in the life of any organization by most scholars. Some see inventory as what an organization cannot do without. Because of their indispensable functions, inventories have been considered as important to an organization as blood is to the human body; furthermore, the sizable investment in inventories, most apparent in manufacturing activities warrants particular care in their planning and control; Howard and Baltz supported this fact when they assert that inventory is the lifeblood of production and sales activities; if it were improperly managed, production processes would collapse.*

Inventory also influences the working capital needs of the firm from the financial standpoint. Funds tied up in inventory are one step further removed from cash in the working capital cycle. Since inventory is farther removed from cash than receivables are, it needs financial attention if the firm’s liquidity is to be maintained.

According to Hadley and Whitin,11 the fundamental reason for maintaining inventory is that it is either physically impossible or economically unsound to have goods arrive in a given system precisely when demands for them occur. To Samuel and Wilkes,12 there are two main functions of stock. Firstly, to enable production (or ordering as the case may be) to
take place in economic quantities, and secondly, to enable orders to be filled promptly from stock. In both cases, production is shielded from the day-to-day vagaries of demand and supply, and can take place at a rate and to a total level which if not optimum is at least practical. As an ideal, inventory theory would seek to trade-off these benefits optimally against the costs.

To Martin and David, there are three general motives for holding inventories;

1. The transaction motive which emphasizes the need to maintain inventories to facilitate smooth production and sales operation.
2. The precautionary motive which necessitates holding of inventories to guard against the risk of unpredictable changes in demand and supply and other forces.
3. The speculative motive which influences the decision to increase or decrease inventory levels to take advantage of price fluctuation.

Amey and Egito shared the view with Martin and David when they agreed that firms hold inventories for transaction, precautionary and speculative motives. They went on to assert that management should be aware that optimum stock levels do depend to a certain extent on expected price movement.
To Richard et al., inventories add an operating flexibility that would not otherwise exist. In manufacturing, work-in-progress inventories are an absolute necessity unless each individual part is to be carried from machine to machine and those machines set up to produce that single part. They enumerated the importance of inventories as:

a. filling the gap between supply and demand
b. making possible lower production costs
c. allowing organization to cope with perishable materials
d. storing labor.

2.4 INVENTORY MANAGEMENT PROBLEM:
According to Kostas, the inventory problem involves the formulation of decision rules that answer two important questions:

a. When is it necessary to place an order (or set up for production) to replenish inventory?

b. How much is to be ordered (or produced) for each replenishment?

According to him, the decision rules must aim at satisfying anticipated demand at minimum cost or maximum profit. Hadley and Whitin, reasoned along the same line. To them, "the two fundamental questions that must be answered in controlling the inventory of any physical
good are when to replenish the inventory and how much to order for replenishment. Essentially every decision which is made in controlling inventories in any organization regardless of how complicated the inventory supply may be, is in one way or another associated with the question of when to order and how much to order.

Kim classified inventory problem into two: deterministic and probabilistic. Suppose that the demand for an item during a specified period is known in advance and the lead time is either zero or a known constant, then we have what is called a deterministic inventory management problem. It is true that those assumed conditions do not quite obtain in most actual inventory management situations. Nevertheless, there is a class of inventory management problem for which these assumptions are quite adequate for example when the item in question is used as raw material for a stable production process. Furthermore, it has been found in practice that deterministic inventory models are quite helpful in controlling the stock of many regularly used low-value items.

In many situations our assumptions of known quantity, and zero or constant lead time do not hold. Often the demand and lead time are variable quantities, so that we know at best only their probability distribution. If we assume that both demand and lead time are random variables, the analysis of inventory management problem will become very complex. It has been found however, that reasonably good situations can be obtained for many practical
inventory management problems by assuming that the lead time is a known constant.

2.5 THE ECONOMIC ORDER QUANTITY:

The derivation of the basic Economic Order Quantity (EOQ) model is quite easy in a situation where both the amount of product needed during a given period and the lead time for stock replenishment are known. If the time that elapses between the placement of an order and its receipt in inventory is 10 days and daily usage rate is 20 units, the order point according to Flippo and Musinger [17] should be set at any inventory level of 200 units. In other words, when the stock is reduced to 200 units, an order should be placed. The unit on hand will meet daily demand until the order is received. When lead time is not known with certainty, it can be treated as a random variable and an appropriate decision rule can be developed to specify the re-order level of stock.

Fig. 2.4. Economic Order Quantity
To determine the economic order quantity given the fixed demand assumption, we can evaluate the following general model:

Let:

\[ D = \text{Total annual demand in unit} \]
\[ Q = \text{Economic order quantity in unit} \]
\[ D/Q = \text{Number of orders placed and received during the year} \]
\[ Q/2 = \text{Average inventory} \]
\[ C_o = \text{Cost of placing an order} \]
\[ C_c = \text{Carrying cost per unit of inventory during the year} \]

Total inventory cost is defined as the sum of ordering cost and carrying cost. To define total inventory cost in terms of the controllable variable order quantity (Q), we must express both types of cost in terms of quantity. Total ordering cost can be obtained by multiplying the number of orders \( D/Q \) by the cost of placing an order \( C_o \), hence:

\[
\text{Annual ordering cost} = D/Q \cdot C_o
\]

Similarly, annual carrying cost can be found by multiplying the carrying cost per unit of inventory by the average inventory:

\[
\text{Annual carrying cost} = C_c \cdot (Q/2)
\]
inventory (Cc) by the average number of units in stock (Q/2). This expression for average inventory assumes a constant rate of demand throughout the year.

Annual carrying cost = D/2 Cc

Combining the two components, we obtain total inventory cost for the period:

\[ TC = \frac{D}{Q} C_C + \frac{Q}{2} C_c \]

Recall that this variable can be manipulated by management to yield the minimum cost for inventory during a specific time period. From Fig. 2.4 we know that optimum solution is that quantity (Q*) that can therefore be obtained by setting the equation for ordering cost equals to the equation for carrying cost and solving for Q: hence:

Annual carrying cost = annual carrying cost

\[ C_c \frac{Q}{2} = \frac{DCo}{Q} \]

\[ C_c \frac{Q^2}{2} = 2DCo \]

\[ Q = \pm \sqrt{\frac{2DCo}{Cc}} \]

The optimum solution is also obtained by differentiating the total cost function to obtain an equation that expresses the rate of change in total cost with respect to changes in quantity. When the first derivative of the total cost function is set equal to zero, the economic order quantity is obtained by solving for Q.

The operation is as follows in three steps:
1. Take the first derivatives of total cost function:

\[ TC = \frac{D}{Q} C_0 + \frac{Q}{2} C_C \]

\[ \frac{dT(C)}{dQ} = -\frac{D C_0}{Q^2} + \frac{C_C}{2} \]

2. Set the first derivative equal to zero, and solve for \( Q \):

\[ -\frac{D C_0 Q^2}{2} + \frac{C_C}{2} = 0 \]

\[ Q = \sqrt{\frac{2 C_C}{C_0}} \]

3. Test to determine the solution is a minimum.

\[ \frac{d^2(TC)}{dQ^2} = \frac{2 D C_0}{Q^3} \]

Given the assumption of fixed demand, the general formula can be utilized in finding the economic order quantity \( (Q^*) \), which is equal to the square root of 2 times demand \( (D) \) times ordering cost \( (C_0) \) divided by carrying cost \( (C_C) \).

For example, assume the following problem:

\[ D = 3000 \text{ units per annum} \]

\[ C_0 = N 30 \]

\[ C_C = N 2 \text{ per unit per year}. \]
To obtain the Economic order quantity, we evaluate the basic equation using the values for demand, ordering cost and carrying cost.

\[ Q = \sqrt{\frac{2DC}{C_C}} \]

\[ Q = \sqrt{\frac{2 \times 3000 \times 30}{2}} = \sqrt{9000} \]

\[ Q = 300 \text{ units} \]

The optimum order quantity is 300 units. Observe that a total of ten orders will be placed.

\[ D = \frac{3000}{300} = 10 \]

\[ Q^* = 300 \]

For a total cost due to ordering of 300, average inventory will be 150 units.

\[ Q^* = \frac{300}{2} = 150 \]

An inventory carrying cost will equal N300. Therefore, total inventory cost will be equal to N600.
2.6 EVALUATION OF ECONOMIC LOT SIZE FORMULA:

In any attempt to apply the economic lot size approach to inventory control, the firm will experience such things as rates of use, ordering cost, carrying costs, and lead times. According to Raymond, these estimates are not easily made, and a risk of error always exists. But if an appropriate economic lot size formula can be derived, the company must use either the formula or judgement. However, when a company stores thousands of different items, as many do, one would be reluctant to recommend that order quantities, for what may be the majority of these items controlled by a semiautomatic routine such as the economic lot size approach. While it is true that some of the estimates may prove to be relatively poor, it is possible that they will yield approximate result which, for all practical purposes, will be satisfactory.

It should also be recognized that the application of economic lot size formulas may serve to introduce undesirable fluctuations in the production schedule. For example, the demand for a manufactured part might be fairly uniform. This suggests, the use of an economic lot size formula that will yield an order quantity which, if adhered to, will create peaks in the production schedule for this item. And as we know, there are costs to be associated with the resultant fluctuations. Unfortunately, there is no way of incorporating these costs in the economic lot size calculation itself. Of course, it is possible that when the fluctuating
production schedule for many such parts are combined, the result will be a fairly level composite schedule. But if not, the company might find that the most economical production schedule is not the one based on the result of economic lot size computations.

Finally, there are many cases in which the economic lot size approach to inventory control must be abandoned for the simple reason that an appropriate formula cannot be derived. Such formulas are possible only if the forces are at par, such as demand, unit prices, procurement time, carrying costs, and ordering costs, are of a nature which permits the development of a mathematical expression which serves to describe the total cost function. Yet, in the real world, the nature of the factors relevant to the inventory problem is such that their combined effect cannot always be described by means of a mathematical model.

Consequently, an appropriate formula cannot be derived. When this is true, many companies adopt rules of thumb to arrive at order quantities for certain raw materials, component parts, and finished products. This is to say that they conclude that the proper lot size for one class of item is a one-month supply, for another a three-month supply, for still another a six-month supply, and so on. Very often, the only way to arrive at such ordering rules is on the basis of judgement and intuition. But on other occasions, there is an alternative. In brief, it requires that more than one rule of thumb be considered and that the most economical of
Numerous other inventory-control issues can be treated with variations on the basic model. For example, the model can be modified to accommodate a situation in which units are received into stock continuously rather than in a batch of size Q. This would apply in the management of inventory for a manufacturer who sets up to produce a batch of component parts that are used as inputs for some other phase of the operation. Rather than incurring order costs, the manufacturer incurs cost of setting up the production facility.

A few of these variations to the general economic order quantity will be analyzed.

2.7 ANOTHER ECONOMIC LOT SIZE FORMULA:

If the assumptions that underlie the economic lot size formula we have just developed are not valid, the formula cannot be used. However, other formulas have been derived for other set of conditions.

In some cases, the entire lot is not delivered at one time but at a uniform rate over a period of time. For example, it may be that a firm's stockroom will submit a manufacturing requisition for 500 units of a given item. The shop may go into production of this item a
week later. When it does, it may produce the item at a rate of 100 units a day for five days. However, rather than temporarily store the completed units until the entire order is completed, the shop may arrange to have 100 units delivered to the stockroom each day. As a result, the delivery would take place over a period of five days. During this period, there would of course, be some demand for the item. If the rate of use is, say, 20 units per day, the inventory will be built up at a rate of 100 minus 20, or 80, units per day for five days. This can be represented graphically.

![Diagram of inventory control system](image)

**Fig. 2.5** The maximum-minimum system of inventory control when delivery occurs over a period of time.
According to Mayer, the model above has the following assumptions: the minimum inventory is to be zero. Second, the rate of use is assumed to be constant. Third, it is assumed that the item will be received at a uniform rate over some period of time.

Finally, an implied assumptions that the procurement time is constant and that the rate of use and the rate of delivery can be predicted with a fair degree of accuracy. Hence assuming:

\[ R = \text{delivery rate} \]
\[ C = \text{consumption rate} \]
\[ V = \text{direct production costs} \]
\[ B = \text{ordering cost} \]
\[ E = \text{carrying cost and } E_0 = 3000 = \text{E.O.Q under consideration.} \]

Therefore:

Average daily ordering cost \[= \frac{C}{2} (B) \times X \]

Maximum inventory \[= \frac{X (R-C)}{2} = X (1-E) \times R \]
Average inventory \( = \frac{X}{2} (1-C) R \)

Average daily carrying cost \( = \frac{X}{2} (1-C) (E) \)

Total average daily cost \( = C \cdot B + \frac{X}{2} (1-C) (E) \)

The first item in the total average daily cost equation represents the average daily ordering cost; the second term represents the average daily carrying cost. As in the earlier case we had considered, it has been found that the nature of this total cost function is such that the total average daily cost \( Y \) will be a minimum for that value of the lot size \( X \) at which the average daily ordering cost is equal to the average daily carrying cost. This permits us to say that the total cost will be minimum when:

\[ CB = \frac{X}{2} (1-C) (E) \]

When we solve this expression for the unknown lot size \( X \), we obtain:
with the use of this formulae, we can substitute the data available under the assumed conditions.

2.8 QUANTITY DISCOUNTS:

One of the restrictions on the use of the general economic lot size formula is that, in the case of a purchased item, the unit purchased price is constant or that, in the case of a manufactured item, the direct unit manufacturing cost is constant. When this condition is not satisfied, it becomes necessary to modify the way in which the formulas are used to obtain the economic order quantity.

In brief, when quantity discounts are available, the analysis begins with a determination of the economic lot size for cash price level. For a given price level, this lot size is ascertained by first substituting the corresponding carrying cost in the economic lot size formula. If the calculated lot size is less than or equal to the minimum quantity that must be purchased to obtain that price, this minimum quantity is the economic lot size at the price; see fig. 2.6.
But if the calculated lot size exceeds this minimum quantity, the calculated lot size is the economic lot size at that price. Once the economic lot size for each price level has been determined, the firm can go on to compute the total cost generated by each of the alternatives and identify the one that yields the minimum cost.

![Diagram](image.png)

Fig. 2.6 - Total cost curve generated by two unit prices $P$.

Although this procedure has been explained with an example involving a purchased item, the same approach would be employed when the unit cost of a manufactured item decreases when the lot size reaches a certain value. This is not too common, but it can occur when a larger
Lot size calls for a change in the method of production with the result that unit direct manufacturing costs decrease to some new level.

2.9 INVENTORY CONTROL UNDER RISK AND UNCERTAINTY:

According to Charles, even when demand is not known for certain, the basic economic order quantity model often can be used to obtain a reasonably accurate estimate of the optimal order or batch size. As has been observed, the conditions for decision making under uncertainty frequently do not exist. The rudiment of one’s approach to the inventory decision under conditions where demand is not known are discussed briefly at this point. The intention here is only to illustrate one approach and not to present a comprehensive treatment of the issue and the models that can be used to facilitate inventory control decision under condition of uncertainty.

The method to be illustrated here is the incremental or marginal approach. In this approach, we investigate the effect a unit increase in order size will have on profit. If the incremental unit is sold, profit will be increased. We can refer to this increase as marginal profit (MP).

If the additional unit is not sold, we will sustain a loss equal to the carrying cost plus any
reduction in the value of the unit not included in the computation of carrying cost. Thus, a marginal loss (ML) can potentially result from adding a unit to the order quantity.

Net profit will be maximized when the margin from adding an additional unit is equal to the marginal loss. To effect this relationship, we must have some indication of the probability that the additional unit will be used (SOD). Let the probability of using one or more additional units be represented by P. Note that because the unit is either used or not used (it is sold or it remains in inventory), the probability that one or more additional units are not used is (1-P).

The incremental profit that can be expected from stocking an additional unit is therefore the probability that it will be used times the marginal profit accruing from its use (F(MP)). Likewise, the expected incremental loss caused by the decisions to stock an additional unit is the probability that it will not be used multiplied by the marginal loss (1-P)(ML).

So long as the expected incremental (marginal) profit exceeds expected incremental loss, the order size should be increased. However, as the order size increases, the probability of using one or more additional units will decline. Therefore, an order level will eventually be reached where the expected increases in profits will equal the expected increase in cost.
Symbolically, this point is represented as follows:

\[ P(M) = (1-P)(ML). \]

Observe that if \( P(MP) \) is greater than \( (1-P)(ML) \), additional units should be ordered, and if \( P(MP) \) is less than \( (1-P)(ML) \), the order size should be reduced.

The optimum order size can be defined by solving this maximizing equation for \( P \) to determine the break-even probability of using one or more additional unit.

\[
\begin{align*}
P(MP) &= (1-P)ML \\
P(MP) &= (ML) \times P(ML) \\
P(ML) + P(MP) &= ML \\
P^* &= \frac{ML}{MP+ML}
\end{align*}
\]

\( P^* \) is the break-even or critical probability of using one or more additional units. If the probability of using an additional unit is greater than \( P^* \), the order quantity should be increased by one unit. If the probability of using one or more additional units is less than \( P^* \), the order quantity should not be increased. The optimum order quantity is defined as the point where the probability of using one or more additional units is equal to \( P^* \).

To illustrate this approach, assume that a retailer is uncertain with respect to the number of units of a product that will be sold during the year. Further assume that each unit sold yields...
a profit of N100 (MP = 100) and the cost of
100
unit stocked but not sold is N50 (ML = 50).

Evaluating our equation for $P^*$, we obtain:

$$P^* = \frac{50}{100+50} = \frac{50}{150} = 0.33$$

The break-even probability is 0.33, hence, the retailer will increase the order size to match the level of demand at which there is a one-in-three chances of selling an additional unit.
REFERENCES:


16 Kim; "Economic order quantity" Quantitative analysis for Managerial decision, Addison-Wesley publishing company, 1976, pp. 71-93


18 Raymond, R. Mayer; "Inventory Control under certainty". Production and Operation Management, 1975.
Harold Bierman, jr; Charles "Quantitative", *Analysis for Business Decision*, 3rd
Hansman: 10 and 12).
3.1 DEFINITION OF AREA AND POPULATION OF STUDY

It would have been best to conduct this research in all the manufacturing companies in the country in order to pursue excellence and at the same time achieve the best possible result. However, such a large population will pose some problems. As a result of the attendant financial, time, and other constraints, the researcher has narrowed his investigation to only one manufacturing company in Enugu State: The Nigeria Cement Company Nkalagu. This is not to say that all the available information came from the Nigeria Cement Company, Nkalagu, as questionnaires were sent to other manufacturing companies. Nigeria Cement Company, Nkalagu is the case study company and hence received about 57% of the total questionnaire distributed for the study.

3.2 PROCEDURE FOR DATA COLLECTION AND ANALYSIS:

The data used for this analysis were collected from primary and secondary sources of information.
3.2.1 PRIMARY SOURCES:

The data were collected from the works accountant, production managers, marketing managers, sales executives and other people from the selected companies. It was facilitated through the administration of questionnaires, observation and oral interview. These instruments and other means of data collection were found appropriate for this study because they helped to get the view of the literate members of the companies in concise form. Secondly, in a research work of this nature, where data collected will be completely analyzed, the researcher deemed it very wise to use more of questionnaires in order to avoid gathering a mass of data that may have very little or no relevance to the subject matter under study. Also, considering the kind of respondent being addressed, it was found most attractive because it does not require elaborate answer. Most of the questions are simple "yes" or "no" type. Yet others are such that require the respondent to rate a statement into options; such as "strongly agreed", "undecided", "disagree" etc. The questionnaire, generally utilizes a printed format that systematically specifies all the questions as well as the sequence to which they are to be presented. All these steps were made for easier analysis of data and result.

3.2.2 SECONDARY SOURCES:

The result of existing literatures on inventory management aided immeasurably in guiding the researcher during the study. Other secondary sources of data include:
3.3 PILOT SURVEY:
A pilot survey was carried out to eliminate all ambiguous questions from the survey instrument used. The pilot study was equally carried out because the level of understanding differs amongst the respondents. The sample for this pre-testing was drawn from the companies reviewed. The pilot survey enabled the researcher to test the respondents' attitudes to the questions and terms used.

3.4 SAMPLE TECHNIQUES:
For easier collection of data, one of the manufacturing companies studied was used as a case study, since all others could not be covered as a result of time and financial constraints. The observations and results got from the company were used to generalize and predict what is
obtainable in all other manufacturing companies, especially in the areas of their inventory management.

3.5 PROCEDURE AND TECHNIQUES FOR DATA ANALYSIS:

Majority of the questions in the questionnaire have relevance to the hypothesis and research questions raised earlier. Data from the various questions were categorized according to their relevance to the verification of the hypothesis of this research project and realization of the stated objectives. The data were analyzed using simple statistical (e.g., mean, chi-square, regression and correlation co-efficient) and mathematical techniques. The economic order quantity of the company was calculated after estimating some figures, as some of the required figures were not in existence in the company's books.

However, from the available data, relationship between certain variables were determined and analyzed. The relationship that existed between variables have been tested in the hypothesis for validity and reliability.

Data for literature review were obtained from relevant books. Most quantitative data were drawn from the accounts department of the Nigeria Cement Company, Nkalagu. There are
a lot of materials found in the inventory system of the Nigerian Cement Company, Nkalagu (see Appendix 3:1), but only gypsum and coal were selected for the necessary analysis and calculations. The reason is that the other major raw materials like limestone is located at the factory site, hence management do not make such inventory plan for it. Gypsum, on the other hand is imported from abroad and as a result, it becomes very necessary to make sound inventory plan for it.

APPENDIX 3:1

THE PRACTICE OF INVENTORY MANAGEMENT IN THE NIGERIAN CEMENT COMPANY, NKalagu

NATURE AND PURPOSE OF THE ORGANIZATION:
The Nigerian Cement Company, Nkalagu was established in 1957 as joint venture between the Federal Government and the then government of Eastern Nigeria. Its corporate objective is the production and sale of cement. It rolled out its first batch of cement in 1959.

NATURE AND SOURCE OF RAW MATERIALS:
The raw materials of the Nigerian Cement Company, Nkalagu are numerous. The sources of supply of the organization’s raw materials fall into two categories, some of the raw materials are sourced locally while others are imported. The major direct material that goes
into cement production is richly deposited at the factory site by nature. This is limestone which is the most important reason why the factory is located at Nkalagu. Apart from limestone, 75% (in terms of cost) of the other materials that go into cement production have been sourced from foreign countries. This is represented by gypsum which has been the most expensive of all the materials that go into the production of cement.

Because of the prohibitive cost of the foreign input materials - Gypsum, there has been this call by the management of the company, especially to the Federal Government to allow them produce most of their materials locally.

The major raw materials used in the production of cement are limestone, gypsum, coal, and others. Presently, gypsum has not been discovered in commercial quantities anywhere in the country, hence it is imported into the country.

The sourcing of raw materials needed for cement production are tabulated below:

<table>
<thead>
<tr>
<th>RAW MATERIALS</th>
<th>LOCAL</th>
<th>IMPORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Gypsum</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Coal</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1: Sources of raw materials

Source: From the Company’s published gazettes.
RAW MATERIALS CONTROL AND MANAGEMENT:
The need for management and control of raw materials arises in view of the fact that it is highly important to ensure that the objectives of the organization as far as management of materials is concerned are achieved. One of the major objectives of the management is to produce cement at the least possible cost while earning the highest possible return on investment. To achieve this laudable objective, there is the need for an effective, control system, starting from the procurement of raw materials to the final stage of production.

The stores department of the company is charged with the responsibility of managing and controlling the raw materials and the finished goods inventory to ensure efficient, effective and adequate use in order to minimize wastage that lead to a reduction in the profit of the organization. To this effect, the following internal control measures are adopted:

a. Provision of the control of stocks of materials by establishing maximum and minimum quantity limits through and independent recording in stock ledger control accounts as well as continuous recording.

b. Physical stock checks in order to determine the exact quantity of stock on hand and subsequently, reconcile same with the stock accounts.
c. Continuous stock taking: This form of stock taking goes a long way in placing greater moral checks on the staff of the store department with regards to stealing or mis-appropriation of goods or products.

d. All stock issues to Factory and stores are supported by duly authorized requisitions.

Also, in order to minimize waste, the management of the Nigerian Cement Company, Nkalagu ensures that only the exact quantity of raw materials are supplied to the factory on a daily basis. The method of issuing the raw materials to the production department, is on the basis of last-in-first-out (LIFO). None of the raw materials is perishable hence there is no need for special storage arrangement.

RAW MATERIAL PROCUREMENT AND DISTRIBUTION:

The board of directors of the company is the principle policy making body. The board is headed by the appointed chairman.

The authority for purchasing and inventory control is in the purchasing divisions; which has the store as one of its units. This function is delegated to the purchasing manager, and is performed after receiving request from each of the departmental managers. The accounting department ensures that payments for raw materials purchased are made and necessary records kept. In the Nigerian Cement Company, there is a laid down procedure for stock
procurement and handling. This is depicted in the chart below:

Production department → stores → purchasing

Accounting dept. ← Supplier

Goods received

Source: From the company

PRODUCTION DEPARTMENT:

The department estimates its total consumption of raw materials for a period of one year and places an order to the stores department. This department raises the requisition, and receives materials finally as required.

STORE DEPARTMENT:

The stores department is responsible for keeping all the necessary records as regards raw materials, such as stock re-order level, safety stock, store ledger card, bin card etc. In the company, the store plays a dual role in that it receives orders from the production department as the need arises.

68
The stock re-order level quantities of Nigerian Cement Company are provided on the next page.

Table 3:1:2: MATERIALS RE-ORDER LEVEL

<table>
<thead>
<tr>
<th>RAW MATERIALS</th>
<th>RE-ORDER LEVEL QUANTITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime Stone</td>
<td>No re-order level</td>
</tr>
<tr>
<td>Coal</td>
<td>- do -</td>
</tr>
<tr>
<td>Gypsum</td>
<td>40 days stock</td>
</tr>
<tr>
<td>Others</td>
<td>No re-order level</td>
</tr>
</tbody>
</table>

PURCHASING DEPARTMENT:

The purchasing department is the next stage in the process of getting raw materials. They receive the requisition from the store department stating exactly the right amount of raw materials needed by the production department. It is responsible for all the raw materials purchases of the company. All the materials required during a financial period are purchased in batches. The company adopts this policy to ensure continuous production. The local raw materials are obtained by inviting application for tender from suppliers. It should be mentioned here that two of the major raw materials used by the company have a single
supplier each - the Nigerian Coal Corporation and foreign firm for gypsum. For coal, the quantity of an order cannot be fixed because to a large extent, it depends on the rate of usage which is usually variable and the availability of storage space. This is to say that the company buys coal on a daily basis except when there is no storage space.

RECEPTION AND INSPECTION DEPARTMENT:
On getting to the company, the raw materials purchased are inspected on arrival as regards the quantity and quality. If any circumstances for rejection arises, a "Debit Note" is sent to the suppliers. The production manager certifies the quality and quantity actually received before placing it into the stores. If everything is satisfactory to them, they issue out a goods received note which goes to the accounts department, which then issues out a cheque for payment to the suppliers.
4.1 DATA PRESENTATION

In addition to other sources of data mentioned earlier, this study made use of questionnaires. In this chapter, the data collected from the respondents regarding the basic issue involved in the research work are presented and analyzed.

The analysis starts by presenting the background information about the respondents. This preliminary or background information is considered necessary as respondents depended on such things as the position/office of the respondents in the company.

A total of 350 (three hundred and fifty) questionnaires were provided and distributed out of which 332 (three hundred and thirty two) were returned, thus giving a response of 95 percent (%). For a study of this nature, such percentage is very high, thereby indicating the willingness of the respondents to cooperate.

It was however found that 22 (twenty two) out of the 332 questionnaires returned were not properly filled and were therefore consequently rejected. The researcher was left with a total
of 310 (three hundred and ten) questionnaires; representing 89 percent (%) response rate.

The summary of the response rate can be found in table 4.1 below:

Table 4.1 QUESTIONNAIRE RESPONSE RATE

<table>
<thead>
<tr>
<th>FEATURES OF QUESTIONNAIRE</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaires administered</td>
<td>350</td>
<td>100</td>
</tr>
<tr>
<td>Questionnaires collected/returned</td>
<td>332</td>
<td>95</td>
</tr>
<tr>
<td>Questionnaires rejected</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>Questionnaires used for analysis</td>
<td>310</td>
<td>89</td>
</tr>
</tbody>
</table>

However, the Nigerian Cement Company, Nkalagu is not the only company studied. In fact, respondents for this analysis were selected from four (4) manufacturing companies of which the Nigerian Cement Company, Nkalagu is but one. The fact remains that being the case study of this research project, the Nigerian Cement Company, Nkalagu received 200 (two hundred) out of the 350 (three hundred and fifty) questionnaires administered; which is about 75%.

Details of the companies, the number of questionnaires administered and collected are shown in table 4.2 on the next page.
Table 4.2 COMPANIES AND THE ADMINISTRATION OF QUESTIONNAIRES:

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>NO. ADMINISTERED</th>
<th>NO. RETURNED</th>
<th>NO. REJECTED</th>
<th>NO. USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nig. Cement Co. Nkalagu</td>
<td>200</td>
<td>192</td>
<td>12</td>
<td>180</td>
</tr>
<tr>
<td>Stavico (Nig) Ltd., Orlu</td>
<td>80</td>
<td>77</td>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>Premier Breweries, Onitsha</td>
<td>40</td>
<td>33</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Benue Cement Co., Gboko</td>
<td>30</td>
<td>30</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>350</td>
<td>332</td>
<td>22</td>
<td>310</td>
</tr>
</tbody>
</table>

Questionnaires were not distributed on the basis of the various manufacturing companies but also on the basis of the position/office of the various respondents. This is to emphasize that specified numbers of questionnaires were distributed to specific office/departments in the various companies. This became so necessary since certain information can only be collected from certain departments or offices in a particular company. For example, answers to such questions as the carrying cost of inventory and the profit figure can only be provided by the accounts department or the companies.

Details of the various departments and the number of questionnaires distributed and returned by each are found in Table 4.3 on the next page.
Table 4.3  DEPARTMENTS AND THE DISTRIBUTION OF QUESTIONNAIRES:

<table>
<thead>
<tr>
<th>DEPARTMENTS</th>
<th>NO. ADMINISTERED</th>
<th>NO. RETURNED</th>
<th>NO. REJECTED</th>
<th>NO. USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNTS</td>
<td>70</td>
<td>68</td>
<td>2</td>
<td>66</td>
</tr>
<tr>
<td>MARKETING</td>
<td>70</td>
<td>70</td>
<td>8</td>
<td>62</td>
</tr>
<tr>
<td>PRODUCTION</td>
<td>70</td>
<td>62</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>PURCHASING</td>
<td>70</td>
<td>67</td>
<td>1</td>
<td>66</td>
</tr>
<tr>
<td>OTHERS</td>
<td>70</td>
<td>65</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>TOTAL</td>
<td>350</td>
<td>332</td>
<td>22</td>
<td>310</td>
</tr>
</tbody>
</table>

4.2 ANALYSIS OF PRIMARY DATA (QUESTIONNAIRE)

The analysis and subsequent conclusions reached were based upon the 350 (three hundred and ten) questionnaires that were administered, returned and accepted.

The analysis of the data collected were carried out mathematically and statistically by applying the appropriate formula. The following statistical formula have been applied; the mean, coefficient of correlations. Others include the Chi-square ($X^2$) which is applied at 5%
level of significance ($\alpha = 5\%$), percentages and regression analysis.

Where the questions require the respondent to rank his/her response, the following weights are applied:

<table>
<thead>
<tr>
<th>OPTIONS</th>
<th>WEIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Strongly agreed</td>
<td>5</td>
</tr>
<tr>
<td>b. Agreed</td>
<td>4</td>
</tr>
<tr>
<td>c. Undecided</td>
<td>3</td>
</tr>
<tr>
<td>d. Disagreed</td>
<td>2</td>
</tr>
<tr>
<td>e. Strongly disagreed</td>
<td>1</td>
</tr>
</tbody>
</table>

All the questions posed in the questionnaire are very vital for the research work, but some of them answered the research questions and the hypothesis specifically. The data analysis, hence were mainly an attempt to answer the research questions and the hypothesis already stated during the introduction chapter of this project work.

4.3 RESEARCH QUESTION 1:

Does the company (Nigerian Cement Company, Nkalagu) buy at economic lot sizes?
ANALYSIS OF RESULT:

From the questions 7 and 8 of section B part of the questionnaire it was gathered that the company presently buys 13,000 tons of gypsum at a time. This is for six months agreement, hence an annual requirement of 26,000 tons.

From the accounts department of the company, the following information on the purchase of 13,000 tons of gypsum were gathered.

COST STRUCTURE FOR THE PURCHASE OF 13,000 TONS OF GYPSUM IN FEBRUARY, 1994.

<table>
<thead>
<tr>
<th></th>
<th>$</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase price</td>
<td>$487,5000</td>
<td>$10,725,000</td>
</tr>
<tr>
<td>Freight (FOB)</td>
<td>$101,400</td>
<td>$2,230,800</td>
</tr>
<tr>
<td>Clearing charge</td>
<td>$68,182</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>Transportation</td>
<td>$777,273</td>
<td>$3,900,00</td>
</tr>
<tr>
<td>Total</td>
<td>$834,355</td>
<td>$18,335,800</td>
</tr>
</tbody>
</table>
\[ \text{Cost per ton} = \frac{N18,356,300}{13,000} = N1,412. \]

\( B. \) Insurance premium for 13,000 tons = N41,000

Therefore insurance premium per ton = \( \frac{N41,000}{13,000} = N3.00 \)

C.

<table>
<thead>
<tr>
<th>CARRYING COST/TON</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of capital (* 21% of N1,412)</td>
<td>297</td>
</tr>
<tr>
<td>Insurance cost (N41,000 ÷ 13,000)</td>
<td>3</td>
</tr>
<tr>
<td>Total carrying cost per ton</td>
<td>300</td>
</tr>
</tbody>
</table>

*NB: The 21% cost of capital is the interest as at the 1994 budget."
D.

<table>
<thead>
<tr>
<th>ORDERING COST PER ORDER</th>
<th>($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration/clerical costs</td>
<td>500</td>
</tr>
<tr>
<td>Stationery</td>
<td>300</td>
</tr>
<tr>
<td>Postage</td>
<td>350</td>
</tr>
<tr>
<td>Telephone</td>
<td>900</td>
</tr>
<tr>
<td>Receiving etc</td>
<td>600</td>
</tr>
<tr>
<td>Total ordering cost/order</td>
<td>2,650</td>
</tr>
</tbody>
</table>

**CALCULATION OF THE ECONOMIC QUANTITY USING THE INFORMATION PROVIDED:**

\[
EOQ = \sqrt{\frac{2AO}{C}}
\]

\begin{align*}
A &= \text{Annual requirement} \\
O &= \text{Ordering cost per order} \\
C &= \text{Carrying cost per unit (ton)}
\end{align*}

\[
\text{Therefore } EOQ = \sqrt{\frac{2 \times 26,000 \times 2,650}{300}}
\]

78
678 tons
\[\times\] 1,000 tons

*NB: The approximation to 1,000 tons is because the American Company that sells gypsum does so in lots of 1000’s.

Therefore, from the above calculation, it could be seen that the Nigerian Cement Company, Nkalagu does not buy at the Economic lot size. Instead of buying 1,000 tons of gypsum at a time, they buy 13,000.

4.3 RESEARCH QUESTION 2:
If they (the management) do not buy at the economic lot size, how much are they losing annually?

<table>
<thead>
<tr>
<th></th>
<th>OPTION I</th>
<th>OPTION II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual requirement</td>
<td>26,000</td>
<td>26,000</td>
</tr>
<tr>
<td>Order size</td>
<td>13,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Average inventory</td>
<td>6,500</td>
<td>500</td>
</tr>
<tr>
<td>No. of purchase orders</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>COSTS</td>
<td>OPTION I</td>
<td>OPTION II</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Purchase price of Average Inventory (cost per ton x Av. I)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Capital: 21% of (cost per ton x Av. I)</td>
<td>1,927,380</td>
<td>148,260</td>
</tr>
<tr>
<td>Insurance cost (3.00/ton x Av. I)</td>
<td>19,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Total carrying cost</td>
<td>1,946,880</td>
<td>449,760</td>
</tr>
<tr>
<td>ANNUAL ORDRBRING COST, (2,650 x No. of purchase orders)</td>
<td>5,300</td>
<td>68,900</td>
</tr>
</tbody>
</table>
* Cost per ton = 1,412
* Av. I = Average Inventory

\[
\therefore \text{Annual loss} = \frac{1,952,180}{218,660} \\
\text{Annual loss} = 1,733,520
\]

Therefore, from the analysis, it can be seen that the Nigerian Cement Company, Nkalagu is losing about 1,733,520 (One million seven hundred and thirty three thousand, five hundred and twenty Naira) annually for not buying at the Economic lot size.

The management of the company can stop further loss of this amount by buying in lots of one thousand tons (1000) instead of the current practice of buying 13,000 tons at a time.

However, it should be noted that prior to the regulation of economy by the 1994 budget, that this loss would have been more since the interest then was as high as 70% in some financial
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>Weekly usage</td>
<td>( \text{Weekly usage} = 500 \text{ tons (i.e. 26,000 - 52)} )</td>
</tr>
<tr>
<td>ii.</td>
<td>Lead time</td>
<td>( \text{Lead time} = 2 \text{ weeks} )</td>
</tr>
<tr>
<td>iii.</td>
<td>Lead time usage</td>
<td>( \text{Lead time usage} = 1000 \text{ tons (i.e. 2 wks x 500 tons)} )</td>
</tr>
<tr>
<td>iv.</td>
<td>Re-order level</td>
<td>( \text{Re-order level} = \text{Lead time usage} + \text{Buffer stock} )</td>
</tr>
<tr>
<td>v.</td>
<td></td>
<td>( = 1,500 \text{ tons} )</td>
</tr>
<tr>
<td>vi.</td>
<td>Buffer stock</td>
<td>( = 500 \text{ tons} )</td>
</tr>
<tr>
<td>vii.</td>
<td>Maximum inventory</td>
<td>( \text{Maximum inventory} = \text{EOQ} + \text{Re-order level quantity} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( = 1000 \text{ tons} + 1,500 \text{ tons} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( = 2,500 \text{ tons} )</td>
</tr>
<tr>
<td>viii.</td>
<td>Minimum inventory</td>
<td>( \text{Minimum inventory} = \text{Re-order level} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( = 1,500 \text{ tons} )</td>
</tr>
<tr>
<td>ix.</td>
<td>Average inventory</td>
<td>( \text{Average inventory} = \frac{\text{Max.} + \text{Min.}}{2} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( = \frac{2,500 + 1,500}{2} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( = 2000 \text{ tons.} )</td>
</tr>
</tbody>
</table>
The implication of the above calculation, is that production must not necessarily start as soon as the company purchases the first batch of raw material. This is because the company needs more than two purchases to maintain good inventory policy like the Re-order level, maximum and minimum inventory etc. This can be seen from the calculation made before the inventory graph.

4.4 HYPOTHESIS 1:

Most inventory managers do not know about the existence of the Economic order quantity.
ANALYSIS AND TESTING:

From questions 2 of the questionnaire (most inventory managers do not know about EOQ) the following responses were gathered:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly</td>
<td>1</td>
</tr>
<tr>
<td>Agreed</td>
<td>11</td>
</tr>
<tr>
<td>Undecided</td>
<td>36</td>
</tr>
<tr>
<td>Disagree</td>
<td>168</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>94</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
</tr>
</tbody>
</table>

Mean \( (X) \) = \[ \frac{\sum WX}{\sum X} \]

Where:
- \( \Sigma \) = Summation
- \( X \) = Number
- \( W \) = Weight

\[ X = \frac{(1 \times 5) + (11 \times 4) + (36 \times 3) + (168 \times 2) + (94 \times 1)}{310} \]

84
Testing the hypothesis using $X^2$

<table>
<thead>
<tr>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
<th>$O - E$</th>
<th>$(O - E)^2$</th>
<th>$E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>-61</td>
<td>3,721</td>
<td>60.02</td>
</tr>
<tr>
<td>11</td>
<td>62</td>
<td>-51</td>
<td>2,601</td>
<td>41.95</td>
</tr>
<tr>
<td>36</td>
<td>62</td>
<td>-26</td>
<td>676</td>
<td>10.90</td>
</tr>
<tr>
<td>168</td>
<td>62</td>
<td>106</td>
<td>11,236</td>
<td>181.23</td>
</tr>
<tr>
<td>94</td>
<td>62</td>
<td>32</td>
<td>1,024</td>
<td>16.52</td>
</tr>
</tbody>
</table>

\[ \chi^2 = \sum \frac{(O - E)^2}{E} \]

Where:

- $\Sigma$ = Summation
- $O$ = Observed frequency

\[ \chi^2 = 310.01 \]
\[ Y = \text{Expected frequency} \]

Degree of freedom = 5 - 1

= 4

At \( \alpha = 0.05 \) and degree of freedom 4, the tabular value = 9.488

Since the calculated value (310.61) is greater than the table value, we reject the null hypothesis and accept the alternative which means that most inventory managers know about the existence of the Economic Order Quantity.

4.5 HYPOTHESIS 2:

A significant number of inventory managers do not apply the Economic Order Quantity (EOQ) model in making inventory decision.
ANALYSIS AND TESTING:

The analysis of this hypothesis is done, using results from question 3 (Do you apply the EOQ model in making inventory decision?) of the questionnaire. From that question, the following information is gathered.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>12</td>
</tr>
<tr>
<td>Agreed</td>
<td>38</td>
</tr>
<tr>
<td>Undecided</td>
<td>59</td>
</tr>
<tr>
<td>Disagree</td>
<td>141</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
</tr>
</tbody>
</table>

$$\bar{X} = \frac{(12 \times 5) + (38 \times 4) + (59 \times 5) + (141 \times 2) + (60 \times 1)}{310}$$

$$\bar{X} = \text{Mean} = \frac{731}{310} = 2.36$$

The mean indicates that majority of the respondents do not agree that inventory managers do
not apply EOQ model in making decision. This is because the mean is less than 2.5 which is the mid point between "strongly agreed" and "strongly disagreed".

Testing the hypothesis using $X^2$

<table>
<thead>
<tr>
<th>Observed frequency</th>
<th>Expected frequency</th>
<th>(O - E)$^2$</th>
<th>(O - E)$^2$ E</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>62</td>
<td>-50</td>
<td>2500</td>
</tr>
<tr>
<td>38</td>
<td>62</td>
<td>-24</td>
<td>576</td>
</tr>
<tr>
<td>59</td>
<td>62</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>141</td>
<td>62</td>
<td>79</td>
<td>6241</td>
</tr>
<tr>
<td>60</td>
<td>62</td>
<td>-2</td>
<td>4</td>
</tr>
</tbody>
</table>

$X^2 = \sum \frac{(O - E)^2}{E}$

$Df = 4$ (i.e. 5 observations minus 1)
\[ \alpha = 0.05 \ (5\%) \]

At \( \alpha \), 5\% and degree of freedom 4, the tabular Chi-square value = 9.488

Since the calculated value (150.48), is greater than the table value, we reject the null hypothesis (A significant number of the inventory managers do not apply EOQ model in making inventory decisions); hence accept the alternative; which means that significant number of inventory managers apply EOQ model in making inventory decisions.

This result of course synchronizes with the initial one we got using the weighted mean method; hence the analysis is correct.
4.6 HYPOTHESIS 3:

Inadequate stock leads to disruption in production and loss of sales.

ANALYSIS AND TESTING:

The analysis of this hypothesis is done with reference to question 4 (Does inadequate stock lead to production stoppages and loss of sales?) of the questionnaire. From that question, the following figures were got:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agreed</td>
<td>65</td>
</tr>
<tr>
<td>Agreed</td>
<td>61</td>
</tr>
<tr>
<td>Undecided</td>
<td>63</td>
</tr>
<tr>
<td>Disagreed</td>
<td>68</td>
</tr>
<tr>
<td>Strongly disagreed</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
</tr>
</tbody>
</table>

Mean (X) = \( \frac{\sum_{i=1}^{N}X_i}{N} \)

Where: \( X = \) Number
The value of the mean indicates that majority of the respondents agree that inadequate stock lead to production stoppages and loss of sales. This is because 3.06 is greater than 2.5 which is the mid point between strongly agreed and strongly disagreed.

Testing the hypothesis, using the test statistic - Chi-square ($X^2$)

\[
\alpha = 5\% (0.05)
\]

Degree of freedom = 4 (5 - 1)
The Chi-square value falls in the acceptance region. Since the calculated value (2.07), is smaller than the table value 9.488, we have to accept the null hypothesis meaning that there are not much difference between the observed and expected values. As a matter of fact, there is evidence to believe that inadequate stocks lead to production stoppages and loss sales. This conclusion synchronizes with the result got from the weighted mean method.

*N.B:- Note the calculation of Expected Frequency.

<table>
<thead>
<tr>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible options</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$= 310$</td>
</tr>
<tr>
<td>$62$</td>
</tr>
<tr>
<td>$5$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observed frequency</th>
<th>Expected frequency</th>
<th>$O - E$</th>
<th>$(O - E)^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$65$</td>
<td>$62$</td>
<td>$3$</td>
<td>$9$</td>
</tr>
<tr>
<td>$61$</td>
<td>$62$</td>
<td>$-1$</td>
<td>$1$</td>
</tr>
<tr>
<td>$63$</td>
<td>$62$</td>
<td>$1$</td>
<td>$1$</td>
</tr>
<tr>
<td>$68$</td>
<td>$62$</td>
<td>$6$</td>
<td>$36$</td>
</tr>
<tr>
<td>$53$</td>
<td>$62$</td>
<td>$-9$</td>
<td>$81$</td>
</tr>
</tbody>
</table>

$X^2 = 2.07$
4.7 HYPOTHESIS 4:

There is no significant relationship between the inventory level and turnover in manufacturing companies.

ANALYSIS AND TESTING:

The analysis of this particular hypothesis made use of regression technique and the coefficient of correlation. The figures used for the analysis came from the records of the Nigerian Cement Company, Nkalagu, the case study for this research project.

The following data were obtained from the records of the company.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>INVENTORY (GYPSUM) TONS</th>
<th>TURNOVER (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>11,000</td>
<td>125.68</td>
</tr>
<tr>
<td>1989</td>
<td>13,000</td>
<td>186.1</td>
</tr>
<tr>
<td>1990</td>
<td>16,000</td>
<td>268.9</td>
</tr>
<tr>
<td>1991</td>
<td>20,000</td>
<td>399.4</td>
</tr>
<tr>
<td>1992</td>
<td>25,000</td>
<td>450.3</td>
</tr>
</tbody>
</table>

(SEE GRAPH 4.1) is the rough graph.
The general form of the equation for a straight line:

\[ y = a + bx \]

Where \( a \) and \( b \) are constants and \( a \) represents the fixed element and \( b \), the slope of the line.

The regression line is found by solving (simultaneously) the following equations:

\[
\begin{align*}
\Sigma x + b \Sigma x^2 &= \Sigma y \\
as + b \Sigma x &= \Sigma xy
\end{align*}
\]

Where \( n \) = number of pairs of figures

\( = 5 \)

| Gypsum (X) (Tons) '000' | Turnover (Y) (\( \text{M} \) Millions) | (XY) | (X
[^2]) | (Y
[^2]) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>125.68</td>
<td>1,382.48</td>
<td>121</td>
<td>15,795.462</td>
</tr>
<tr>
<td>13</td>
<td>136.1</td>
<td>2,419.3</td>
<td>169</td>
<td>34,633.21</td>
</tr>
<tr>
<td>16</td>
<td>268.9</td>
<td>4,302.4</td>
<td>256</td>
<td>72,307.21</td>
</tr>
<tr>
<td>20</td>
<td>369.3</td>
<td>7,988.0</td>
<td>400</td>
<td>159,520.36</td>
</tr>
<tr>
<td>25</td>
<td>430.3</td>
<td>11,257.5</td>
<td>625</td>
<td>202,770.09</td>
</tr>
<tr>
<td>35</td>
<td>1430.38</td>
<td>27,349.68</td>
<td>1571</td>
<td>485,026.33</td>
</tr>
</tbody>
</table>

The general form of the equation for a straight line:

\[ y = a + bx \]

Where \( a \) and \( b \) are constants and \( a \) represents the fixed element and \( b \), the slope of the line.
Graph 4.1 Rough Graph:

\[ X = \text{Inventory in tones} \]
\[ Y = \text{Turn in Naira (N'000,000)} \]

**TABLE OF VALUES:**

<table>
<thead>
<tr>
<th>Inventory</th>
<th>11</th>
<th>13</th>
<th>16</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover</td>
<td>125.68</td>
<td>186.1</td>
<td>268.9</td>
<td>399.4</td>
<td>450.3</td>
</tr>
</tbody>
</table>

Scale:

\[ \text{X axis : 1cm} = 2.5 \]
\[ \text{Y axis : 1cm} = 25 \]
GRAPH 4.1  Rough Graph

GRAPH 4.2  LINE OF BEST FIT

\[ y = 123.17 + 24.07x \]

Where \( x \) = Inventory (tons); N'000'
\[ y \] = Turnover; N'000,000'

TABLE OF VALUES:

<table>
<thead>
<tr>
<th>Inventory</th>
<th>11</th>
<th>13</th>
<th>16</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover</td>
<td>141.6</td>
<td>189.74</td>
<td>261.95</td>
<td>358.23</td>
<td>478.58</td>
</tr>
</tbody>
</table>
Scale:

X axis : 1 cm = 2.5
Y axis : 1 cm = 25

GRAPH 4.2 \( Y = -123.7 + 24.05 \times X \)
The equations became:

\[
\begin{align*}
5a + 85b &= 1,430.38 \quad \text{(i)} \\
85a + 1,571b &= 27,349.68 \quad \text{(ii)}
\end{align*}
\]

\[\therefore 7,855a + 133,535b = 2,247,127 \quad \text{(iii)}\]

\[7,225a + 133,535b = 2,324,722.8 \quad \text{(iv)}\]

\[630a = -77,595.8\]

\[a = -77,595.8 \quad \text{and} \quad 630\]

\[a = -123.17\]

Substituting \(a\) in equation (i)

\[
\begin{align*}
5(-123.17) + 85b &= 1,430.38 \quad \text{(v)} \\
-615.85 + 85b &= 1,430.38
\end{align*}
\]

\[\therefore 85b = 2,046.23\]

\[85\]
The regression equation becomes:

\[ Y = -123.17 + 24.07X \]

See Graph 4.2 for the line of best fit using the Regression Equation.

**THE CORRELATION COEFFICIENT (r)**

\[
 r = \frac{n \bar{xy} - (\bar{x})(\bar{y})}{\sqrt{n \bar{x}^2 - (\bar{x})^2} \sqrt{n \bar{y}^2 - (\bar{y})^2}}
\]

\[
 r = \frac{(5)(27,349.68) - (85)(1,430.38)}{\sqrt{(5)(157)^2} \cdot \sqrt{(5)(485,024.38) - (1,430.38)^2}}
\]

\[
 r = \frac{193,748.4 - 121,582.3}{\sqrt{7,885 - 7225} \cdot \sqrt{2,425,1317 - 2,045,066}}
\]
The regression line and the consequent coefficient of correlation ($r = 0.98$) prove that the degree of relationship between the level of inventory and the turnover in the Nigerian Cement Company, Nkalagu is very high.

Therefore, we reject the null hypothesis and accept the alternative; hence concluding that there is a significant relationship between the level of inventory and turnover in the Nigerian Cement Company, Nkalagu.
4.8 HYPOTHESIS 5:

Inventory management problem revolves around the determination of the optimum stock level to hold/carry at any point in time.

ANALYSIS OF DATA:

The analytical method used here is just simple percentage. The data for the analysis are derived from the respondents' responses to question number 5 of the questionnaire/which states that inventory management in your company revolves around:

a. Stock level to carry
b. Risk of obsolescence
c. Risk of production stoppage
d. Not meeting customers' orders

<table>
<thead>
<tr>
<th>RESPONSE OPTION</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock level to hold/carry</td>
<td>102</td>
<td>32.9</td>
</tr>
<tr>
<td>Risk of obsolescence</td>
<td>67</td>
<td>21.6</td>
</tr>
<tr>
<td>Risk of production stoppage</td>
<td>72</td>
<td>23.2</td>
</tr>
<tr>
<td>Not meeting customers' order</td>
<td>69</td>
<td>22.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>
From the data above, option (I) has the highest percentage of 32.9; hence we accept the null hypothesis and conclude that inventory management problems in most manufacturing companies revolve around the optimum stock level to hold/carry at any point in time.

4.9 RESEARCH QUESTION 3:
How big should inventory be?

ANALYSIS OF RESULT:
The analysis of this research question is from question 6 and 7 of the questionnaire (which of the following is used for controlling stock in your company?).

<table>
<thead>
<tr>
<th>RESPONSE OPTION</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock budget</td>
<td>82</td>
<td>26.5</td>
</tr>
<tr>
<td>Availability of money</td>
<td>86</td>
<td>27.7</td>
</tr>
<tr>
<td>Tonnage to produce</td>
<td>60</td>
<td>19.4</td>
</tr>
<tr>
<td>Max - Min stock level</td>
<td>58</td>
<td>18.7</td>
</tr>
<tr>
<td>Any other</td>
<td>24</td>
<td>7.7</td>
</tr>
</tbody>
</table>

From the above, it could be seen that stock of inventory depends on the availability of fund.
This is because that option had about 27.7% of the total number of questions distributed and this is the highest. From the table too, one can conclude that most other firms prepare raw materials budget for that year or season.

Therefore, how big stock should be, is a function of many things; and this depends on:

a. **Availability of finance**
b. **Stock budget for that year**
5.1 SUMMARY:

Inventories in one form or another are important in almost every business. Their importance is such that few inventory/materials managers can escape the need to control them. The inter-relationship of inventory with every facet of the business makes the solving of inventory problems complex. Inventories occur at the interfaces between economic and organizational units. Thus, we find distribution of inventories between plants and customers and manufacturing inventories between vendors and plants, and within plants.

Although there has been much in the literature in recent years on techniques to solve particular inventory problems, there has been little awareness on the part of businessmen that there is a general approach which can be applied to an inventory problem. Real life problems are often much different from 'classical' problems which abound in the literature.

A general approach to an inventory problem can be based on the disciplined application of scientific inquiry, breaking the inventory process down into the various phases. These phases are:
a. Consideration phase that asks such questions as: what is the product?, why control?
b. Analysis phase: that tries to find out the relationship between inventory and production, order sizes, demand rate variation, customers services etc.
c. Synthesis phase
d. Control phase
e. Action and evaluation phase.

Much of the difficulty with the solving of inventory problems has been the failure to recognize all these phases and their facets. By answering certain key questions at each phase of the inventory process, management will be able to get a better understanding of the process and so will be able to resolve many of the so called "different" problems. "The separation of inventory from production is not an isolated trend in modern industry. It is part and parcel of an evolutionary process whose result can perhaps be represented by a fanciful motor vehicle with four controls and four wheels. The ability of the car ----, and the coordination among all the four wheels. Companies which tread -------- direction at the same time inevitably attain the same destination - the ditch of bankruptcy which lines both sides of the road. Needless to say, one of those wheels is inventory and one the drives is the inventory controller. The others are: (2) budgeting control for planning all operations to secure maximum profit from minimum investment in working and fixed assets. (3) Sales control
to plan sales activities for selling the maximum quantity of the most profitable product and the lowest possible selling price. (4) Production control to secure the maximum production of products of standard quality at lowest cost and at the right time.

Inventory control - production, sales and budgeting control is meaningless and as ludicrous as a one-wheeled motor car. Hence, prior to attempting regulation of inventory, management might well follow the advice "physician, cure yourself". Only if the other three controls are present, can inventory control be considered seriously. Reversely, the others can hardly succeed unless inventory is carefully regulated".

---------- Benjamin Melnitsky

For much of the post-world war II period, the world economy was beset by capacity and materials shortages, and high interest rate. This environment stimulated much interest in inventory policy among managers.

The 1970's present many of the same pressure, but this time with a difference. A great deal has been learned about inventory policies, and sophisticated tools, such as computers have appeared to aid in maintaining them.
Though the researcher is not claiming that the findings made in this work is final, this project provides an overview of inventory management in manufacturing companies. Five (5) manufacturing companies were involved in this study though most of the analysis and findings were made based on the data collected from only one of them: the Nigerian Cement Company, Nkalagu, which incidentally is used as a case study for this research project. The results from the rest of the companies were used as dummies just to reach/arrive at a general conclusions.

5.2 RESEARCH FINDINGS:

The information given under this sub heading reflects the researcher’s findings; which are based on the analysis of the research questions and the hypothesis already formulated at the introductory chapter. The research questions and their analysis were designed to make specific conclusions, regarding operations at the Nigerian Cement, Nkalagu. On the other hand, findings from the testing of hypothesis guided the researcher to make general conclusions about manufacturing companies.

Because of the nature of the study and what it hopes to achieve, the use of hypothesis and research questions as a basis for analysis of the research findings have been found most relevant.
From the various analysis, the following findings were made:

1. At present, the Nigerian Cement, Nkalagu does not buy their raw material (Gypsum) at the Economic lot size, otherwise known as the Economic order quantity (EOQ).

From the available data, it is calculated that the Economic lot size for efficient purchase of gypsum is 1000 tons (One thousand) at a time, which invariably means that they are supposed to place order twenty six (26) times in a year considering the current annual requirement of 26,000 tons. But right now, they buy in the lots of 13,000 tons and as such place order only two times in a year. The implication is that the disadvantages that arise from excessive holding cost exceed the advantages of holding adequate/excess inventory as a cushion for production stoppages.

Though no study was made in respect of the other companies, evidence from the responses to the questionnaire shows that the issue of not buying the economic lot size is not peculiar to Nigercem; rather all other manufacturing companies.
2. The company (Nigerian Cement Company, Nkalagu) is currently losing the sum of one million, seven hundred and thirty three thousand, five hundred and twenty Naira (N1,733,520.00) for not buying at the Economic lot size. This amount represents the difference between the cost of buying in the lots of one thousand tons (1000) at a time and the current practice of 13,000 tons (thirteen thousand) at a time. Hence, the company can increase their annual profit by N1,733,520.00, just by changing the current inventory policy of buying in lots of 13,000 tons to buying in the lots of 1000.

3. Analysis of data shows that almost every inventory manager in manufacturing companies is aware of the existence of the Economic order quantity model. In spite of this awareness, there are reasons to believe that they apply it with variable degree of modifications.

4. A significant number of inventory managers not only know about the existence of the Economic order quantity model, but also, they apply it in making inventory decisions.

5. Available records reveal that inadequate stock/inventory often lead to production stoppages, loss of sales and as a result also, loss of customer goodwill.
6. There is significant relationship between the level of inventory and the turnover in the Nigerian Cement Company, Nkalagu. The correlation coefficient of 0.98 shows a strong positive relationship. A close look at the available data indicates that turnover increased at an increasing rate over the ranges of inventory from 11,000 (Eleven thousand) tons, to 16,000 (Sixteen thousand) tons, and thereafter increased at a decreasing rate.

7. Inventory problems in manufacturing companies revolve around the optimum stock level to hold/carry at any point in time.

8. The decision as to how big inventory/stock should be is mainly a function of the availability of funds and the stock budget made for the financial year/period.

5.3 CONCLUSION:

It is worthy of note that inventory management in practice is different from what exists in most textbooks as theories. This is because theories are ideal states or situations, while practice relates to what is obtainable in real life situations. Majority of what is known about inventory management as found in most theories are found by many companies to be either impracticable or too complex to be applied in their peculiar circumstances and as such, very expensive to maintain by them. Every organization hence evolves an inventory management system that would suit its peculiar situation.
Summarily, this is the situation in the Nigerian Cement Company, Nkalagu. The company actually deserves some praise though there is still room for improvement, hence they should keep working on their inventory system for further improvement as well as to adapt to any future changes in the operation of the organization.

That the optimum order size for the Nigerian Cement Company, Nkalagu is 1000 tons rather than the current quantity (13,000 tons) is not actually absolute. The computation depends on the available data. Like I did mention, at the introductory chapter, most of the required data are not available hence estimates were used in the computation most of the time. On the other hand, some of the available data are not constant over a range of time. One of such datum is the transportation cost, which is positively correlated to the inflationary trend. Another example is the purchase price of Gypsum itself. Gypsum is sold in Dollars; and the value has not been very stable over a period of time. The current year budget rate of $1 (One dollar) to N22 (twenty two) was used for the computation; despite the fact that the figures used were those of between 1988 and 1992.

Finally, in this area, the interest rate, which is the cost of capital used in the calculation has not been steady from year to year. The 21% used for the computation is based on the current year budget. The implication is that the figure (1000) could be a different thing assuming that either or all of these variables change.
Hence, the loss of N1,733,520.00 (One million, seven hundred and thirty three thousand, five hundred and twenty Naira) is equally not absolute. The reliability of that figure depends on how close the various estimates made are. Determinants like transportation cost, insurance, freight etc. are not fixed, rather they increase at a decreasing rate as quantity increases. Therefore, there is likely to be some statistical/mathematical error since the estimate is made from the purchase of 13,000 tons.

There is no contradiction between the third and the last research findings. The analysis reveals that most inventory managers are aware of the existence of the Economic order quantity model; all the same the research project concludes that the level of stock/inventory depends on such things as the availability of money and stock budget. The fact remains that the awareness of the model does not automatically result in its use. Most of them either do not use the model or they do with various forms of modification to suit their particular circumstance. In fact, it is found that most of the assumptions of the Economic order quantity do not hold in real/practical situations; and as a matter of fact, most inventory managers look at the model as a theoretical construct. Their use of the model is to the extent of achieving their peculiar objectives.

Carrying inadequate inventory could lead to production stoppage and loss of sales, but it is
not the only reason. Often times, production stoppages result from either mechanical or electrical problems. The same goes to loss of sales and customers good will. For example, since the past five years, there has been no record of shortage of raw material, yet the Nigerian Cement Company, Nkalagu has not been able to produce enough to satisfy their ever increasing customers. In fact, customers get their orders filled by the company at a minimum of one year after the order is placed. Hence this goes to prove that their problem is not that of carrying inadequate inventory, rather other managerial and financial problems.

The regression analysis and correlation coefficient reveal a strong relationship between the level of inventory and turnover in the Nigerian Cement Company, Nkalagu. The relationship shows a pattern: in the first place, turnover increased at an increasing rate, after which it increased at a decreasing rate. The idea is that there is a maximum quantity of inventory that the company can effectively use. This then is a function of many things like their capacity utilization and the skill of their managerial team.

5.4 RECOMMENDATION:
Materials management, offer an important opportunity for many companies, and as such, the profit center approach in particular could make this function an important contributor to corporate earning. Therefore, the manager of materials should be expected to take the same
entrepreneurial approach that most other company executives do. During the stage covered by material management, value by distribution is added and capital is tied up. In principle therefore, material managers should charge a price that gives them a reasonable return on the capital employed.

In the course of the research, it was noticed that the records office of these manufacturing companies are either neglected or are not in existence. Those in existence are not well organized and staffed. Office of statistics (well organized and staffed) is very important for the companies; hence I recommend that a detailed account of various costs no matter how minute, should also be kept and maintained by these companies.

Though in process, the company is advised to quicken the installation of its computer department as a means of enhancing the effectiveness of their inventory management.

Finally, it is recommended that research students should carry out further research in this area.
REFERENCES:

1. Melnitsky Benjamin, Management of Industrial Inventory.
   Philadelphia, chilton company, first ed; 1951, p.4
BIBLIOGRAPHY


12. KIM: "Economic order quantity" Quantitative analysis for Managerial decision, Addison-Wesley publishing company. 1976, pp. 71-93


16. Melnitsky Benjamin: *Management of Industrial Inventory*, Philadelphia, Chilton company, first ed. 1951, p.4


Dear Sir/Madam,

The purpose of this questionnaire is to gather information as regards the inventory management of manufacturing companies.

This information is purely for academic purposes and has nothing whatsoever against the company’s welfare.

Thank you for your anticipated co-operation.

OFURUM CLIFFORD O.

QUESTIONNAIRE

SECTION A

(please tick or fill in, box or space, whichever is applicable)

State the name of your Company..........................................................

..........................................................

..........................................................

..........................................................

120
1. What is the name of your department?
   a. Production
   b. Sales/stores/marketing
   c. Accounts
   d. Purchasing
   e. Others (specify)

2. Most inventory managers do not know about EOQ. Do you agree?
   a. Strongly agree
   b. Agreed
   c. Undecided
   d. Disagree
   e. Strongly disagree

3. A significant number of inventory managers do not apply the Economic Order Quantity (EOQ) model in making inventory decisions. Do you agree?
   a. Strongly agree
   b. Agreed
   c. Undecided
   d. Disagree
4. Inadequate stock leads to production stoppages and loss of sales.
   a. Strongly agree
   b. Agreed
   c. Undecided
   d. Disagree
   e. Strongly disagree

5. On which of the following options does inventory management problem in your company revolves?
   a. Stock level to hold/carry
   b. Risk of obsolescence
   c. Risk of production stoppage
   d. Not meeting customers order

6. Which of the following is used for controlling inventory/stock in your company?
   a. Stock budget
   b. Naira invested
   c. Tonnage to produce
d. Maximum - minimum stock level

e. Any other (Specify)

7. Which of these factors influences the level of stock of raw materials?
   a. Anticipated production
   b. Seasonality of production
   c. Reliability of sources of supply
   d. Any other reason (Specify)
   e. Availability of money

8. Do you think EOQ assumptions are applicable to your organization?

SECTION B

Note: This section should be completed by any of the following:

a. Chief accountant
b. Works/cost accountant
c. Production Manager
d. Purchasing Manager (ONLY Nigerian Cement Company, Nkalagu).

1. What is your major (imported) raw materials?
2. What is its source of supply?

3. What is the annual requirement? Specify unit of measure.

4. Cost per unit of measure?

5. What is your holding cost per unit of measure?

6. What is your ordering cost per order?

7. How many times do you place order in a year?

8. How many units do you purchase at a time?