

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**COLLEGE OF SCIENCE**

**INSTITUTE OF DISTANCE LEARNING**

**DEPARTMENT OF MATHEMATICS**

**SOFTWARE FOR THE NATIONAL HEALTH INSURANCE SCHEME:  
PHARMACY MANAGEMENT**

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES,  
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF MASTER OF SCIENCE (M.SC) INDUSTRIAL  
MATHEMATICS.**

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**JANUARY, 2008**

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# DECLARATION

I hereby declare that this thesis is my own work towards the Master of Science degree and that, to the best of my knowledge it contains no material previously published by another person nor material, which has been accepted for award of any other degree of the university, except due acknowledgement has been made in the text.

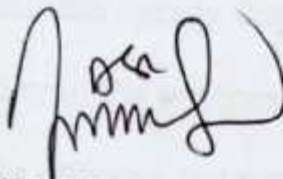
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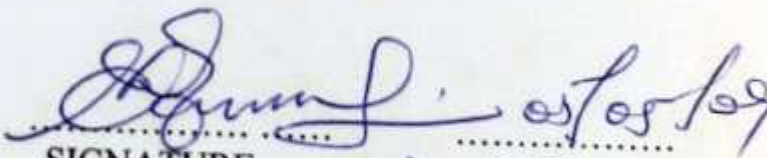
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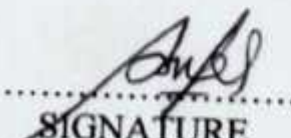
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## ABSTRACT

The National Health Insurance Scheme (NHIS) has a drug list with predetermined maximum price of the drugs for accredited providers of Pharmaceutical Services. These accredited Pharmacy shops encounter difficulties as regards dispensing drugs to the clients of the scheme as it is done manually. Again the processing of claims is also very cumbersome and at a cost to the service providers. Therefore, the need to design software to eliminate the deficiencies in the existing system.

The main result for the thesis is that we used Visual Basic and SQL Server to design Pharmacy Management Software (Pharmas) for NHIS to make potential service providers readily apply for accreditation, generate all required reports, monitor inventory levels and finances, speed up the processing of claims, facilitate speedy dispensing of drugs to the clients, monitor events and assess the profitability of the services being rendered, and to provide comprehensive and up-to-date reports for effective and timely decision-making.

## ACKNOWLEDGEMENT

I thank the Almighty God for the great and wonderful things He has done in my life especially for providing me with the strength and knowledge to come out with this work.

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I dedicate this work to my brother, Lt Col Augustine Ansu, whose assistance and encouragement have pushed me to the heights beyond my own expectations. I love you for the strength you have in your convictions and for motivating me to be the best that I can be.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Background to the Study

Following a chronic shortage and irrational use of drugs within the public health system, the government of Ghana introduced a national drug revolving fund scheme known as 'cash and carry system', a product of the structural adjustment programme which the International Monetary Fund (IMF) and the World Bank prescribed and which Ghana adopted. It involved the withdrawal of government subsidies on health delivery (New Internationalist Magazine, 1997).

The main aim of the scheme was to allow the Ministry of Health to provide an efficient pharmaceutical service at its facilities. It was introduced in 1990 in the Greater Accra and Volta regions on a pilot basis and extended nationwide in January 1992. The general objective of the revolving drug fund scheme was to establish a user-financed system which seeks to establish and sustain the essential drug supply and to provide all public health facilities with adequate and safe drugs at affordable prices (MOH, 1992).

Most prescribers who had become cost-conscious devised various strategies to help the patients. Indications were that there had been a reduction in the quantity of a given drug prescribed in many facilities. Only the most important drugs which would cure the disease were prescribed. Sometimes the patient's financial background was solicited as a guide for the choice of drugs to prescribe. If it became clear that a patient could not afford the drug bill, the quantity of drugs was cut down or the less important ones were

deleted. In some cases even the patients themselves pleaded with the prescriber to reduce the number of drugs so that they could afford them.

Patients who did not have the ability to pay for medical services were turned away from hospitals only to die at home. The poor, the disabled and accident victims were asked to pay on the spot before getting the needed medical attention.

The pressure to sustain the cash and carry system of procuring drugs was blamed for over prescription, inconsistent pricing of prescriptions, avoidable deaths and subsequent fall in clinic attendance.

With regard to the problems associated with the "cash and carry" system of financing health care, the Government of Ghana sought to abolish it in 2002 and to replace it with a National Health Insurance Scheme. After a series of consultations and studies with health development partners such as World Health Organisation (WHO), Danish International Development Agency (DANIDA), and German Agency for Technical Co-operation (GTZ) as well as other relevant national agencies, the government realized it would not be feasible to establish a single National Health Insurance fund (Ministry of Health, 2002). This was because about seventy percent (70%) of Ghanaians are in the non-formal sector of the economy and at least forty percent (40%) of the Ghanaian population live below the poverty line and may not be able to afford high premiums (Ghana Living Standards, 2000). This meant that the traditional mechanisms for organizing communal contributions needed to be examined and factored into the design of the health insurance scheme. A Ministerial Task Team on Health Care Financing was established in March 2002 to conduct further studies and recommend an appropriate scheme for Ghana. The Team's proposals were submitted to the Parliament of Ghana and in 2003, an Act of

Parliament was passed to establish and regulate health insurance operations in the country (Act 650, 2003). The National Health Insurance Bill passed into law by the parliament of Ghana seeks to set up a National Health Insurance Scheme (NHIS), which would enable residents in Ghana to obtain, at least, basic healthcare services without paying money at the point of delivery of the service. This has replaced the cash and carry system.

## **1.2 The Vision, Goal and Objectives of the National Health Insurance Scheme in Ghana**

### **The Vision**

The ultimate vision of the National Health Insurance Scheme in Ghana is “to assure equitable universal access for all residents of Ghana to an acceptable quality of a package of essential health services without out-of-pocket payment being required at the point of service use” (Ministry of Health, 2002). It is hoped this system would protect everyone from the problems that are associated with having to find money at the time of illness before necessary services can be provided.

### **The Goal**

The goal of the National Health Insurance is, “Health Insurance will replace out of pocket payment for a certain minimum benefit package at point of service use over time” (Ministry of Health, 2002). The replacement process will however be a gradual one.

### **Objectives**

The long term policy objective is that every resident of Ghana shall belong to a health insurance scheme that adequately covers him or her against “cash and carry” in order to

have access to a defined package of acceptable quality needed health services. There are medium and short-term objectives indicating a gradual percentage achievement till the long-term objective of universal coverage is achieved.

## **Sources of Financing**

### **Informal Sector Contributions**

Premium rates are based on one's ability to pay. Community health insurance committees are to identify and categorize residents into social groups to enable individuals in each group know their premium rates. The social groups are the core poor, poor, middle income and the rich. The core poor (indigent) are exempted from paying any premium. Those in the paying categories pay not less than seventy-two thousand cedis (¢72,000.00) per annum (Ghana Health Service, 2004).

### **Formal Sector Contributions**

For those in the formal sector (both private and public), two and a half percent (2.5%) of their contribution to the Social Security and National Insurance Trust (SSNIT) is taken monthly as their health insurance contribution. Thus workers in the formal sector become automatic members of the National Health Insurance Scheme, but they have to register with their respective District Health Insurance Scheme.

All contributors' premiums cover their children and dependants below the age of seventeen years. This means anybody from birth up to seventeen years of age does not pay a premium but is entitled to full benefits as with contributors. Other categories of people exempted from premium contribution are those above the age of seventy years

and former SSNIT contributors on retirement. All adults have to join as members and contribute (so spouse is not a dependant).

### **Other Sources of Funds**

The government has introduced a two and half percent (2.5%) sales levy as an earmarked fund for health insurance in Ghana. Other sources include the exemption fund (from the government health budget), which was used to pay for the cost of special health services and health care cost of indigents as well as donors' contributions.

### **Pooling of Funds**

With the exception of contributions from the informal sector, all the other funds will be collated to form the National Health Insurance Fund (NHIF). The National Health Insurance Council (NHIC) will administer the NHIF and it is to be used to finance exemptions for the poor as well as for reinsurance of schemes, cross-subsidization and risk equalization through an allocation formula that will be developed.

### **Benefit Package**

The NHI Act and the Legislative Instrument (LI) (GOG, 2003), set out the minimum benefit package to members of health insurance schemes. These include general out-patient services, in-patient services, oral health, eye care, maternity care and emergencies. Only a few specialized services such as HIV antiretroviral drugs, VIP accommodations etc are excluded from the health insurance benefit package. According to the LI (2004), the benefit package covers about 95% of all essential / common health problems in Ghana.

## **Operations of the Scheme**

The scheme has accredited hospitals and pharmacy shops which render services to its clients. Accreditation is open to both private and public health centres.

## **Problems Facing the Scheme**

The NHIS has been welcome in principle by all and sundry since the cash and carry system is not the best of schemes considering the socio-economic or socio-cultural status of the Ghanaian. However, the politics, funding and its implementation have left much to be desired. The following are some of the problems facing the scheme currently:

- i. The low level of Information Technology skills on the part of the service providers,
- ii. Insufficient education about the benefits to be derived from the scheme and hence low level of patronage,
- iii. The politicians are taking advantage of a very important and crucial issue to play politics. The ruling government having used the scheme as political bait to win voters is bent on rushing the scheme through with the danger of it not being sustainable. The opposition NDC who introduced the cash and carry system but started a similar NHIS on a pilot basis in the districts wants that to be continued. This the current government sees as a political threat,
- iv. Low levels of income on the part of the people in the rural communities to register, and
- v. Delays in the reimbursement of service providers after they have provided services to members of the various schemes. Mr Anthony Evans Amoah, the Western Regional Minister, appealed to the various Mutual Health Insurance

Schemes and the National Health Insurance Council to expedite action in the reimbursement of Service Providers to ensure the sustainability of the scheme (Takoradi, July 10, GNA).

### **Positive Effects of the National Health Insurance Scheme**

- i. Mobilising private funds for improving health care delivery at the macro level. The National Health Insurance Bill imposed a national health insurance levy on members of the scheme to finance it. This is typical of premiums paid for health insurance schemes. Some people who register with the scheme do not visit hospital and as such the premium paid by such persons are used to cater for the vulnerable in the society.
- ii. Access to health care at a predetermined rate. Premiums are paid by the insured and an identification card given. This allows the insured to access health care without paying any money at the point of service. The premium paid covers a period of twelve (12) months and within that period the insured is permitted to access health care.
- iii. Elimination of the cash and carry system.
- iv. Reduction of preventable deaths. With health insurance, people do not have to pay for health care at the point of service and as such the insured can regularly go for medical check up.
- v. Creation of employment opportunities for the Ghanaian youth. The national health insurance scheme employs variety of professionals such as Insurers, Accountants, Managers, Computer Scientists and many others. Many young

graduates have been employed by the scheme. This has also increased the government direct tax revenue.

### **Negative Effects of the National Health Insurance Scheme**

- i. The increase in paid up members has also increased the number of people who need health attention. Most people who did not previously visit the formal health centers for health care now troop to the hospitals upon small illness because they have paid their premium. This has put pressure on the scheme, as they have to pay colossal amount of money to the service providers.
- ii. Poor health facilities to care for large number of patients. Most districts have no district hospitals but health centres, which are overflowing with patients as well as being understaffed. Since the facilities are poor, performances are being constrained.  
The roads leading to the most health centres are very poor, infrastructure very inadequate.
- iii. High cost associated with training of medical personnel and putting up health facilities.

In the midst of high cost of health care both at the macro and micro levels, health insurance becomes a viable alternative for financing health care in Ghana as it is a way of mobilising private funds for improving health care delivery at the macro level. However, the National Health Insurance Scheme can only become sustainable if the right tools are applied effectively and efficiently. One of such tools is software, which will help the service providers render the needed services in this era of information technology. A pharmacist who has received accreditation approached us to come out with solution to his problem to help render effective services. Further investigations were made as regards

visiting other accredited service providers and finding out how they go about the service. Most pharmacy shops visited expressed the same sentiments and others said they would not be able to provide the service because of the difficulties involved, to the extent of locking capital because of delays associated with the processing of claim forms. We accepted the challenge and hence this project.

### **1.3 Problem Statement**

The National Health Insurance Scheme has a drug list with predetermined prices for accredited providers of the pharmaceutical services. There are difficulties associated with these services as regards the processing of claims, monitoring of inventory levels, dispensing of drugs and determining whether it is economically viable, feasible and sustainable to accept rendering the services. There is therefore the need to develop pharmacy management software for the National Health Insurance Scheme (NHIS).

### **1.4 Objectives**

The objective of this thesis is to develop a Pharmacy Management Software for NHIS service providers to:

- i. determine the right quantity of drugs to stock to avoid overstocking, stock out and under stocking,
- ii. assess and analyse the profitability of the service,
- iii. provide comprehensive and up-to-date reports for effective and timely decision-making.

## **1.5 Significance of the Study**

The justifications of the study are to:

- i. help improve the health delivery system in the country
- ii. allow the Health Insurance Scheme function to serve the purpose for which it was introduced
- iii. make providers of pharmaceutical service readily apply for accreditation to render services to their clients
- iv. reduce the cost of processing claims
- v. speed up dispensing of drugs to the clients

## **1.6 Methodology and Data Source**

1. We shall employ the following mathematical tools in our study

- (a) Inventory models, and
- (b) Regression models (Simple and Multiple)

2. The Programming tools for our study will include:

- a) Visual Basic 6
- b) Microsoft SQL Server 2000
- c) Crystal Report
- d) Rose Indigo Setup Factory
- e) Windows XP (Professional Edition)

3. The sources of the data for the study are:

- a) The most currently negotiated National Health Insurance medicine list and prices.
- b) The detailed drugs retailed by the pharmacy shops

- c) The information obtained from client served from the system

## 1.7 Organisation of the Study

The project is organised into four (4) chapters. Chapter one deals with the introduction, which consists of the background to the study, statement of the problem, the objectives of the study, significance of the study, methodology and the organisation of the study.

Chapter two (2) reviews the relevant literature of the system detailing the concepts of inventory models; statistical models and the programming languages use to develop the software. Chapter three (3) considers the methodology and the implementation of the study. The various forms or interfaces are also explained to make it easier for users. Finally chapter four (4) constitutes the conclusion and recommendations.

## 1.8 Summary

In this chapter, we considered how the National Health Insurance Scheme came into existence in Ghana, reasons for the study, spelling out the objectives, strengths, weaknesses, opportunities and threats of the NHIS. It also detailed how the study has been organised.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1.0 Introduction

In this chapter, we shall investigate the various mathematical models we employ in the study. The objectives of mathematical modeling are:

- i. Forecasting
- ii. Understanding various natural and unnatural phenomenon (Zill, 1997)

We shall consider

- (a) Inventory models, and
- (b) Regression models (Simple and Multiple).

The inventory models will be used to compute optimum quantities of stock to keep in shop to reduce cost and increase profit whereas the statistical models will be used to analyse the profitability and effectiveness of the service.

### 2.1.1 Inventory Model

Inventory is an idle stock of items for future use (Bronson, Naadimuthu, 2004).

It is a quantity or store of goods that is held for some purpose or use (the term may also be used as a verb, meaning to take inventory or to count all goods held in inventory).

Inventory may be kept "in-house," meaning on the premises or nearby for immediate use; or it may be held in a distant warehouse or distribution center for future use. With the exception of firms utilizing just-in-time methods, more often than not, the term

"inventory" implies a stored quantity of goods that exceeds what is needed for the firm to function at the current time (e.g., within the next few hours).

The two key issues of inventory models are the quantity and timing of the orders. The objective is to minimise the total inventory cost comprising carrying (holding) and ordering costs.

An inventory model may be of independent demand or dependent demand. In an independent demand model, the demand for an item is independent of the demands for other items in the inventory and demand tends to be uncertain. In a dependent demand model, the demand for an item is dependent upon the demands for other items in inventory and demand tends to be certain. Usually end-products (finished goods) are examples of independent demand inventories while assembly components are examples of dependent demand inventory (Bronson R., Naadimuthu G., 2004).

In this thesis we shall consider the independent demand inventory system.

### **2.1.2 Stock Costs**

Stock represents an investment by an organization (Drury, 2004). As with any other investment, the cost of holding stock must be related to the benefits to be gained. The four categories of stock costs are:

- a) Cost of holding stock
- b) Cost of obtaining stock
- c) Stock out cost
- d) The cost of the stock itself

### a) Cost of holding stock

Holding cost, also called carrying cost, is the cost associated with having inventory on hand. It is primarily made up of the costs associated with the inventory investment and storage cost. For the purpose of the EOQ calculation, if the cost does not change based upon the quantity of inventory on hand it should not be included in carrying cost. In the EOQ formula, carrying cost is represented as the annual cost per average on hand inventory unit. Below are the primary components of carrying cost.

**Interest on the capital invested in the stock.** If you had to borrow money to pay for your inventory, the interest rate would be part of the carrying cost. If you did not borrow on the inventory, but have loans on other capital items, you can use the interest rate on those loans since a reduction in inventory would free up money that could be used to pay these loans. If by some miracle you are debt free you would need to determine how much you could make if the money was invested.

**Insurance.** Since insurance costs are directly related to the total value of the inventory, you would include this as part of carrying cost.

**Taxes.** If one is required to pay any taxes on the value of his or her inventory they would also be included.

Storage charges (rent, lighting and heating, air condition), Stores staffing, equipment maintenance and running costs, Handling costs, Deterioration and obsolescence, Audit, stocking or perpetual inventory cost, security cost are also incurred.

The most obvious holding costs include rent for the required space; equipment, materials, and labor to operate the space; insurance; security; interest on money invested in the inventory and space, and other direct expenses. Some stored goods become obsolete before they are sold, reducing their contribution to revenue while having no effect on

their holding cost. Some goods are damaged by handling, weather, or other mechanisms. Some goods are lost through mishandling, poor record keeping, or theft, a category euphemistically called shrinkage.

Holding cost also includes the opportunity cost of reduced responsiveness to customers changing requirements, slowed introduction of improved items, and the inventory's value and direct expenses, since that money could be used for other purposes.

Holding cost may be reduced by:

- i. The regular delivery system JIT (just in time) delivery
- ii. Operational research and statistical techniques
- iii. Taking notice of behavioral factors
- iv. Regular reviews of stock levels

#### b) The cost of obtaining stocks

These costs are sometimes called the ordering or the procurement costs and include the following:

- i. The clerical and administrative cost associated with purchasing, accounting, and goods received stores
- ii. Transport costs
- iii. The set up and tooling costs associated with each production where goods are manufactured internally

#### c) Stock out costs

These are the cost associated with running out of stock, the avoidance of which is the main reason for holding stocks (Lucey, 2002). The costs including the following:

- i. Lost contribution through the lost of sales caused by the stock out
- ii. Loss of future sales because customers go elsewhere
- iii. Loss of customer goodwill
- iv. Labour frustration over stoppages
- v. Extra cost associated with urgent, often small quantity, replenishment purchases

### 2.1.3 Reasons for Holding Stocks

(a) The main reasons for holding stocks are:

- i. to ensure that sufficient goods are available to meet anticipated demand
- ii. to absorb variations in demand and production
- iii. to provide a buffer between production processes
- iv. to take advantage of bulk purchasing discounts
- v. to meet possible shortage in the future
- vi. to absorb seasonal fluctuations in usage or demand

(b) The alternative reasons for the existence of stock are:

- i. obsolete items are retained in stock
- ii. poor or non-existent inventory control resulting in over-large orders, replenishment orders being out of phase with production or sales
- iii. Inadequate or non-existent stock records
- iv. Poor liaison between the production control, purchasing and marketing departments (Lucey,2002)

#### 2.1.4 Fixed Order Quantity Models

In fixed order quantity model, the quantity (how much) of the order is fixed while the timing (when) of the order varies.

##### **Determination of Fixed Order Quantities**

The economic order quantity (EOQ) is the quantity that minimizes total holding and ordering cost for the year (Lucey, 2004). It gives a good indication of whether or not current order quantities are reasonable. The EOQ is used as part of a continuous review inventory system, in which the level of inventory is monitored at all times, and a fixed quantity is ordered each time the inventory level reaches a specific reorder point. The EOQ provides a model for calculating the appropriate reorder point and the optimal reorder quantity to ensure the instantaneous replenishment of inventory with no shortages. It can be a valuable tool for business owners who need to make decisions about how much inventory to keep on hand, how many items to order each time, and how often to reorder to incur the lowest possible costs.

The optimal order quantities known as Economic Order Quantities (EOQ) for four cases will be considered

- i. Economic Order Quantity for purchasing,
- ii. Economic Order Quantity for production,
- iii. Economic Order Quantity for quantity discounts, and
- iv. Economic Order Quantity where stock outs are permitted.

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i. **Economic Order Quantity (EOQ) for purchasing:**

In economic order quantity for purchasing model, the total inventory cost (TC) is determined as

TC = annual carrying cost + annual ordering cost

$$= \left(\frac{Q}{2}\right)C + \left(\frac{D}{Q}\right)S$$

Where  $D$  = annual demand (units per year)

$Q$  = quantity ordered (units per order)

$C$  = unit carrying cost per year

$C$  = holding rate ( $R$ )  $\times$  unit price ( $P$ )

$S$  = ordering cost (cedis per order)

$TC$  = total annual inventory cost (cedis per year)

To obtain the  $EOQ$ , the derivative of  $TC$  with respect to  $Q$  is equated to zero and solved for  $Q$

$$\text{Thus, } TC = \frac{QC}{2} + \frac{DS}{Q}$$

$$\text{Taking the derivative, } \frac{d}{dQ}(TC) = \frac{C}{2} - \frac{DS}{Q^2}$$

$$\text{Equating to zero, } \frac{C}{2} - \frac{DS}{Q^2} = 0$$

Multiplying through by  $2Q^2$  gives  $Q^2C - 2DS = 0$

$$Q^2C = 2DS$$

$$Q^2 = \frac{2DS}{C}$$

$$Q = \sqrt{\frac{2DS}{C}} \text{ .....(1.0)}$$

The second derivative is

$$\frac{d^2TC}{dQ^2} = \frac{2DS}{Q^3}$$

Because the value of the second derivative is greater than zero,  $Q$  in equation (1.0) is the minimum cost solution (Anderson, Sweeney, Williams, 2003).

### Economic Order Quantity Assumptions

- a) Demand is known, constant and independent.
- b) Lead Time is known and constant.
- c) Receipt of material Instantaneous
- d) No quantity discounts
- e) Only order (setup) cost and holding cost
- f) No stock outs if orders are placed at the right time
- g) Order Quantity received all at once

### Examples to illustrate the use of the formula

- 1) Given that  $D = 4200$  units per year, Ordering cost  $S = \text{¢}5,000,000$  and carrying cost  $C = \text{¢}500,000$ . Find the EOQ.

#### Solution

$$\begin{aligned} EOQ &= \sqrt{\frac{2 \times 4200 \times 5000000}{500000}} \\ &= \sqrt{2 \times 4200 \times 10} \end{aligned}$$

$$= \sqrt{84000}$$

$$= 289.83 \text{ units}$$

$$\text{Frequency of ordering } F = \frac{D}{EOQ} = \frac{4200}{289.83} = 14.49$$

(No of order per year)

- 2) Kwame runs a mail-order business for gym equipment. Annual demand for the TricoFlexers is 16,000. The annual holding cost per unit is GH¢2.50 and the cost to place an order is GH¢50. What is the economic order quantity?

Solution

$$EOQ = \sqrt{\frac{2 \times 16000 \times 50}{2.5}}$$

$$= 800 \text{ units per order}$$

## ii. Economic Order Quantity (EOQ) for Production

In EOQ for production model, the annual inventory cost is determined as

TC = annual carrying cost + annual set up cost

$$= \left(\frac{Q}{2}\right) \left[\left(\frac{p-d}{p}\right)\right] C + \left(\frac{D}{Q}\right) S$$

Where  $d$  = demand rate (units per time period)

$P$  = production rate (units per time period)

$S$  = set up cost (cedis)

$$\left(\frac{Q}{2}\right) \left[\left(\frac{p-d}{p}\right)\right] = \text{average inventory levels (units)}$$

To determine the EOQ, set the derivative of TC with respect to Q to zero and solve for Q

$$Q = \sqrt{\left[ \frac{(2DS)}{C} \right] \left[ \frac{P}{(P-d)} \right]}$$

Assuming the production rate is larger than the demand rate, the maximum inventory, Im is

$$Im = \sqrt{\frac{2DS}{C} \frac{(p-d)}{p}}$$

iii. Economic Order Quantity (EOQ) for quantity discounts

TC = annual carrying cost + annual ordering cost + annual acquisition cost

For instantaneous delivery, TC is given by

$$TC = \left( \frac{Q}{2} \right) \times C + \left( \frac{D}{Q} \right) S + DP$$

For gradual delivery, TC is given by

$$TC = \frac{Q}{2} \times \left[ \frac{(P-d)}{p} \right] \times C + \left( \frac{D}{Q} \right) \times S + DP$$

The price reductions are usually offered in a series of ranges (Bronson, Naadimuthu, 2004).

iv. **Determination of EOQ where Stock Out is Permitted:**

To find the carrying and stock outs, it is necessary to find how much of the time the firms carry's stock or it's out of stock thus:

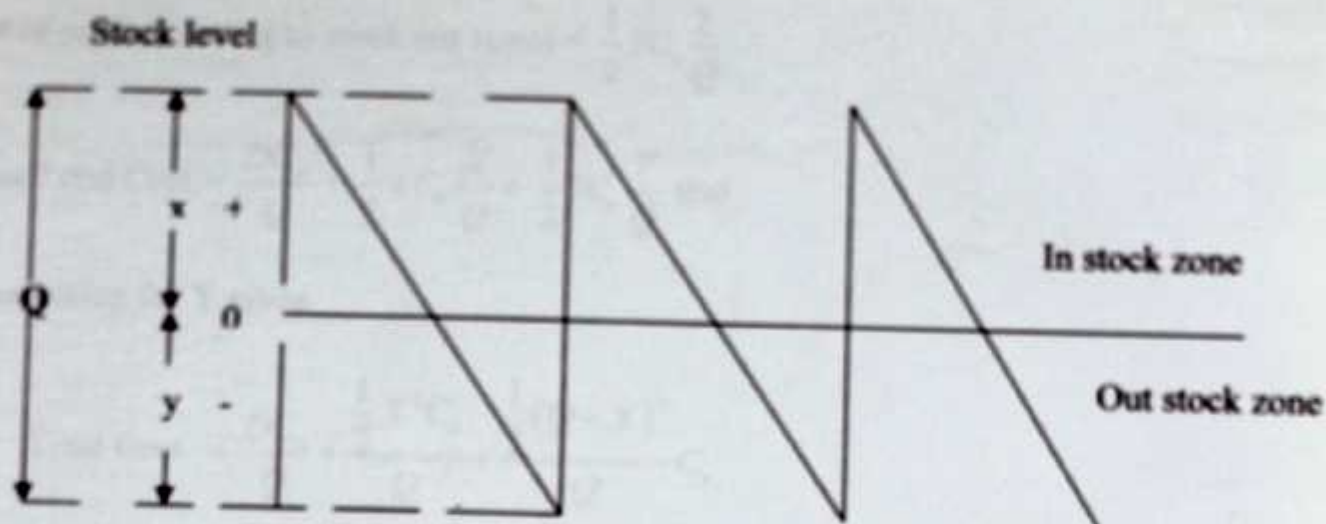


Figure 2.0

From Figure 2.0,

$$\text{Proportion of time in stock} = \frac{X}{Q}$$

$$\text{Proportion of time out of stock} = \frac{Y}{Q}$$

and as average stock is  $\frac{1}{2}$  the maximum level

$D$  = annual demand

$O$  = order quantity

$C_o$  = cost of ordering for one order

$C_c$  = carrying cost for one item per annum

$C_s$  = stock out cost

$T_c$  = ordering cost + carrying cost + stock out

$$\text{Where annual ordering cost} = \frac{DC_o}{Q}$$

$$\text{Carrying cost (out of cost zone)} = \frac{1}{2} \times C_c \frac{X}{Q}$$

$$\text{Out of stock (relating to stock out zone)} = \frac{1}{2}YC_s \frac{Y}{Q}$$

$$\text{Thus Total Cost} = \frac{DC_o}{Q} + \frac{1}{2} \times C_c \frac{X}{Q} + \frac{1}{2}YC_s \frac{Y}{Q} \text{ and}$$

Substituting for Y gives

$$\text{Total Cost} = \frac{DC_o}{Q} + \frac{\frac{1}{2}X^2C_c}{Q} + \frac{\frac{1}{2}(Q-X)^2}{Q}C_s$$

To find the minimum of the cost function, it is differentiated and the result set to zero.

There are two independent variables,  $X$  and  $Q$  and it is necessary to partially differentiate with respect to  $X$  and  $Q$  and set the results to zero (0).

$$\frac{\partial TC}{\partial X} = \frac{XC_c}{Q} - \frac{(Q-X)C_s}{Q}$$

$$\frac{\partial TC}{\partial Q} = \frac{-DC_o}{Q^2} - \frac{\frac{1}{2}X^2C_c}{Q^2} + \left( \frac{Q(Q-X)C_s - \frac{1}{2}(Q-X)^2}{Q^2} \right) C_s$$

$$\left( \frac{Q(Q-X)C_s - \frac{1}{2}(Q-X)^2}{Q^2} \right) C_s$$

Setting the results to zero and solving, we have

$$\frac{1}{Q}(XC_c - (Q-X)C_s) = 0$$

solving for  $X$  gives

$$X = \frac{Q \times C_s}{C_c + C_s}$$

$$-\frac{1}{Q^2} \left( DC_o + \frac{1}{2}X^2C_c - \frac{1}{2}(Q^2 - X^2)C_s \right) = 0$$

$$\Rightarrow Q^2 = \frac{2DC_o}{C_s} + \frac{X^2 C_c}{C_s} + X^2$$

$$= \frac{2DC_o}{C_s} + \frac{X^2 C_c + C_s}{C_s}$$

And as

$$X = Q \times \frac{C_s}{C_c + C_s}$$

This can be substituted as follows:

$$Q^2 = \frac{2DC_o}{C_s} + \frac{Q^2 C_s}{C_c + C_s}$$

$$Q^2 \left( 1 - \frac{C_s}{C_c + C_s} \right) = \frac{2DC_o}{C_s}$$

$$Q^2 \left( \frac{C_c}{C_c + C_s} \right) = \frac{2DC_o}{C_s}$$

$$Q^2 = \frac{2DC_o (C_c + C_s)}{C_c C_s}$$

$$Q = EOQ = \sqrt{\frac{2 \times D \times C_o}{C_c}} \times \sqrt{\frac{C_c + C_s}{C_s}}$$

It will be seen that the formula is the basic EOQ formula multiplied by new expression containing the stock out cost. (Lucy, 2002)

It must be emphasized that the system does not allow stock out and therefore the first model, the Economic Order Quantity for purchasing will be used in this study.

### **2.1.5 Stock Control Level**

Inherent in any system of inventory control is the concept of stock levels, which are normally expressed in physical units but may also be in monetary terms. The objective of establishing control levels is to ensure that excessive stocks are not carried and working capital is not sacrificed, thereby avoiding the likelihood of being out of stock of any material.

The following factors are to be considered when establishing control levels:

1. Working capital available and the cost of capital;
2. Average consumption or production requirements;
3. The re-order period (the period between placing the order and receiving delivery);
4. Storage space available;
5. Market conditions;
6. Economic order quantity;
7. Possibility of loss through deterioration or obsolescence;
8. Costs of ordering, receiving, inspecting and accounting.

The stock levels used in inventory control systems for both accounting and physical measures are minimum stock, maximum stock, re-order level and the re-order quantity or economic order quantity.

#### **Minimum Stock Level**

This the lowest level to which stocks should normally be allowed to fall, and is held as buffer stock to be made available in situations of non-delivery by a supplier. It takes into account the re-order level and average consumption in the average delivery period.

### **Maximum Stock Level**

This is the highest level to which stock should normally be allowed to rise, otherwise too much working capital is tied up, thus sacrificing liquidity, and there is a risk of loss through deterioration and obsolescence. It takes account of the re-order level, the re-order quantity and the minimum consumption in the minimum delivery period.

### **Re-order Level**

This is the level at which an order would normally be raised. It takes into account the maximum usage in the maximum delivery period (Lucey 2002). This system is also called the two-bin systems. The name 'two-bin systems' comes from the simplest method of operating the system whereby the stock is segregated into two bins. Stock is initially drawn from the first bin and a replenishment order issued when it becomes empty. Its characteristics are as follows:

- a) A predetermined re-order level is set for each item,
- b) When the stock level falls to the re-order level, a replenishment order is issued,
- c) The replenishment order is invariably the EOQ.

Once the re-order quantity has been determined, the other control levels can be determined by the following formulae:

Minimum stock level = Re-order level - (average usage in average delivery period).

Maximum stock level = Re-order level + re-order quantity - (minimum usage in minimum delivery period).

Re-order level = maximum usage x maximum delivery period.

### Illustration of a Re-order Level System

The following data relate to a particular stock item

Normal usage	110 per day
Minimum usage	50 per day
Maximum usage	140 per day
Lead-time	25-30 days
EOQ	5000

To compute the various control levels,

$$\begin{aligned} \text{(i) Reorder level} &= \text{maximum usage} \times \text{maximum lead time} \\ &= 140 \times 30 \\ &= 4200 \text{ units} \end{aligned}$$

$$\begin{aligned} \text{(ii) Minimum level} &= \text{Reorder level} - \text{Average usage in Average Lead Time} \\ &= (4200 - 110 \times 27.5) \\ &= 1175 \text{ units} \end{aligned}$$

$$\begin{aligned} \text{(iii) Maximum level} &= \text{Reorder level} + \text{EOQ} - \text{minimum anticipated usage in lead} \\ &\text{time} \\ &= 4200 + 500 - (50 \times 25) \\ &= 7,950 \text{ units} \end{aligned}$$

## 2.1.6 Probabilistic Model

A statistical Model is applicable when Product demand or any other variable is not known but can be specified by means of a probability distribution.

- i. This model shows how much and when to order
- ii. Demand is allowed to vary
  - Follows normal distribution
  - Other EOQ assumptions apply
- iii. It considers service level and safety stock
  - Service level = 1 - Probability of stockout
  - Higher service level means more safety stock
- iv. More safety stock means higher Re-Order-Point

### **Single – Period Inventory Model with Probabilistic Demand**

In situations in which the demand rate is not deterministic, models have been developed that treat demand as probabilistic and best described by a probability distribution (Anderson, Sweeney, Williams, 2003).

The single-period inventory model refers to inventory situations in which an order is placed for the product; at the end of the period, the product has either sold out, or a surplus of unsold items will be sold for a salvage value. The single-period inventory model is applicable in situations involving seasonal or perishable items that cannot be carried in inventory and sold in future periods. Seasonal clothing (such as bathing suits and winter coats) are typically handled in a single-period manner. In these situations, a

buyer places one pre-season order for each item and then experiences a stockout or holds a clearance sale on the surplus stock at the end of the season. No items are carried in inventory and sold the following year. Newspapers are another example of a product that is ordered one time and is either sold or not sold during the single period. Although newspapers are ordered daily they cannot be carried in inventory and sold in later periods. Thus, newspaper orders may be treated as a sequence of single-period models; that is, each day or period is separate, and a single-period inventory decision must be made each period (day). Because one orders only once for the period, the only inventory decision one must make is how much of the product to order at the start of the period.

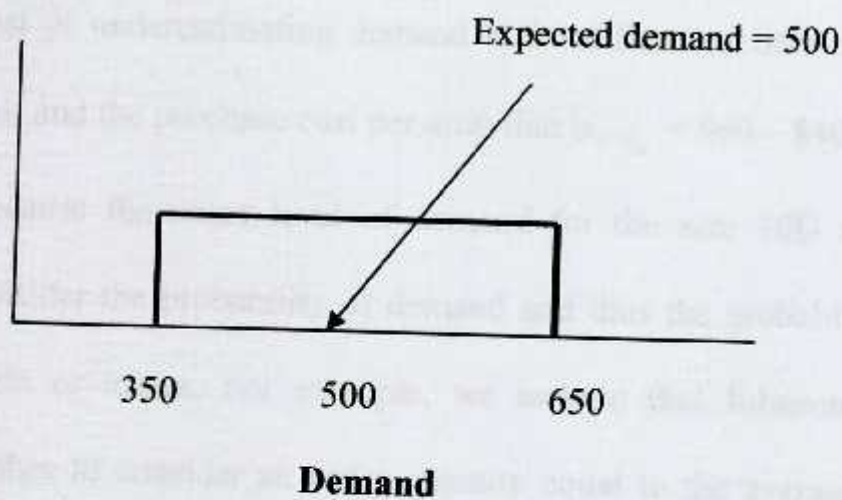
Obviously, if the demand were known for a single-period inventory situation, the solution would be easy; one would simply order the amount one knew would be demanded. However, in most single-period models, the exact demand is not known. In fact, forecasts may show that demand can have a wide variety of values. To analyze this type of inventory problem in a quantitative manner, one needs information about the probabilities associated with the various demand values. Thus, the single-period model is based on probabilistic demand.

### **Johnson Shoe Company**

We consider a single-period inventory model that could be used to make a how-much-to-order decision for the Johnson Shoe Company. The buyer for the Johnson Shoe Company has decided to order a shoe for men that has just been shown at a buyers' meeting in New York City. The shoe will be part of the company's spring-summer promotion and will be sold through nine retail stores in the Chicago area. Because the shoe is designed for spring and summer months, it cannot be expected to sell in the fall. Johnson plans to hold

a special August clearance sale in an attempt to sell all shoes that have not been sold by July 31. The shoe costs \$40 a pair and the retail for \$60 a pair. At the sale price of \$30 a pair, all surplus shoes can be expected to sell during the August sale. How many pairs of the shoes would one order?

An obvious question at this time is what are the possible values of demand for the shoe? One needs this information to answer the question of how much to order. Let us suppose that the uniform probability distribution shown in Figure 2.1 can be used to describe the demand for the size 10D shoes. In particular, note that the range of demand is from 350 to 650 pairs of shoes, with an average, or expected, demand of 500 pairs of shoes.



**Figure 2.1 Uniform probability Distribution of demand for the Johnson shoe company problem**

Incremental analysis is a method that can be used to determine the optimal order quantity for a single-period inventory model. Incremental analysis addresses the how-much-to-

order question by comparing the cost or loss of ordering one additional unit with the cost or loss of not ordering one additional unit. The costs involved are defined as follows:

$c_o$  = Cost per unit of overestimating demand. This cost represents the loss of ordering one additional unit and finding that it cannot be sold.

$c_u$  = Cost per unit of underestimating demand. This cost represent the opportunity loss of not ordering one additional unit and finding that it could have been sold.

In the Johnson Shoe Company problem, the company will incur the cost of overestimating demand whenever it orders too much and has to sell the extra shoes during the August sale. Thus, the cost per unit of overestimating demand is equal to the purchase cost per unit minus the August sale price per unit; that is,  $c_o = \$40 - \$30 = \$10$ .

Therefore, Johnson will lose \$10 for each pair of shoes that it orders over the quantity demanded. The cost of underestimating demand is the lost profit (contribution) because a pair of shoes that could have been sold was not available in inventory. Thus, the per-unit cost of underestimating demand is the difference between the regular selling price per unit and the purchase cost per unit; that is,  $c_u = \$60 - \$40 = \$20$ .

Because the exact level of demand for the size 10D shoes is unknown, one has to consider the probability of demand and thus the probability of obtaining the associated costs or losses. For example, we assume that Johnson Shoe Company management wishes to consider an order quantity equal to the average or expected demand for 500 pairs of shoes. In incremental analysis, we consider the possible losses associated with an order quantity of 501 (ordering one additional unit) and an order quantity of 500 (not ordering one additional unit). The order quantity alternatives and the possible losses are summarized here.

Order Quantity Alternatives	Loss Occurs If	Possible Loss	Probability Loss Occurs
$Q = 501$	Demand overestimated; the additional unit cannot be sold	$c_o = \text{¢}10$	$P(\text{demand} \leq 500)$
$Q = 500$ $P(\text{demand} > 500)$	Demand underestimated; an additional unit could have been sold	$c_u = \text{¢}20$	

By looking at the demand probability distribution in Figure 2.1, we see that  $P(\text{demand} \leq 500) = 0.5$  and that  $P(\text{demand} > 500) = 0.5$ . By multiplying the possible losses,  $c_o = \text{¢}10$  and  $c_u = \text{¢}20$ , by the probability of obtaining the loss, we can compute the expected value of the loss, or simply the expected loss (EL), associated with the order quantity. Thus

$$EL(Q = 501) = c_o P(\text{demand} \leq 500) = \$10(0.50) = \$5$$

$$EL(Q = 500) = c_u P(\text{demand} > 500) = \$20(0.50) = \$10$$

Based on these expected losses, does one prefer an order quantity of 501 or 500 pairs of shoes? Because the expected loss is greater for  $Q = 500$ , and because we want to avoid this higher cost or loss, we should make  $Q = 501$  the preferred decision. We could consider incrementing the order quantity by one additional unit to  $Q = 502$  and repeating the expected loss calculations.

Although we could continue this unit-by-unit analysis, it would be time-consuming and cumbersome. We would have to evaluate  $Q = 502$ ,  $Q = 503$ ,  $Q = 504$ , and so on, until we

found the value of  $Q$  where the expected loss of ordering one incremental unit is equal to the expected loss of not ordering one incremental unit; that is, the optimal order quantity  $Q^*$  occurs when the incremental analysis shows that

$$EL(Q^* + 1) = EL(Q^*) \dots \dots \dots (2.1)$$

when the relationship holds, increasing the order quantity by one additional unit has no economic advantage. Using the logic with which we compute the expected losses for the order quantities of 501 and 500, the general expression for  $EL(Q^* + 1)$  and  $EL(Q^*)$  can be written

$$EL(Q^* + 1) = c_o P(\text{demand} \leq Q^*) \dots \dots \dots (2.2)$$

$$EL(Q^*) = c_u P(\text{demand} > Q^*) \dots \dots \dots (2.3)$$

Because we know from basic probability that

$$P(\text{demand} \leq Q^*) + P(\text{demand} > Q^*) = 1$$

we can write

$$P(\text{demand} > Q^*) = 1 - P(\text{demand} \leq Q^*)$$

Using this expression, equation (2.3) can be rewritten as

$$EL(Q^*) = c_u [1 - P(\text{demand} \leq Q^*)] \dots \dots \dots (2.4)$$

Equations (2.2) and (2.4) can be used to show that  $EL(Q^* + 1) = EL(Q^*)$  whenever

$$c_o P(\text{demand} \leq Q^*) = c_u [1 - P(\text{demand} \leq Q^*)] \dots \dots \dots (2.5)$$

Solving for  $P(\text{demand} \leq Q^*)$ , we have

$$P(\text{demand} \leq Q^*) = \frac{c_u}{c_u + c_o} \dots \dots \dots (2.6)$$

which provides the general condition for the optimal order quantity  $Q^*$  in the single-period inventory model (Anderson, Sweeney, Williams, 2003).

In the Johnson Shoe Company problem  $c_o = \text{€}10$  and  $c_u = \text{€}20$ . Thus, equation (2.6) shows that the optimal order size for Johnson shoes must satisfy the following conditions:

$$P(\text{demand} \leq Q^*) = \frac{c_u}{c_u + c_o} = \frac{20}{20 + 10} = \frac{20}{30} = \frac{2}{3}$$

The optimal order quantity  $Q^*$  can be found by referring to the probability distribution shown in Figure 2.1 and finding the value of  $Q$  that will provide  $P(\text{demand} \leq Q^*) = \frac{2}{3}$ .

To find this solution, we note that in the uniform distribution the probability is evenly distributed over the entire range of 350 – 650 pairs of shoes. Thus, one can satisfy the expression for  $Q^*$  by moving two-thirds of the way from 350 to 650. Because this range is  $650 - 350 = 300$ , we move 200 units from 350 towards 650. Doing so provides the optimal order quantity of 550 pairs of size 10D shoes.

The key to establishing an optimal order quantity for single-period inventory model is to identify the probability distribution that describes the demand for the item and the costs of overestimation and underestimation. Then using the information for the cost of overestimation and underestimation, equation (2.8) can be used to find the location of  $Q^*$  in the probability distribution.



## Nationwide Car Rental (Illustration 2)

As another example of a single-period inventory model with probabilistic demand, we consider the situation faced by Nationwide Car Rental. Nationwide must decide how many automobiles to have available at each car rental location at specific point in time throughout the year. Using the Myrtle Beach, South Carolina, location as an example, management would like to know the number of full-sized automobiles to have available for the Labor Day weekend. Based on a previous experience, customer demand for full-sized automobiles for the Labor Day weekend has a normal distribution with mean of 150 automobiles and a standard deviation of 14 automobiles.

The Nationwide Car Rental situation can benefit from use of a single-period inventory model. The company must establish the number of full-size automobiles to have available prior to the weekend. Customer demand over the weekend will then result in either a stockout or a surplus. We denote the number of full-sized automobiles available by  $Q$ . If  $Q$  is greater than customer demand, Nationwide will have a surplus of cars. The cost of a surplus is the cost of overestimating demand. This cost is set at \$80 per car, which reflects, in part, the opportunity cost of not having the car available for rent elsewhere.

If  $Q$  is less than customer demand, Nationwide will rent all available cars and experience a stock out or shortage. A shortage results in an underestimation cost of \$200 per car. This figure reflects the cost due to lost profit and lost goodwill of not having a car available for a customer. Given this information, how many full-sized automobiles should Nationwide make available for the Labor Day weekend?

Using the cost of underestimation,  $c_u = \text{€}200$ , and the cost of overestimation,  $c_o = \text{€}80$ ,

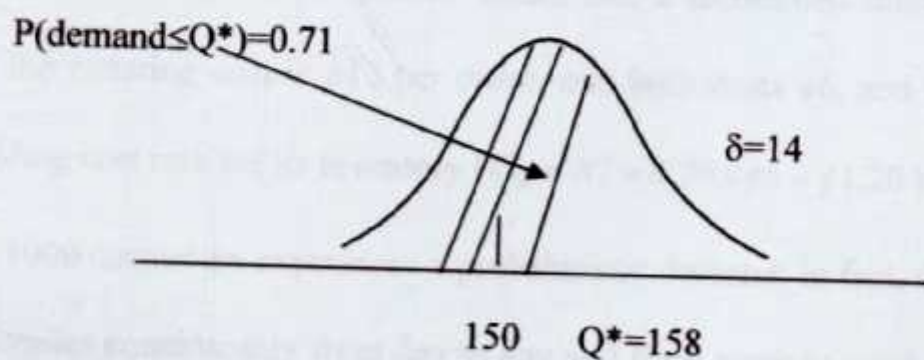
equation (2.6) indicates that the optimal order quantity must satisfy the following conditions:

$$P(\text{demand} \leq Q^*) = \frac{c_u}{c_u + c_o} = \frac{200}{200 + 80} = 0.7143$$

we can use the normal probability distribution for demand as shown in Figure 2.2 to find the order quantity that satisfies the condition that  $P(\text{demand} \leq Q^*) = 0.7143$ . We see that 0.7143 of the area in the left tail of the normal probability distribution occurs at  $z = 0.57$  standard deviation above the mean. With a mean demand of  $\mu = 150$  automobiles and a standard deviation of  $\sigma = 14$  automobiles, we have

$$\begin{aligned} Q^* &= \mu + 0.57\sigma \\ &= 150 + 0.57(14) = 158 \end{aligned}$$

Thus, Nationwide car rentals should plan to have 158 full-sized automobiles available in Myrtle Beach for the Labor Day weekend. In this case the cost of overestimation is less than the cost of underestimation. Thus, Nationwide is willing to risk a higher probability of overestimating demand and hence a higher probability of a surplus. In fact, Nationwide optimal order quantity has a 0.7143 probability of a surplus and a  $1 - 0.7143 = 0.2857$  probability of a stockout. As a result, the probability is 0.2857 that all 158 full-sized automobiles will be rented during the Labor Day weekend.



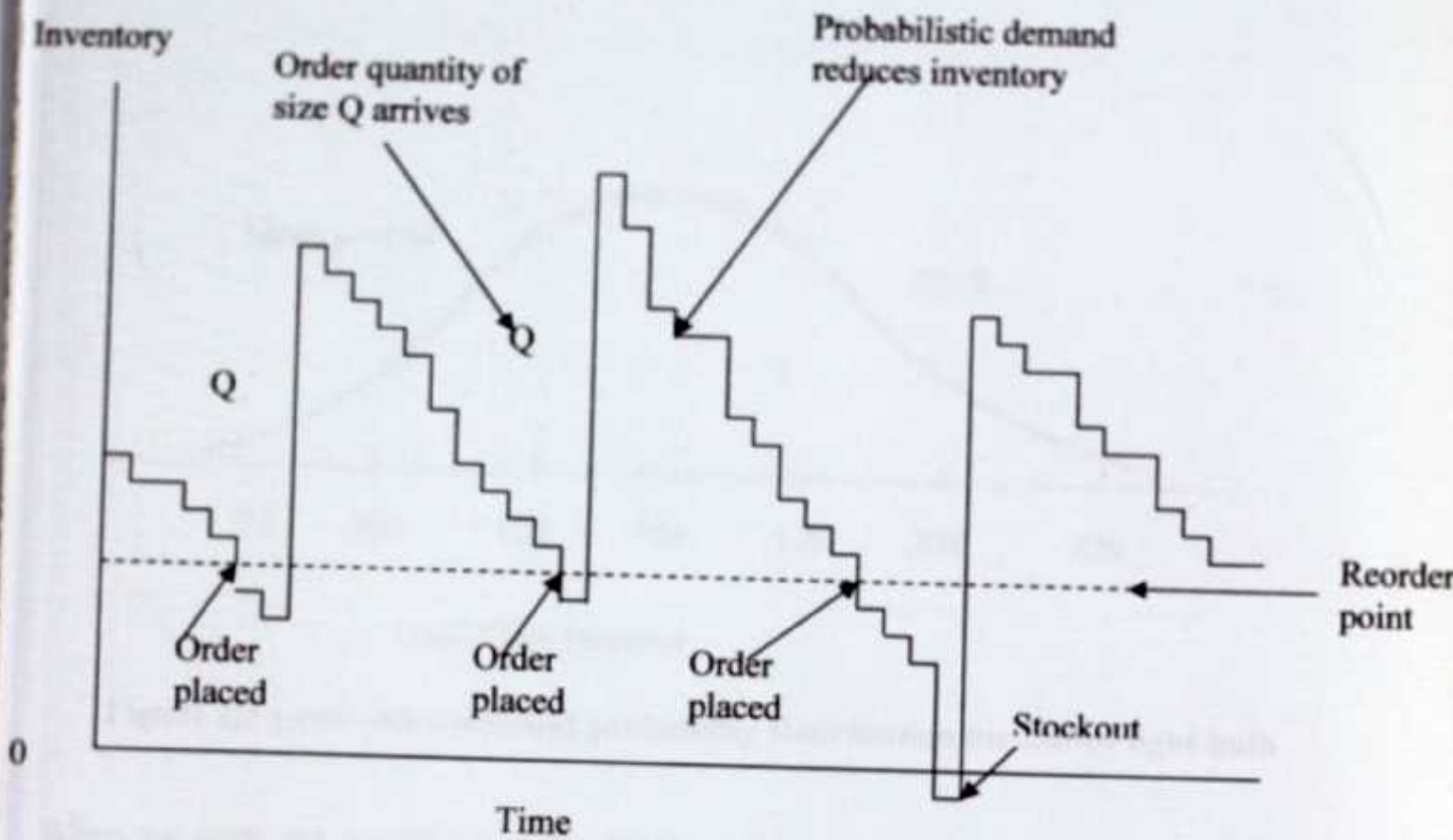
### Order - Quantity, Reorder Point Model with Probabilistic Demand

In the multi-period model, the inventory system operates continuously with many repeating period or cycles; inventory can be carried from one period to the next. Whenever the inventory position reaches the reorder point, an order for say  $Q$  units is placed. Because demand is probabilistic, the time the reorder point will be reached, the time between orders, and the time the order of  $Q$  units will arrive in inventory cannot be determined in advance.

The inventory decreases at a non-constant rate based on the probabilistic demand. A new order is placed whenever the reorder point is reached. At times, the order quantity of  $Q$  units will arrive before inventory reaches zero. However, at other times, demand will cause a stockout before a new order is received. As with other order - quantity, reorder point models, the manager must determine the order quantity  $Q$  and the reorder point  $r$  for the inventory system.

We consider the inventory problem of Dabco Industrial Lighting Distributors. Dabco purchases a special high - intensity light bulb for industrial lighting systems from a well-known light bulb manufacturer. Dabco would like a recommendation on how much to order that the ordering cost is €12 per order, one bulb costs €6, and Dabco uses a 20% annual holding cost rate for its inventory ( $C_h = IC = 0.20 \times €6 = €1.20$ ). Dabco, which has more than 1000 customers experience a probabilistic demand; in fact, the number of units demanded varies considerably from day to day and from week to week. The lead-time for

1-week lead-time can be described by a normal probability distribution with a mean of 154 light bulbs and a standard deviation of 25 light bulbs. The normal distribution of demand during the lead-time is shown in Figure 2.3. Because the mean demand during 1-week is 154 units, Dabco can anticipate a mean or expected annual demand of 154 units per week  $\times$  52 weeks per year, which gives 8008 units per year.

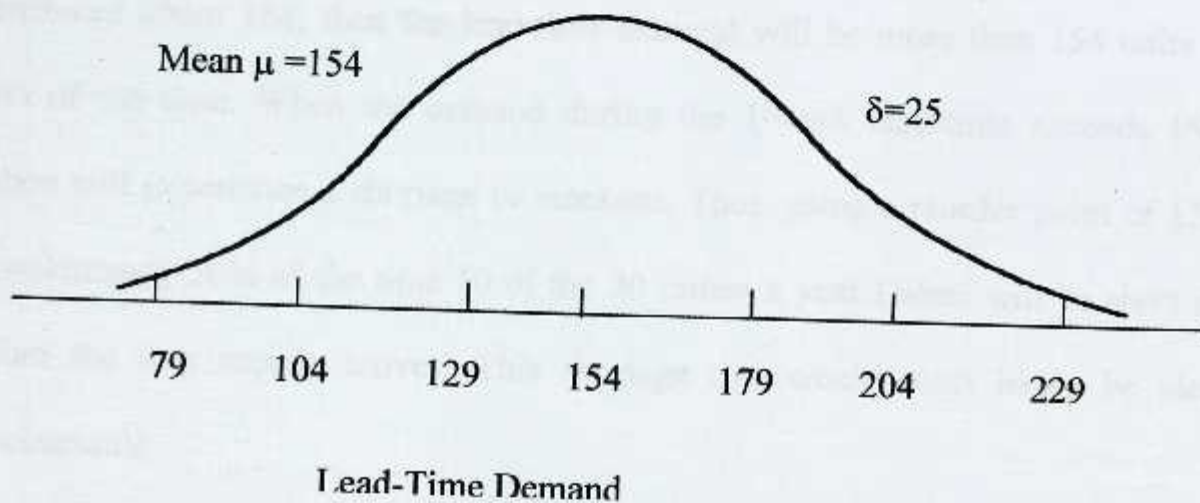


**Inventory Pattern for an order quantity, reorder point model with probabilistic demand**

## THE HOW MUCH TO-ORDER DECISION

Although we are in a probabilistic demand situation, we have an estimate of the expected annual demand of 8008 units. We can apply the EOQ model as an approximation of the best order quantity, with the expected annual demand used for  $D$ . In Dabco's case

$$Q^* = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2(8008)(12)}{1.20}} = 400 \text{ units}$$



**Figure 2.3 Lead-time demand probability Distribution for Dabco light bulb**

When we study the sensitivity of the EOQ model, it will be seen that the total cost of operating an inventory system is insensitive to order quantities that are in the neighborhood of  $Q^*$ . Using this knowledge, we expect 400 units per order to be a good approximation of the optimal order quantity. Even if annual demand were as low as 7000 units or as high as 9000 units, an order quantity of 400 units should be a relatively good low-cost order size. Thus, given the best estimate of annual demand at 8008 units,  $Q^* = 400$  will be used. The 400-units order quantity can be established by ignoring the fact that demand is probabilistic. Using  $Q^* = 400$ , Dabco can anticipate placing approximately

$\frac{D}{Q^*} = \frac{8008}{400} = 20$  orders per year with an average of approximately  $\frac{250}{20} = 12.5$  working days between orders.

### The When-to-Order Decision

We now want to establish a when-to-order decision rule or reorder point that will trigger the ordering process. With a mean lead-time demand of 154 units, one might first suggest a 154-unit reorder point. However, considering the probability of demand now becomes extremely important. If 154 is the mean lead demand, and if demand is symmetrically distributed about 154, then the lead-time demand will be more than 154 units roughly 50% of the time. When the demand during the 1-week lead-time exceeds 154 units, Dabco will experience a shortage or stockout. Thus, using a reorder point of 154 units, approximately 50% of the time 10 of the 20 orders a year Dabco will be short of bulbs before the new supply arrives. This shortage rate would most likely be viewed as unacceptable.

Refer to the lead-time demand distribution shown in figure 2.3. Given this distribution, we can now determine how the reorder point  $r$  affects the probability of a stockout. Because stockouts occur whenever the demand during the lead-time exceeds the reorder point, we can find the probability of a stockout by using the lead-time demand distribution to compute the probability that demand will exceed  $r$ .

One can now approach the when-to-order problem by defining a cost per stockout and then attempting to include this cost in a total cost equation. Alternatively, one can ask management to specify the average number of stockouts that can be tolerated per year. If demand for a product is probabilistic, a manager who will never tolerate a stockout is

being somewhat unrealistic because attempting to avoid stockouts completely will require high reorder points, high inventory, and an associated high holding cost.

Suppose in this case that Dabco management is willing to tolerate an average of one stockout per year because Dabco places 20 orders per year. This decision implies that management is willing to allow demand during lead-time to exceed the reorder point one time in 20, or 5% of the time. The reorder point  $r$  can be found by using the lead-time demand distribution to find the value of  $r$  with a 5% chance of having a lead-time demand that will exceed it. This situation is shown graphically in figure 2.4.

From the standard normal distribution table, the  $r$  value is 1.645 standard deviations above the mean. Therefore, for the assumed normal distribution for lead-time demand with  $\mu = 154$  and  $\delta = 25$ . The reorder point  $r$  is

$$r = 154 + 1.645(25) = 195$$

If a normal distribution is used for lead time demand, the general equation for  $r$  is

$$r = \mu + z\sigma \dots \dots \dots (2.7)$$

Where  $z$  is the number of standard deviations necessary to obtain the acceptable stockout probability.

Thus, the recommended inventory decision is to order 400 units whenever the inventory reaches the reorder point of 195. Because the mean or expected demand during the lead-time is 154 units, the  $195 - 154 = 41$  unit serve as a safety stock which absorbs higher-

than-usual demand during the lead-time. The anticipated annual cost for this system is as follows:

$$\text{Holding cost, normal inventory } \left(\frac{Q}{2}\right)C_h = \left(\frac{400}{2}\right)(1.20) = \text{¢}240$$

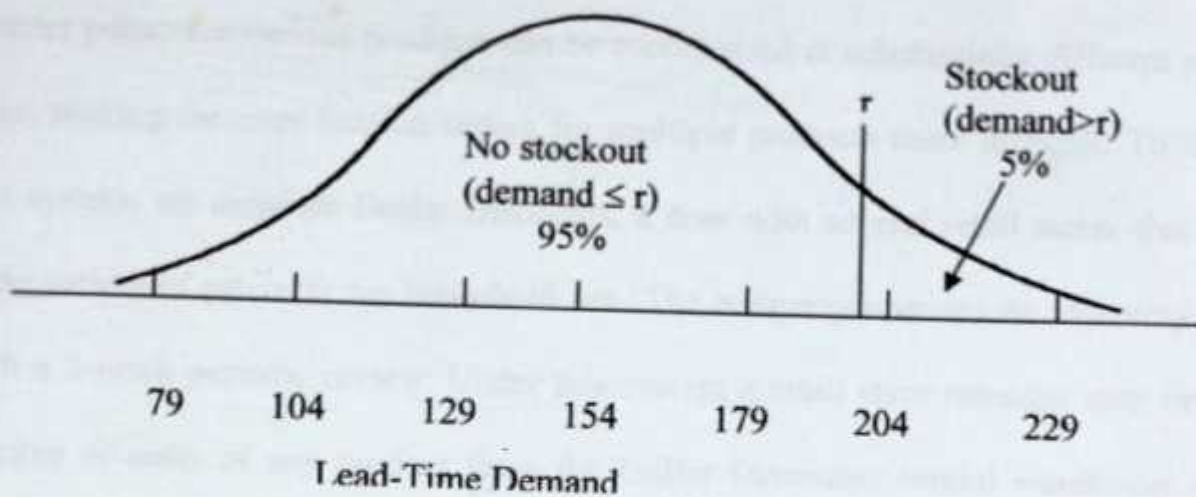
$$\text{Holding cost, safety stock } (41)C_h = 41(1.20) = \text{¢}49$$

$$(D/Q)C_o = \left(\frac{8008}{400}\right)12 = \text{¢}240$$

Ordering cost

$$\text{TOTAL} = \underline{\underline{\text{¢}529}}$$

If Dabco could have assumed that a known, constant demand rate of 8008 unit per year existed for the light bulbs,  $Q^* = 400$ ,  $r = 154$ , and a total annual cost of  $\text{¢}240 + \text{¢}240 = \text{¢}480$  would have been optimal. When demand is uncertain and can only be expressed in probabilistic terms, a larger total cost can be expected. The larger cost occurs in the form of larger holding costs because more inventories must be maintained to limit the number of stockouts. For Dabco, this additional inventory or safety stock was 41 unit, with an additional annual holding cost of  $\text{¢}49$ .



**Figure 2.4** reorder point  $r$  that allows a 5% chance of a stockout for Dabco light bulbs.

### Periodic Review Model with Probabilistic Demand

In a continuous review inventory system, the position is monitored continuously so that an order can be placed whenever the reorder point is reached. Computerized inventory systems can easily provide the continuous review required by the order-quantity, reorder point models.

An alternative to the continuous review system is the periodic review inventory system. With a periodic review system, the inventory is checked and reordering is done only at specified points in time. For example, inventory may be checked and orders placed on a weekly, biweekly, monthly or some other periodic basis. When a firm or business handles multiple products, the periodic review system has the advantage of requiring that order for several items be placed at the same preset periodic review time. With this type of inventory system, the shipping and receiving of orders for multiple products are easily

coordinated. Under the previously discussed order-quantity, reorder point systems, the reorder points for various products can be encountered at substantially different points in time, making the coordination orders for multiple products more difficult. To illustrate this system, we consider Dollar Discounts, a firm with several retail stores that carry a wide variety of products for household use. The company operates its inventory system with a 2-week periodic review. Under this system a retail store manager may order any number of units of any product from the Dollar Discounts central warehouse every 2 weeks. Orders for all products going to a particular store are combined into one shipment. When making the order quantity decision for each product at a given review period, the store manager knows that a reorder for the product cannot be made until the next review period.

Assuming that the lead-time is less than the length of the review period. An order placed at a review period will be received prior to the next review period. In this case the how-much- to- order decision at any review period is determined using the following:

$$Q = M - H \dots\dots\dots (2.8)$$

Where

$Q$  = the order quantity

$M$  = the replenishment level

$H$  = the inventory on hand at the review period

Because the demand is probabilistic, the inventory on hand at the review period,  $H$ , will vary. Thus, the order quantity that must be sufficient to bring the inventory position back

to its maximum or replenishment level  $M$  can be expected to vary each period. For example, if the replenishment level for a particular product is 50 units, and the inventory on hand at the review period is  $H = 12$  units, an order of  $Q = M - H = 50 - 12 = 38$  units should be made. Thus, under the periodic review model, enough units are ordered each review period to bring the inventory position back up to the replenishment level.

A typical inventory pattern for a periodic review with probabilistic demand is shown in figure 2.5. The time between periodic reviews is predetermined and fixed. The order quantity  $Q$  at each review period can vary and is shown to be the difference between the replenishment level and the inventory on hand. Finally, as with other probabilistic models, an unusually high demand can result in an occasional stockout.

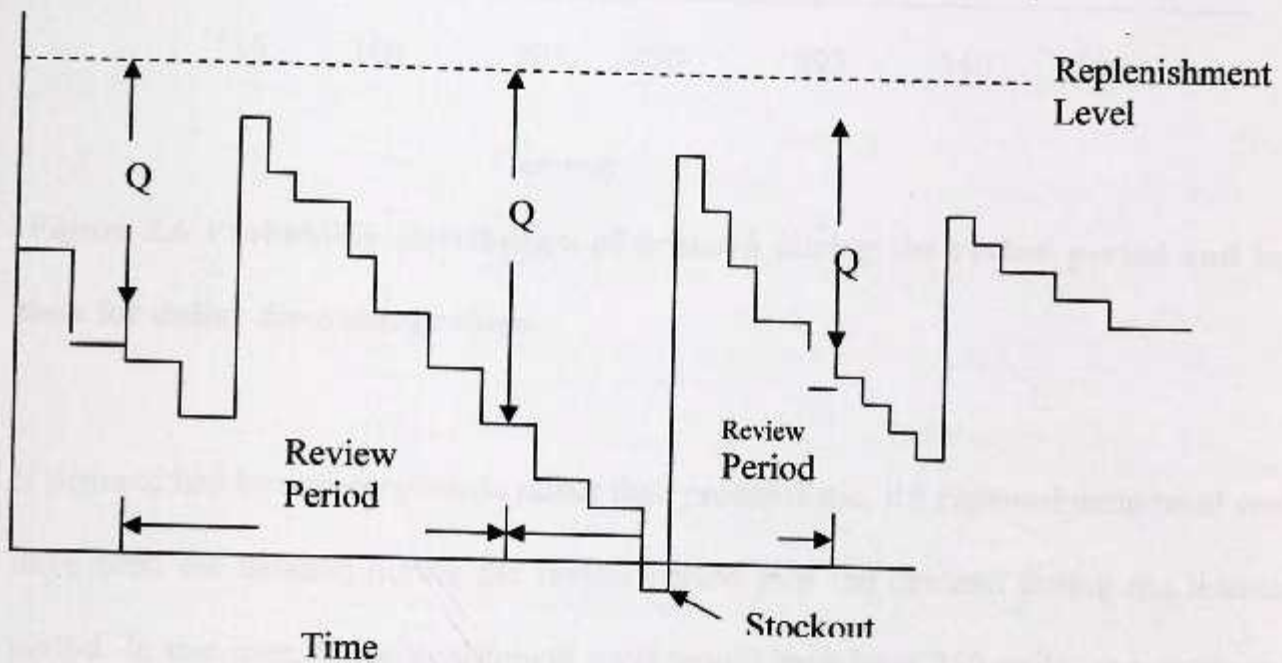
The decision variable in the periodic review model is the replenishment level  $M$ . To determine  $M$ , one can begin by developing a total cost model, including holding, ordering and stockout costs. The approach that is often used in practice is to determine a replenishment level that will meet a desired performance level, such as a reasonably low probability of stockout or a reasonably low number of stockouts per year.

In the Discounts problem, we assume that management's objective is to determine the replenishment level with only 1% chance of stockout. In the periodic review model, the order quantity at each review period must be sufficient to cover demand for the review period plus the demand for the following lead-time. That is, the order quantity that brings the inventory position up to the replenishment level  $M$  must last until the order made at the next review period is received in inventory. The length of this time is equal to the

review period plus the lead-time. Figure 2.6 shows the normal probability distribution of demand during the review period plus the lead-time period for one of the Discounts products. The mean demand is 250 units, and the standard deviation of demand is 45 units. Figure 2.7 shows the replenishment level  $M$  with a 1% chance that demand will exceed that replenishment level. In other words, figure 2.7 shows replenishment level that allows a 1% chance of a stockout associated with the replenishment decision. Using the normal probability distribution table, the value of  $M$  that is 2.33 standard deviation above the mean will allow stockouts with a 1% probability. Therefore for the assumed normal distribution with  $\mu = 250$  and  $\delta = 45$ , the replenishment level is determined by

$$M = 250 + 2.33(45) = 355$$

Inventory

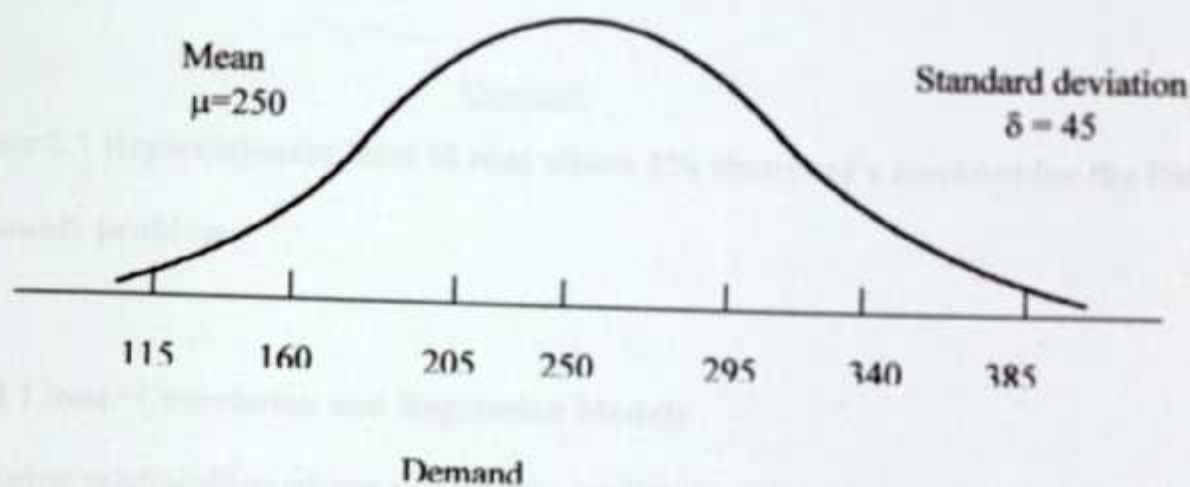


**Fig 2.5 Inventory pattern for periodic review model with probabilistic demand**

Although other probability distribution can be used to express demand during the review period plus the lead-time period, if the normal probability distribution is used, the general expression for  $M$  is

$$M = \mu + z\delta \dots\dots\dots (2.9)$$

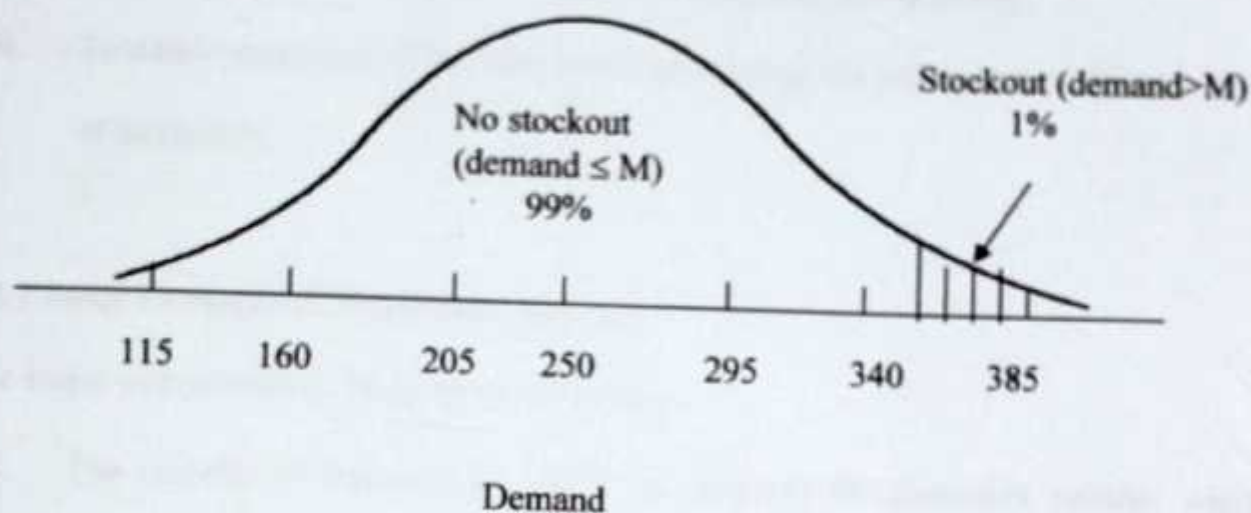
where  $z$  is the number of standard deviations necessary to obtain the acceptable stockout probability.



**Figure 2.6 Probability distribution of demand during the review period and lead-time for dollar discounts problem**

If demand had been deterministic rather than probabilistic, the replenishment level would have been the demand during the review period plus the demand during the lead-time period. In this case, the replenishment level would have been 250 units, and no stockout would have occurred. However, with the probabilistic demand, we see that higher inventory is necessary to allow for uncertain demand and to control the probability of a stockout. In the Dollar Discounts problem,  $355 - 250 = 105$  is the safety stock that is necessary to absorb any higher-than-usual demand during the review period plus the

demand during the lead-time period. This safety stock limits the probability of a stockout to 1%



**Figure 2.7 Replenishment level M that allows 1% chance of a stockout for the Dollar Discounts problem**

### 2.2.1 Linear Correlation and Regression Models

Exploring relationships among variables to predict the value of one variable from a set of related variables is of course important in planning and decision – making. Problems arising from such situations lead to the construction of a mathematical model called Regression, which expresses the functional relationships among the variables. The entire process of developing a regression model usually based on sample data and drawing inferences about results is called regression analysis. This leads to another related analysis called correlation analysis, which is concerned with the strength of association between the variables of interest and other variables. The main objectives of regression analysis are:

- i. To find out the type of association if it exists (whether linear or non-linear association).
- ii. To what extent the knowledge of the independent variables could be used to predict or estimate the variables of interest (dependent variables).
- iii. To obtain measures of the error involved in using the regression model as a basis of estimation.

### 2.2.2 Basic Concepts of Regression Analysis

The major components of Regression model are:

- i. The variable of interest ( $Y$ ) called the response or dependent variable which represents the effects or response resulting from combination of factors.
- ii. The factors, on which the response variable depends, represented by other variables,  $X, W, Z$ , etc called the predictor or independent variables.

For a response variable  $Y$  which depends on the predictor variable  $X, W$  or  $Z$ , the mean response due to specified predictor values  $X = x, W = w, Z = z$  is represented by

$$E(y/x, w, z) = f(x, w, z) \dots \dots \dots (2.10)$$

This is called the regression equation or function.

The regression model therefore takes the form

$$Y = f(x, w, z) + \epsilon \dots \dots \dots (2.11)$$

Where  $\epsilon$  is the error term which represents a random deviation of a typical response value from the mean response. The error term thus caters for errors due to chance and neglected factors which are assumed to be of less importance.

The regression models are classified according unto the number of predictor variables and also the form of the regression function.

**i. Simple Regression Model**

This model has only one predictor variable,  $x$ . Hence equation (2.10) becomes

$$E(y/x) = f(x) \dots \dots \dots (2.12)$$

or equivalently

$$E(y/x, z) = (a + xz)$$

$$Y = f(x) + \epsilon \dots \dots \dots (2.13)$$

**ii. Multiple Regression Model**

It involves more than one predictor variable as in equation (2.10) or (2.11)

**iii. Linear Regression Models**

These are the simplest regression relations in which the regression function  $f(x, w, z)$  is a linear function of the predictor variables. For example,

a) The total production cost ( $Y$ ) and production size ( $X$ ) may take the form:

$$E(y/x) = a + bx, \text{ which is a simple linear regression model.}$$

b) Income ( $y$ ) of persons may be related to number of years of schooling ( $x$ ) and the number of years in the job ( $z$ ), taking the form:

$$E(y/x, z) = a + bx + cz, \text{ which is a linear regression model.}$$

#### iv. **Non-Linear Regression Models**

These models may contain one or more predictor variable and/or with a second or more order degree. For example,

a.  $E(y/x) = a + bx + cx^2$ , or

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \varepsilon_i$$

b.  $E(y/x, z) = (a + xz)$  or

$$Y = \beta_0 + xz$$

c.  $E(y/x) = a + b \log x$

d.  $E(y/x, z) = ax + be^z$

### 2.2.3 Simple Linear Regression Model

#### **Definition and features of model**

The simple linear regression model is given by

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \dots \dots \dots (2.14)$$

where

$Y_i$  - is the value of the response (or dependent) variable in the  $i$ th observation.

$X_i$  - is a known constant which is the value of the predictor (or dependent) variable in the  $i$ th observation.

$\varepsilon_i$  - is the random error term which caters for errors due to chance and neglected factors which we assume are not important.

$\beta_0, \beta_1$  - are the parameters of the model.

$\beta_0$  - gives the intercept on the y-axis



$\beta_1$  - measures the slope of the linear model.

The model is made up of two components:

- i. The constant term,  $\beta_0 + \beta_1 X_i$  and
- ii. The random error term  $\varepsilon_i$ . Hence  $y_i$  is a random variable.

### Assumptions of Model

- (i) The response variable is represented by the probabilistic model given in equation (2.14), where  $X_i$  is measured error and that the values of  $y_i$  are random and independent of each other.
- (ii) The mean of the error term,  $E(\varepsilon_i) = 0$
- (iii) The variance of the probability distribution of  $\varepsilon_i$  is the constant,  $\sigma^2$ , i.e.  
 $Var(\varepsilon_i) = \sigma^2$ , for all  $X_i$
- (iv) The random error,  $\varepsilon_i \sim N(0, \sigma^2)$
- (v) The random errors,  $\varepsilon_i$  and  $\varepsilon_j$  are independent i.e.  
 $Cor(\varepsilon_i, \varepsilon_j) = 0, i \neq j$  (they are uncorrelated)

From the above assumptions the following are established:

(i)  $E(Y_i) = E(\beta_0 + \beta_1 X_i + \varepsilon_i) = \beta_0 + \beta_1 X_i + E(\varepsilon_i)$   
 $E(Y_i) = \beta_0 + \beta_1 X_i \dots \dots \dots (2.15)$

$Var(Y_i) = Var(\beta_0 + \beta_1 X_i + \varepsilon_i) = Var(\varepsilon_i)$

i.e.  $Var(Y_i) = \sigma^2, \forall X_i$

$$(ii) \quad Y_i \sim N(\beta_0 + \beta_1 X_i, \sigma^2)$$

$$(iii) \quad Cov(Y_i, Y_j) = 0$$

The model in equation (2.14) is said to be:

- (i) Simple because there is only one independent variable.
- (ii) Linear in the parameters because no parameter appears as an exponent or is multiplied or divided by another and
- (iii) Linear in the independent variable because this variable appears only in the first order. The model is also said to be a first-order model because it is linear in the parameters and the independent variable.

#### Alternative Versions of Model (2.14)

Sometimes it may be convenient to write the model in question 2.17 in the following equivalent forms:

$$y_i = \beta_0 X_0 + \beta_1 X_i + \varepsilon_i \dots \dots \dots (2.16)$$

Where,  $X_0$  is a dummy variable = 1

$$y_i = \beta_0 + \beta_1(X_i - \bar{X}) + \beta_1 \bar{X} + \varepsilon_i$$

$$y_i = (\beta_0 + \beta_1 \bar{X}) + \beta_1(X_i - \bar{X}) + \varepsilon_i$$

$$y_i = \beta_0^* + \beta_1(X_i - \bar{X}) + \varepsilon_i \dots \dots \dots (2.17)$$

Where  $\beta_0^* = \beta_0 + \beta_1 \bar{X}$  and  $\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$ .

And

$$E(Y_i) = \beta_0^* + \beta_1(X_i - \bar{X}) \dots \dots \dots (2.18)$$

### 2.2.4 Correlation Coefficient

This is a quantitative measure of the strength of linear relationship between two variables, say  $X$  and  $Y$ . There are two types of measures:

- i. Pearson product moment correlation coefficient and
- ii. Spearman's Rank correlation coefficient

#### i. Pearson product-moment correlation coefficient

This is used for quantitative data measured on interval or ratio scale.

It is defined by

$$r = \frac{\text{cov}(x, y)}{\sigma_x \sigma_y} = \frac{SS_{xy}}{\sqrt{SS_{xx}} \sqrt{SS_{yy}}} \dots \dots \dots (2.19)$$

for a given  $n$  observations on  $x$  and  $y$  where

$$SS_{xy} = \sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y}), \text{ Sum of the product } X_i Y_i$$

$$SS_{xx} = \sum_{i=1}^n (X_i - \bar{X})^2 \text{ Sum of the squares for } X_i$$

$$SS_{yy} = \sum_{i=1}^n (Y_i - \bar{Y})^2, \text{ Sum of squares for } Y_i$$

i.e.

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 \sum_{i=1}^n (Y_i - \bar{Y})^2}} \dots \dots \dots (2.20)$$

$$r = \frac{\sum_{i=1}^n X_i Y_i - \frac{\left(\sum_{i=1}^n X_i\right)\left(\sum_{i=1}^n Y_i\right)}{n}}{\sqrt{\left[\sum_{i=1}^n X_i^2 - \frac{\left(\sum_{i=1}^n X_i\right)^2}{n}\right] \left[\sum_{i=1}^n Y_i^2 - \frac{\left(\sum_{i=1}^n Y_i\right)^2}{n}\right]}} \dots\dots\dots (2.21)$$

The Correlation Coefficient, equation (2.21) is the ratio of the covariance to the product of two standard deviations and varies between -1 and +1. A positive covariance tells us that there is there is positive relationship between the two variables but the strength of the relationship is not quantified (quantified by the correlation).

The risk or standard deviation of a portfolio falls when securities that are uncorrelated are combined. The lower the correlation the greater the diversification benefits as quantified through risk reduction.

ii. **Rank Correlation Coefficient**

This coefficient is also known as the Spearman Rank Correlation Coefficient.

Its purpose is to establish whether there is any form of association between two variables arranged in a ranked form.

It is defined by:

$$r = 1 - \frac{6 \sum_{i=1}^n d_i^2}{n(n^2 - 1)} \dots\dots\dots (2.22)$$

where  $d_i$  = difference between the pairs of ranked values

$n$  = total number of pairs of rankings.

The rank correlation coefficient, equation (2.22) is computed when

- a. the underlying relationship between two variables is not necessarily linear
- b. if the data consist of non-numeric observation but can be ranked (Lucey,2002).

### Properties of $r$

(a)  $-1 \leq r \leq 1$ , which means that

- i. When  $|r| = 1$ , we have perfect correlation between  $x$  and  $y$  and all the scatter points lie on the regression line  $E(Y)$ . Generally, if  $|r| > 0.5$ , the degree of relationship is said to be good and if  $|r| < 0.5$ , the degree of relationship is poor.
- ii. When  $r = 0$ , there is no linear correlation between the variables.

(b)  $r$  is independent of the choice of origin and units of  $x$  and  $y$ .

### 2.2.5 Estimation of Simple Linear Model

The linear regression model is estimated by fitting a best prediction linear through a scatter diagram. This then calls for the estimation of the parameters  $\beta_0$  and  $\beta_1$  using the sample data by the method of least squares.

#### The method of Least squares

The main objective of the method is to find the estimates  $\hat{\beta}_0$  and  $\hat{\beta}_1$  for  $\beta_0$  and  $\beta_1$

respectively for which the total sum of squares error  $\sum_{i=1}^n \varepsilon_i^2 = \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i)^2$  is small

as possible. This is the principle of the least squares method which is summarised as follows:

“The unknown regression model is estimated by choosing the regression parameters  $\hat{\beta}_0$  and  $\hat{\beta}_1$  so as to minimise the total sum of squares,  $\sum_{i=1}^n \varepsilon_i^2$ ”

The use of the principle becomes valid if the response variance,  $\text{var}(Y_i) = \sigma^2$ , for all  $X_i$ .

The deviation of  $Y_i$  from its mean,  $E(Y_i)$  is

$$\sum_{i=1}^n \varepsilon_i = \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i) \dots \dots \dots (2.23)$$

Then, by the above principle, we choose  $\hat{\beta}_0$  and  $\hat{\beta}_1$  as to minimise the total sum of squares errors,

$$\sum_{i=1}^n \varepsilon_i^2 = \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i)^2 \dots \dots \dots (2.24)$$

i.e.,  $\hat{\beta}_0$  and  $\hat{\beta}_1$  are obtained such that

$$\left\{ \begin{array}{l} \frac{\partial \sum_{i=1}^n \varepsilon_i^2}{\partial \beta_0} = -2 \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i) = 0 \\ \frac{\partial \sum_{i=1}^n \varepsilon_i^2}{\partial \beta_1} = -2 \sum_{i=1}^n (Y_i - \beta_0 - \beta_1 X_i) X_i = 0 \end{array} \right\} \dots \dots \dots (2.25)$$

From equation(2.25) we obtain the following, called normal equations:

$$\sum_{i=1}^n Y_i = n\beta_0 + \beta_1 \sum_{i=1}^n X_i \dots\dots\dots(2.26)$$

$$\sum_{i=1}^n X_i Y_i = \beta_0 \sum_{i=1}^n X_i + \beta_1 \sum_{i=1}^n X_i^2 \dots\dots\dots(2.27)$$

Or

$$\begin{pmatrix} \sum_{i=1}^n Y_i \\ \sum_{i=1}^n X_i Y_i \end{pmatrix} = \begin{pmatrix} n & \sum_{i=1}^n X_i \\ \sum_{i=1}^n X_i & \sum_{i=1}^n X_i^2 \end{pmatrix} \begin{pmatrix} \beta_0 \\ \beta_1 \end{pmatrix} \dots\dots\dots(2.28)$$

Solving for unknowns, we have

$$\hat{\beta}_0 = \frac{1}{n} \sum_{i=1}^n Y_i - \hat{\beta}_1 \left( \frac{1}{n} \sum_{i=1}^n X_i \right) = \bar{Y} - \hat{\beta}_1 \bar{X}$$

$$\hat{\beta}_1 = \frac{\sum_{i=1}^n X_i Y_i - \frac{1}{n} \left( \sum_{i=1}^n X_i \right) \left( \sum_{i=1}^n Y_i \right)}{\sum_{i=1}^n X_i^2 - \left( \frac{1}{n} \sum_{i=1}^n X_i^2 \right)}$$

$$= \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^n (X_i - \bar{X})^2} = \frac{SS_{xy}}{SS_{xx}}$$

Alternatively, it may also be more convenient to use the equivalent model (2.14),

$Y_i = \beta_0 + \beta_1 (X_i - \bar{X}) + \varepsilon_i$ , from which we have,

$$\sum_{i=1}^n \varepsilon_i^2 = \sum_{i=1}^n [Y_i - \beta_0 - \beta_1 (X_i - \bar{X})]^2 \dots\dots\dots(2.29).$$

$$\frac{\partial \sum_{i=1}^n \varepsilon_i^2}{\partial \beta_0} = -2 \sum_{i=1}^n [Y_i - \beta_0 - \beta_1 (X_i - \bar{X})] = 0 \dots\dots\dots(2.30)$$

$$\frac{\partial \sum_{i=1}^n \varepsilon_i^2}{\partial \beta_1} = -2 \sum_{i=1}^n [Y_i - \beta_0 - \beta_1 (X_i - \bar{X})] = 0 \dots \dots \dots (2.31)$$

i.e.  $\sum_{i=1}^n Y_i = n\beta_0 + \beta_1 \sum_{i=1}^n (X_i - \bar{X}) \dots \dots \dots (2.32)$

$$\sum_{i=1}^n (X_i - \bar{X}) Y_i = \beta_0 \sum_{i=1}^n (X_i - \bar{X}) + \beta_1 \sum_{i=1}^n (X_i - \bar{X})^2 \dots \dots \dots (2.33)$$

From which we have

$$\hat{\beta}_0 = \frac{1}{n} \sum_{i=1}^n Y_i = \bar{Y}, \text{ since}$$

$$\sum_{i=1}^n (X_i - \bar{X}) = 0 \dots \dots \dots (2.34)$$

$$\hat{\beta}_1 = \frac{\sum_{i=1}^n (X_i - \bar{X}) Y_i}{\sum_{i=1}^n (X_i - \bar{X})^2} \dots \dots \dots (2.35)$$

Hence the prediction or fitted linear regression line becomes,

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_i$$

or

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 (X_i - \bar{X}) \dots \dots \dots (2.36)$$

which is also known as regression line of  $Y_i$  on  $X_i$ .

The regression line of  $X_i$  on  $Y_i$  may also be defined as:

$$X_i = \alpha_0 + \alpha_1 Y_i + \varepsilon_i \dots \dots \dots (2.37)$$

Where

$$\hat{X}_i = \hat{\alpha}_0 + \hat{\alpha}_1 Y_i,$$

$$\left\{ \begin{array}{l} \hat{\alpha}_0 = \frac{1}{n} \sum_{i=1}^n X_i - \hat{\alpha}_1 \left( \frac{1}{n} \sum_{i=1}^n Y_i \right) = \bar{X} - \hat{\alpha}_1 \bar{Y} \\ \hat{\alpha}_1 = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (Y_i - \bar{Y})^2} = \frac{SS_{xy}}{SS_{yy}} \end{array} \right\} \dots \dots \dots (3.38)$$

### 2.2.6 Multiple Regression Model Development

A model, which incorporates several independent variables, is known as a multiple regression model (Spiegel M. R. 1998). The development of the model is shown below:

The basic two variable model (one dependent and one independent variable) is:

$$Y = a + bx$$

which can be solved using the Normal Equations thus:

$$\sum Y = an + b \sum x$$

$$\sum XY = a \sum X + b \sum X^2$$

From this can be developed models with more than 2 variables and this is illustrated below using a 3 variable model (one dependent and two independent variables;  $Y, X_1,$  and  $X_2$ ).

$$Y = a + b_1 X_1 + b_2 X_2$$

which can be solved by the Normal Equations for a three variable model, as follows:

$$\sum Y = an + b_1 \sum X_1 + b_2 \sum X_2$$

$$\sum X_1 Y = a \sum X_1 + b_1 \sum X_1^2 + b_2 \sum X_1 X_2$$

$$\sum X_2 Y = a \sum X_2 + b_1 \sum X_1 X_2 + b_2 \sum X_2^2$$

The *line* of best fit gives way to a plane of best fit.  $b_1$  is the slope of the plane along the  $X_1$  axis,  $b_2$  is the slope along the  $X_2$  axis, and the plane cuts the  $Y$  axis at ' $a$ '.

The aim of adding to the simple two variable model is to improve the fit of the data. The closeness of the fit is measured by the co-efficient of multiple determination  $R^2$  for which the general formula and a useful computational formula are given below:

$$R^2 = \frac{\text{Explained Variation}}{\text{Total Variation}}$$

$$= \frac{\sum (YE - \bar{Y})^2}{\sum (Y - \bar{Y})^2}$$

where  $YE$  now equals the estimate of  $Y$  for each value of  $X_1$  and  $X_2$ .

$$R^2 = \frac{a \sum Y + b_1 \sum X_1 Y + b_2 \sum X_2 Y - \frac{(\sum Y)^2}{n}}{\sum Y^2 - \frac{(\sum Y)^2}{n}}$$

It is not necessarily the case that the value of the co-efficient of determination will improve with the addition of extra variables.

### 2.3.1 Programming Platform of the Study

Microsoft Visual Basic 6 (VB 6) works well with most operating systems. VB 6 has the features such as ActiveX Data Object (ADO) that help to develop robust client/server applications quickly, easily and powerfully. ADO based on automation, is a database programming model that allows developers to write applications over OLE DB data from any language including VB, Java, C/C++ and VBScript.

The ADO model is fairly simple. The topmost object, the ADO Connection, contains an Errors collection, which in turn contains Error objects. The Connection also contains Command objects, each of which contains a Parameters collection that contains Parameter objects. The connection object also contains Recordset objects, each of which maintains a Fields collection that houses Field objects.

The purposes of the Connection object are:

- i. To enable the developer open a connection to a data source with the Open method. For Structured Query Language (SQL) data sources that do not have OLE DB provider, connection can be opened using the OLE DB provider for ODBC.
- ii. It allows programmers to execute SQL statement or stored procedures with the Execute method.
- iii. It allows programmers to establish transactions for data updates with the use of the transaction methods BeginTrans, CommitTrans and RollbackTrans (Martiner W., Herion D., Falino J., 2000).

### **The Recordset Object and Fields**

The Recordset is the most robust of all the ADO objects. It has two overall purposes:

- i. It allows us to retrieve row-based data from a data source so that we can make the data available to some presentation sources such as an application interface.
- ii. It enables us to retrieve rows for data modification such as editing, inserting and deleting.

## Databases

Database systems store information in every conceivable business environment. From large tracking databases such as airline reservation systems to a child's baseball card collection, database systems store and distribute the data that we depend on. Until the last few years, large database systems could be run only on large mainframe computers. These machines have traditionally been expensive to design, purchase, and maintain. However, today's generation of powerful, inexpensive workstation computers enable programmers to design software that maintains and distributes data quickly and inexpensively.

### Codd's 12 Rules for a Relational Database Model

The most popular data storage model is the relational database, which grew from the seminal paper "A Relational Model of Data for Large Shared Data Banks," written by E. F. Codd in 1970. Structured Query Language (SQL) evolved to service the concepts of the relational database model. Codd defined 13 rules, oddly enough referred to as Codd's 12 Rules, for the relational model:

0. A relational Database Management System (DBMS) must be able to manage databases entirely through its relational capabilities.
1. Information rule - All information in a relational database (including table and column names) is represented explicitly as values in tables.
2. Guaranteed access - Every value in a relational database is guaranteed to be accessible by using a combination of the table name, primary key value, and column name.
3. Systematic null value support - The DBMS provides systematic support for the treatment of null values (unknown or inapplicable data), distinct from default values, and independent of any domain.

4. Active, online relational catalog - The description of the database and its contents is represented at the logical level as tables and can therefore be queried using the database language.
5. Comprehensive data sub language - At least one supported language must have a well-defined syntax and be comprehensive. It must support data definition, manipulation, integrity rules, authorization, and transactions.
6. View updating rule - All views that are theoretically updatable can be updated through the system.
7. Set-level insertion, update, and deletion - The DBMS supports not only set-level retrievals but also set-level inserts, updates, and deletes.
8. Physical data independence - Application programs and ad hoc programs are logically unaffected when physical access methods or storage structures are altered.
9. Logical data independence - Application programs and ad hoc programs are logically unaffected, to the extent possible, when changes are made to the table structures.
10. Integrity independence - The database language must be capable of defining integrity rules. They must be stored in the online catalog, and they cannot be bypassed.
11. Distribution independence - Application programs and ad hoc requests are logically unaffected when data is first distributed or when it is redistributed.
12. Non subversion - It must not be possible to bypass the integrity rules defined through the database language by using lower-level languages.

## **Structured Query Language (SQL)**

SQL is the de facto standard language used to manipulate and retrieve data from relational databases. SQL enables a programmer or database administrator to do the following:

1. Modify a database's structure
2. Change system security settings
3. Add user permissions on databases or tables
4. Query a database for information
5. Update the contents of a database

Through SQL, records are temporarily created and passed back to the recordset object of the database in Visual Basic. SQL statements are broken down into two distinct classifications, the Data Definition Language (DDL) and Data Manipulation Language (DML). The DDL is used to create, modify or remove the actual definitions in the database. The DML is used to create, modify, remove or gather information that resides in the structure of the database.

## **SQL in Application Programming**

SQL was originally made an American National Standards Institute (ANSI) standard in 1986. The ANSI 1989 standard (often called SQL-89) defines three types of interfacing to SQL within an application program:

1. Module Language-- Uses procedures within programs. These procedures can be called by the application program and can return values to the program via parameter passing.

2. Embedded SQL--Uses SQL statements embedded with actual program code. This method often requires the use of a precompiler to process the SQL statements. The standard defines statements for Pascal, FORTRAN, COBOL, and PL/1.
3. Direct Invocation--Left up to the implementer.

Before the concept of dynamic SQL evolved, embedded SQL was the most popular way to use SQL within a program. Embedded SQL, which is still used, uses static SQL--meaning that the SQL statement is compiled into the application and cannot be changed at runtime. The performance for this type of SQL is good; however, it is not flexible and cannot always meet the needs of today's changing business environments.

The ANSI 1992 standard (SQL-92) extended the language and became an international standard. It defines three levels of SQL compliance: entry, intermediate, and full. The new features introduced include the following:

1. Connections to databases
2. Scrollable cursors
3. Dynamic SQL
4. Outer joins

Database cursors enable us to select a group of data, scroll through the group of records (often called a recordset), and examine each individual line of data as the cursor points to it. You can use a combination of local variables and a cursor to individually examine each record and perform any external operation needed before moving on to the next record.

Dynamic SQL allows one to prepare the SQL statement at runtime. Although the performance for this type of SQL is not as good as that of embedded SQL, it provides the application developer (and user) with a great degree of flexibility. A call-level interface,

such as Open Database Connectivity (ODBC) is an example of dynamic SQL. When using ODBC, for instance, one simply fill a variable with your SQL statement and call the function to send the SQL statement to the database. Errors or results can be returned to the program through the use of other function calls designed for those purposes. Results are returned through a process known as the binding of variables (Shapiro J. R., 2001).

#### **2.4.0 Summary**

In this chapter, we considered the literature review comprising the inventory models, regression models (simple and multiple) and programming platform of the study. In the next chapter, we shall put forward the methodology and implementation of our proposed strategy.

## CHAPTER THREE

### Methodology and Implementation of the Study

#### 3.0 Introduction

In this chapter, forms are designed and the appropriate Visual Basic codes written in the respective code window of the various forms. Some of the code written to implement the study can be seen in the appendix. The various mathematical models explained in Chapter two are implemented in the study through coding. The study considered situations where drugs will be ordered from suppliers, received into the appropriate store before sales are made.

A simple Data flow diagram is illustrated in Figure 3.0. The data flow diagram is the tool that we have used to depict the flow of data and the work or processing performed by the system.

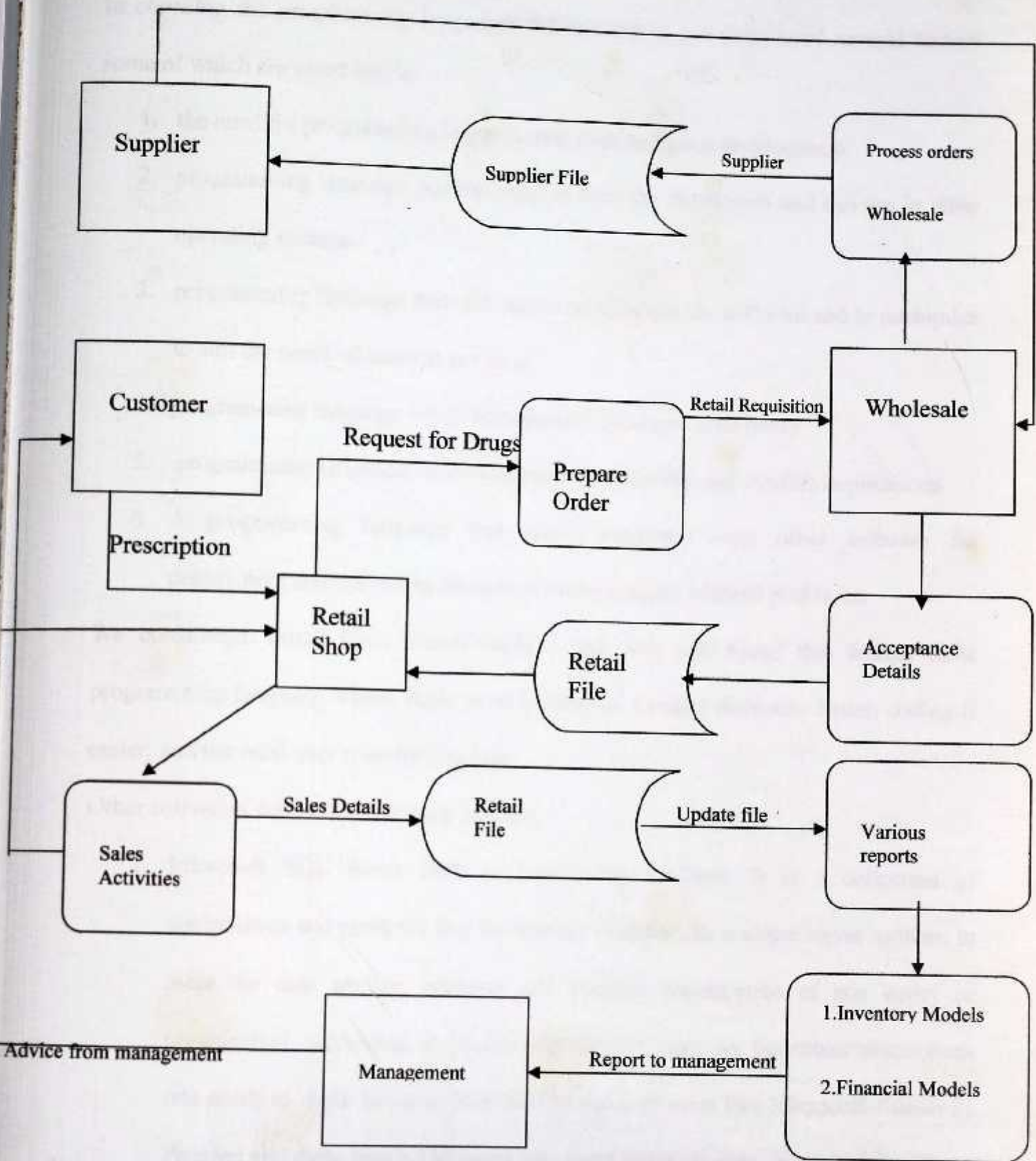


Figure 3.0 Data Flow Diagram

### 3.1 Methodology

In choosing the programming languages for this thesis, we considered several factors some of which are listed below:

1. the need for programming language that eases program development
2. programming language that has support from the developers and can run in other operating systems
3. programming language that will enable us maintain the software and to customize to suit the needs of users at any time
4. programming language which manipulates databases effectively
5. programming language which produces user friendly and flexible applications
6. A programming language that easily integrates with other software for deployment and can run in the network environment without problems.

We considered Visual C++, Visual Basic 6 and Java and found that among these programming language Visual Basic is most flexible, handles databases better, coding is easier, and the most user friendly language.

Other softwares we used in our study include:

1. Microsoft SQL Sever 2000 to handle the database. It is a collection of components and products that holistically combine, as a client/server system, to meet the data storage, retrieval and analysis requirement of any entity or organisation. According to Shapiro J.R (2001) there are important distinctions one needs to make between SQL Server and a product like Microsoft Access or Paradox and these revolve around Concurrent access to data, integrity of data and availability of data. The Joint Engine Technology (Jet) database engine in Access and Borland Database Engine (BDE) in Paradox, uses file/server functionality to

share the database files whilst the SQL server is client/server database where the database server's engine alone controls access to the data, performs the queries, manages the database and the requests of every client and keeps the database server operating in the best possible way. As regards integrity of data, SQL Server 2000 has integrity support in what is known as cascading integrity constraint. It is too easy to bypass validation rules and logic in Access and Paradox. Microsoft SQL Sever was chosen because it is a very strong database handler and preferred to any other database system when the system is to be run in a network environment.

2. Crystal Report to handle all the reports to be generated from the study. Crystal Report allows application developers to write codes to implement whatever the developer wants to do. It also has very useful in-built functions and integrates very well with Microsoft Visual Basic 6 than most programming languages such as visual C++.
3. Rose Indigo Setup Factory. It is a sophisticated tool that gives one complete control over the installation process. Full-featured, fast, and easy to use, Setup Factory's intuitive design maximizes one's ability to deploy software products, data files, graphic images or anything else that one wants to distribute.

### 3.2.0 Implementation of the Study

#### 3.2.1 The Drug set up

Figure 3.1 is the interface for entering the basic data about the drug. After entering the necessary data, we click on the OK button after which it becomes ready for another drug to be entered. We can search, edit, and delete a drug entered into the system. The Visual Basic code for the implementation of this interface can be seen in Appendix A.

The screenshot shows a software window titled "PHARMAS 2007 GENERAL ITEMS[JAMES]". The window contains a form with the following fields and controls:

- Description:** A text box containing "PARACETAMOL TAB".
- Item Code:** A text box containing "002826".
- Vat(%):** An empty text box.
- Size:** A dropdown menu with "5ml" selected.
- Manufacturer:** A dropdown menu with "Ernest Chemist" selected.
- Category:** A dropdown menu with "Analgesics" selected.
- Buttons:** A row of five buttons: "Ok", "Search...?", "Delete", "Clear", and "Close".

Figure 3.1 The Drug set up

### 3.2.2 The Price set up Form

Figure 3.2 shows the form setting up prices and initial quantities of the drug. The same form is used to edit the prices of the drugs anytime there is a change in price. The Visual Basic codes for the implementation of this interface can be found in appendix B.

PHARMAS 2007 WAREHOUSE ITEMS [JAMIS]

Description:  Size:  Item Code:   
Manufacturer:  Category:  Vat(%):   
Expirable:  Store Description:

**PACKS**  
Pack Unit:  No. Of Units:  Quantity Of Crates:   
No. of Boxes If Packed:  Unit Cost:  Cash Price:   
Credit Price:

**SINGLES/UNITS**  
Base Unit:  Current Quantity:  Unit Cost:   
Unit Cash Price:  Unit Credit Price:

Figure 3.2 The Price set up Form

### 3.2.3 Stock Adjustment Form

Figure 3.3 shows the stock adjustment form. This form is used to adjust or set stocks to the right quantities whenever stock is taken. To adjust stocks, we first select the store from the combo box, press the enter key to set focus to description textbox, enter the name of the item, press the enter key to set focus to new stock text box and enter the right quantity counted. The reason for adjustment is selected from the Reason combo box after which the Add New command button is clicked to put the information into the grid. The steps are followed to adjust as many items as possible and finally click on the Save button to send whatever is in the grid into the database

The screenshot shows a software window titled "PHARMAS 2007 STOCK ADJUSTMENTS [JAMES]". The form is divided into several sections:

- Form Fields:**
  - Store: [Dropdown]
  - Description: [Text Box]
  - Item Code: [Text Box]
  - New Stock: [Text Box]
  - Adjusted Qty: [Text Box]
  - Date: [Text Box] (01-Jul-2007)
  - Reason: [Dropdown]
  - Item Unit: [Text Box]
  - Unit Cost: [Text Box]
  - Old Stock: [Text Box]
  - Amount: [Text Box]
  - Comments: [Text Box]
- Grid:**

Date	Item Code	Description	Item Unit	Unit Cost	Old Stock	Adjusted Qty	New Stock	Store
- Bottom Section:**
  - Total Amount: [Text Box]
  - Authoriser: [Text Box] (JAMES)
  - Reference No.: [Text Box]
  - Buttons: Save, Find...?, Clear, Add New, Cancel

Figure 3.3 Stock Adjustment Form

### 3.2.4 The Price set up Form (NHIS)

Figure 3.4 is the form mainly for setting up for National Health Insurance Scheme predetermined prices for pharmaceutical service providers. The prices can be edited as and when necessary.

PHARMAS 2007 RETAIL ITEMS [JAMIS]

Description: MENTHODOX  
Manufacturer: Ernest Chemist  
Expirable: NO

Size: Small  
Category: Antibiotic  
Store Description: LIKERS

Item Code: 2818  
Vat(%): 0

PACKS

Pack Unit: BOX  
No. of Boxes: [ ]  
Credit Price: 6000000

No. of Units: 50  
Quantity Of Crates: 2  
Unit Cost: 5000000  
Cash Price: 6000000

SINGLES/UNITS

Base Unit: SINGLE  
Current Quantity: 124  
Unit Cash Price: ₦124,000.00  
Unit Credit Price: 124000  
Unit Cost: ₦100,000.00

Ok Search...? Delete Clear Close

Figure 3.4 The Price set up Form (NHIS)

### 3.2.5 Supplier set up form

Figure 3.5 shows the interface for capturing the basic information about the suppliers of drugs for the pharmaceutical shops. The information can be edited when required.

The screenshot shows a software window titled "PHARMAS 2007 SUPPLIERS [JAMES]". The window contains a form with the following fields and values:

Category:	NORMAL	Fax Number:	061-26839
Contact Name:	JOY ENT	E-Mail Address:	pk@yahoo.com
Supplier ID:	000006	Credit Limit:	70000000000
Tel No.:	061-26839	Date:	30-Jun-2007
Postal Address:	BOX 45, SUNYANI	Opening Bal:	322711500

At the bottom of the form, there are five buttons: "Ok", "Find....?", "Delete", "Clear", and "Close".

Figure 3.5 Supplier set up Form

### 3.2.6 Ordering Form

Figure 3.6 is the interface used to make orders from suppliers of drugs. We first enter the name of the drug to be ordered, the date of the order and subsequently the drugs. The quantity expected is also entered and the expected date selected. We click on the Order command button to put the item in grid to allow for other items to be entered if any. After enter all the drugs, we click on the Ok button to save the information. The code for implementing the form below is shown Appendix B.

Order Date	Description	Order Qty	Order Unit	Unit Cost	Amount	Order Store
7/1/2007	MENTHDD00	10	BDC	500000	5000000	WAREHOUSE

Figure 3.6 the Ordering Form

### 3.2.7 Order Receivable Form

Figure 3.7 is used to receive orders into stock. The supplier from whom the order is made is first entered followed by date of receipt and the invoice number. The name of item received is the entered from the keyboard after which the right quantity is entered. As many items ordered and received are entered and finally the OK button is clicked to send the information to the database.

The screenshot shows a software window titled "PHARMAS ORDER-RECEIVABLES-AND-PAYMENTS (JAMES)". The window contains several input fields and a table. A small dialog box is overlaid on the main window.

**Supplier Name:** JOY ENT **Received Date:** 01-Jul-2007 **Invoice No:** 1111

**Purchase What?:**  **Item Code:**  **Stock Level:**

**Reorder Level:**  **Received Qty:**  **Expiry Date:** Jul-2015

**Received Unit:**  **Unit Cost:**  **Discount:**

**Receiving Store:**  **Amount:**

Received Date	Description	Unit	Unit Cost	Amount
7/1/2007	MENTHODIOX	Unit	50000000	50000000

**Current Amount:** 50000000 **Outstanding Amount:** 37271500 **Receive** **Remove**

**Receiver Name:** JAMES **Order No.:** 0700013 **Close** **Payments**

**Ok** **Find?.....** **Delete** **Clear** **Close** **12:26 PM**

**Save: Successful**  
1 Ordered Item(s) Saved  
**Ok**

Figure 3.7 Order Receivable Form

### 3.2.8 Direct Purchases Form

Figure 3.8 is the Direct Purchases form. This form is used to enter purchases which did not pass through the ordering process. The procedure for implementing this interface is shown in Appendix B

Supplier Name: JOY ENT Date: 01-Jul-2007 Receipt No: 2323

Purchase What?: Item Code: Stock Level:

Reorder Level: Quantity: Expiry Date: Jul-2016

Purchase Unit: Unit Cost: Discount: Amount:

Receiving Store:

Purchase Date	Description	Receiving Store	Stock	Amount
7/1/2007	MENTHODIX	WAREHOUSE	20	1000000000

Current Total: 1000000000 Outstanding Total: 1372711500

Receiver Name: JAMES Purchase No: 0700014

Buttons: Ok, End?, Delete, Clear, Close, Purchase, Remove

Dialog Box: Save Successful, 1 Purchased Item(s) Saved, Ok

Figure 3.8 Direct Purchases Form

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### 3.2.9 Customer Set Up Form

Figure 3.9 is the Customer set up form. Customer here means those who can purchase on credit. It is used to set up all sponsors.

PHARMAS 2007 CUSTOMER [JAMIES]

Category:	SPECIAL	Fax Number:	06125673
Contact Name:	MUNICIPAL HEALTH INSURANCE	E-Mail Address:	in@gh.com
Customer ID:	000003	Credit Limit:	10000000000
Telephone Number:	06125673	Date:	19-Jan-2007
Postal Address:	BOX 765	Balance:	20100

Ok Find...? Delete Clear Close

Figure 3.9 Customer Set Up Form

### 3.2.10 Sales form for Clients of the National Health Insurance Scheme

Figure 3.10 below is the interface used to sell drugs to the clients of the National Health Insurance Scheme. Contact Name (Sponsor) indicating the name of the Scheme is first input after which the ID, Credit limit and the total debt if any appear. The basic information with regard to the Patient's name, Patient's ID number, sex, age and particular hospital or clinic attended are entered into the respective boxes. The drug(s) prescribed is (are) sold to the patient.

**Customer**  
 Contact Name: MUNICIPAL HEALTH INS ID: 000003 Cr. Limit: 100000000 Tot. Debt: 230,100.00

Patient's Name: KOFI BADU Pat. ID No.: BU345666 Sex: Male Age: 54 Prescriber: Sunyani Reg. Hosp

**Products**  
 Sell What?: Item Code: Stock Level: 0

Reorder Level: Sales Unit: Val: Store Name: Amount Due:

Item Description	Sales Unit	Quantity	Unit Price	Amount	Discount
METHUOX		124000	12.40	1,538,800.00	

Amount Due: 124000 Date: 01-Jul-07

Buttons: OK, End?, Delete, Clear, Close, Print, Add, Remove

Figure 3.10 Sales form for Clients of the National Health Insurance Scheme

### 3.2.11 Claim Processing Form

Figure 3.13 is the Claim Processing Form. When The Date range is selected and the OK button is clicked Table 3.1 is generated. This is what is sent to the sponsors. This interface helps to print claims for reimbursement from the various Schemes.

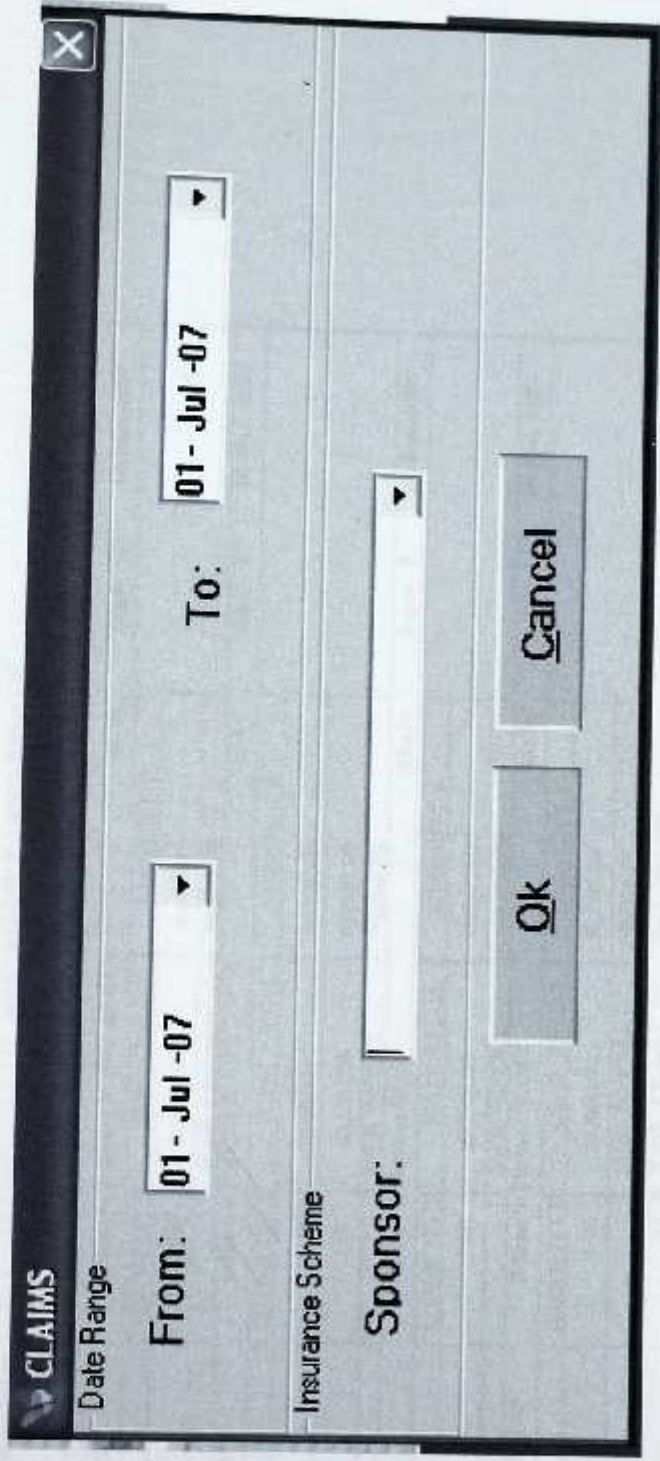


Figure 3.11 Claim Processing Form

### 3.2.12 Claims report

Table 3.1 is the Claims Report for the period selected. This report gives the details of the clients who received services from the Pharmacy.

**PATIENTS HEALTH FACILITY ATTENDANCE CLAIMS FORM**  
**Municipal Health Insurance**  
**JOE BENNETT PHARMACY.**

24-Mar-2008 5:26:46 pm

INSU ID: 34555	Client's Name: K OFI MANU		Male	Age: 27	15-Dec-2007
MEDICINE	QUANTITY	UNIT PRICE	AMOUNT ₺		
MENTHODOX	2.00	25,000.00	50,000.00		
	SUB TOTAL:		50,000.00		
INSU ID: 555666	Client's Name: K OFI		Male	Age: 67	16-Dec-2007
MEDICINE	QUANTITY	UNIT PRICE	AMOUNT ₺		
MENTHODOX	1.00	25,000.00	25,000.00		
MINAMINO SYR	1.00	45,000.00	45,000.00		
	SUB TOTAL:		70,000.00		
INSU ID: 7	Client's Name: MM		Male	Age: 8	17-Dec-2007
MEDICINE	QUANTITY	UNIT PRICE	AMOUNT ₺		
MENTHODOX	7.00	25,000.00	175,000.00		
	SUB TOTAL:		175,000.00		
INSU ID: GJ676788	Client's Name: K OFI		Male	Age: 55	16-Dec-2007
MEDICINE	QUANTITY	UNIT PRICE	AMOUNT ₺		
MENTHODOX	2.00	25,000.00	50,000.00		
	SUB TOTAL:		50,000.00		
SUB TOTAL(₺):			345,000.00		
ADM. CHARGES(₺):			6,000.00		
GRAND TOTAL(₺):			351,000.00		
GH₺:			35.10		Gp

Table 3.1 Claims report

### 3.2.13 Transaction Summary Form

Figure 3.14 and Table 3.2 shows the Transaction Summary form and its Report for the appropriate period selected. When the date is selected and the OK button is clicked, a report of all transaction within the period is generated.

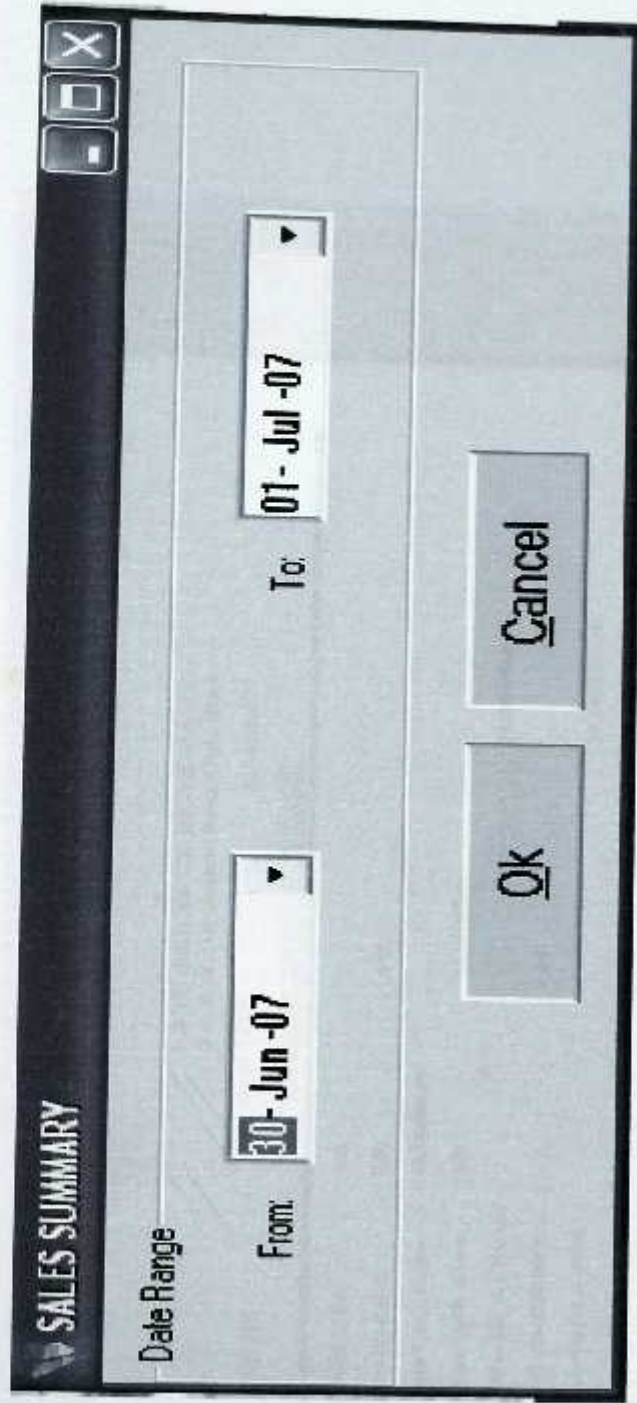


Figure 3.13 Transaction Summary form

### 3.2.14 Transaction Summary Report

Table 3.2 is Summary for transactions for the period selected. This makes it possible for Management to see at a glance all that took place in the period.

**JOE BENNETT PHARMACY.**  
P.O. BOX 1136, Suisun, Bering Alaska, Chaska  
Tel: 223-61-28220      223-61-28222

**TRANSACTIONS SUMMARY**

Retail Cash Sales:	0.00	
Retail Credit Sales:	0.00	0.00
Wholesale Cash Sales:	33,180,000.00	
Wholesale Credit Sales:	0.00	33,180,000.00
<b>Total Sales for the Period</b>		<b>33,180,000.00</b>
Receipt From Debtors:	0.00	
<b>Total Amount Received</b>		<b>33,180,000.00</b>
Total Expenditures:		0.00
<b>Amount To Be Banked</b>		<b>33,180,000.00</b>

### **3.3 Summary**

In this chapter, we considered the methodology and implementation of our proposed strategy explaining why specific tools for the study were chosen. We also designed forms, explained how to use some of the interfaces, tested with live data from the source data and generated some report from the study. In the next chapter, we shall give the Conclusion and the necessary Recommendations.

# CHAPTER FOUR

## Conclusion and Recommendations

### 4.1 Conclusion

The National Health Insurance Scheme (NHIS) has been introduced to enable majority of Ghanaians access health care at a very affordable price. Recent indications are that the NHIS has been accepted by the majority of the populace but to make it sustainable, there is the need for adequate provision of facilities and tools such as health centres, nurses, doctors and the necessary software to facilitate provision of services to the increasing clients. The Pharmacy Management Software (Pharmas) for NHIS has been developed to make potential service providers readily apply for accreditation, generate all required reports, stock the right quantities of drugs, facilitate speedy dispensing of drugs to the clients, monitor events and assess the profitability of the services being rendered. It is envisaged that the introduction and acceptance of Pharmas will eliminate most of the deficiencies in the existing system.

It must however be emphasized that no software is foolproof and that Pharmas is not an exemption.

### 4.2 Recommendations

The Pharmacy Management Software (Pharmas) for National Health Insurance Scheme works very well in the network environment and we recommend that the National Insurance Council (NHIC) adopts it for all accredited providers of pharmaceutical services.

We also recommend that further improvement to this study should be towards making it possible for users to order drugs through the Internet.

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## APPENDIX A

```
Private Sub CmdOK_Click(Index As Integer)
On Error GoTo OkError

Select Case Index

Case Is = 0

For Each Ctrl In Me.Controls

If Trim(Ctrl.Tag) <> "" Then

If Ctrl = "" Then

MsgBox "Please,Enter Or Select " & Ctrl.Tag, vbInformation, "Blank " & Ctrl.Tag

Ctrl.SetFocus: Exit Sub

End If

End If

Next

If sFlag = False Then

' rs.Close

rs.Open "Select ItemID From GeneralItems where Descriptions='" &
ChkQuotes(Me.TxtDescription) & "' and ItemSize='" & ChkQuotes(Me.CboSize) & "'
and ItemBrand='" & ChkQuotes(Me.TxtBrand) & "'"

If rs.RecordCount > 0 Then

MsgBox Me.TxtDescription & " with size " & Me.CboSize & " and Manufacturer "
& Me.TxtBrand & " already exist.", vbInformation, "Duplicate Item Setup"

rs.Close

Me.TxtDescription.SetFocus: Exit Sub

End If

End If
```

rs.Close

Cn.BeginTrans

' Descript = TxtDescription & " " & CboSize & " " & TxtBrand

' Descript = TxtDescription & " " & TxtBrand & " " & CboSize

Cn.Execute "Insert Into GeneralItems

([ItemID],[Descriptions],[ItemBrand],[Category],[UserID],[ItemSize],[Vat])" &

"Select " & TxtItemCode & "," & ChkQuotes(TxtDescription) & "," &

ChkQuotes(TxtBrand) & "," & ChkQuotes(CboCategory) & "," & UserCode & "," &

ChkQuotes(CboSize) & "," & Val(TxtVat) & """, Y

If Y > 0 Then

Cn.CommitTrans

MsgBox "Item Added Successfully!", vbInformation, "Addition of New Item"

Else

Cn.RollbackTrans

MsgBox "Sorry,Unable to Add Item:Please Try Again!", vbInformation, "Item

Addition Failed"

End If

' rs.Close

Else

Cn.BeginTrans

Cn.Execute "Update GeneralItems Set [ItemBrand]= " & TxtBrand &

",[Descriptions]= " & ChkQuotes(TxtDescription) & ",[Category]= " &

ChkQuotes(CboCategory) & ",[ItemSize]= " & ChkQuotes(CboSize) & " where ItemID

= " & Trim(TxtItemCode.Text) & """, Y

```

If Y > 0 Then
    Cn.CommitTrans
    MsgBox "Item Edited Successful!", vbInformation, "Edit Successful"
Else
    Cn.RollbackTrans
    MsgBox "Sorry,Unable to Edit Item:Please Try Again!", vbInformation, "Item Edit
Failed"
End If
End If
'rs.Close
ClearFields
Case Is = 1
    Me.TxtItemCode = ""
    strg = Trim(InputBox("Enter All Or the first few Characters of the Item
Description,Item Code"))
    If strg <> "" Then
        rs.Close
        rs.Open "Select Distinct * from GeneralItems Where GeneralItems.Descriptions like
"" & strg & "%" & "" Order By GeneralItems.Descriptions Asc"
        If rs.RecordCount > 0 Then
            rs.MoveFirst
            FLXG1.Rows = rs.RecordCount + 1
            rs.MoveFirst
            For x = 1 To rs.RecordCount

```

```

FLXG1.TextMatrix(x, 0) = rs.Fields!ItemID
FLXG1.TextMatrix(x, 1) = rs.Fields!Descriptions
FLXG1.TextMatrix(x, 2) = rs.Fields!ItemBrand
FLXG1.TextMatrix(x, 3) = rs.Fields!ItemSize
FLXG1.TextMatrix(x, 4) = rs.Fields!Category
FLXG1.TextMatrix(x, 5) = rs.Fields!Vat

rs.MoveNext

Next

FLXG1.Visible = True

MsgBox rs.RecordCount & " Item(s) Found!" & vbCrLf & "Please View The
Items To Select The Item You Are Looking For", vbInformation, "Search Successful"

Else

MsgBox "There Is No Item With Description Or Code Like " & strg & " Make
Sure You Enter The Correct Description Or Code", vbInformation, "Search Failed"

Me.CmdOk(1).SetFocus

End If

rs.Close

End If

Case Is = 2

If sFlag = False Then Exit Sub

If MsgBox("This Operation Will Remove The Item Permanently,Do you want to
continue The Operation ? ", vbYesNo + vbCritical, "Confirm Delete") = vbNo Then Exit
Sub

Cn.BeginTrans

```

```

Cn.Execute "Delete from GeneralItems where ItemID = " & TxtItemCode & "", Y
If Y > 0 Then
    Cn.CommitTrans
    MsgBox "Item Deleted Successfully!", vbInformation, "Deletion Successful"
Else
    Cn.RollbackTrans
    MsgBox "Sorry,Unable to Delete Item:Please Try Again!", vbInformation, "Item
Deletion Failed"
End If
ClearFields
Case Is = 3
    If MsgBox("Are You Sure You Want To Clear All The Fields On The General Items
Form?", vbYesNo + vbQuestion, "Confirm Clear") = vbNo Then Exit Sub
    ClearFields
Case Is = 4
    Unload Me
End Select
Exit Sub
OnError:
    If rs.State <> 0 Then
        rs.Close
    End If
    If sFlag = False Then
        ErrorMessage "Save", "General Item Setup"

```

Else

ErrorMessage "Edit", "General Item Setup"

End If

Exit Sub

End Sub

## APPENDIX B

```
Private Sub CmdOK_Click(Index As Integer)
'On Error GoTo OrderErr
If Fvall <= 0 Then MsgBox "You Must Have At Least One Order Item Before Saving
Data", vbInformation, "Blank Order": Me.TxtItemCode.SetFocus: Exit Sub
If Trim(Me.TxtReptName) = "" Then MsgBox "You Must Enter Orderer Name",
vbInformation, "Blank Orderer Name": Me.TxtReptName.SetFocus: Exit Sub
If sFlag = False Then
    Cn.BeginTrans
    For x = 1 To Fvall
        Cn.Execute "Insert Into
Orders([OrderDate],[Description],[OrderQty],[OrderUnit],[UnitCost],[OrderNo],[ItemID
],[OrdererID],[ExpectedDate],[ContactName],[SupplierID],[Discount],[Vat],[OrderStore]
,[UserID],[Received])Select "" & Me.FLXG1.TextMatrix(x, 0) & "","" &
ChkQuotes(Me.FLXG1.TextMatrix(x, 1)) & "","" & Me.FLXG1.TextMatrix(x, 2) & "",""
& Me.FLXG1.TextMatrix(x, 3) & "","" & Me.FLXG1.TextMatrix(x, 4) & "","" &
Me.FLXG1.TextMatrix(x, 7) & "","" & Me.FLXG1.TextMatrix(x, 8) & "","" &
Me.TxtReptName & "","" & Me.FLXG1.TextMatrix(x, 0) & "","" & TxtContactName &
"","" & TxtSupplierID & "","" & Me.FLXG1.TextMatrix(x, 10) & "","" &
Me.FLXG1.TextMatrix(x, 11) & "","" & Me.FLXG1.TextMatrix(x, 6) & "","" & UserCode
& "","No", Y
    If Y <= 0 Then
        Exit For
    End If
End For
End If
End Sub
```

End If

Next

If Y > 0 Then

Cn.CommitTrans

MsgBox Fval1 & " Ordered Item(s) Saved!", vbInformation, "Save Successful"

Else

Cn.RollbackTrans

MsgBox "Unable to Save " & Fval1 & " Ordered Item(s)! Please Try Again",  
vbInformation, "Save Failed"

End If

Else

Cn.BeginTrans

For x = 1 To Fval1

Cn.Execute "Update Orders Set [OrderDate]=' " & Me.FLXG1.TextMatrix(x, 0) &  
"',[OrderQty]=' " & Me.FLXG1.TextMatrix(x, 2) & "',[OrderUnit]=' " &  
Me.FLXG1.TextMatrix(x, 3) & "',[UnitCost]=' " & Me.FLXG1.TextMatrix(x, 4) &  
"',[ExpectedDate]=' " & Me.FLXG1.TextMatrix(x, 9) & "',[SupplierID]=' " &  
Me.lblSupplierNo & "',[Discount]=' " & Val(Me.FLXG1.TextMatrix(x, 10)) & "',[Vat]=' "  
& Val(Me.FLXG1.TextMatrix(x, 11)) & "',[OrderStore]=' " & Me.FLXG1.TextMatrix(x,  
6) & "',[OrdererID]=' " & Me.TxtReptName & " where ItemID = " &  
Me.FLXG1.TextMatrix(x, 8) & " And OrderNo = " & Me.TxtOrderNo & " And  
OrderDate=' " & Me.FLXG1.TextMatrix(x, 0) & " And SupplierID=' " &  
Me.TxtSupplierID & " And Received='No'", Y

If Y <= 0 Then

Exit For

End If

Next

If Y > 0 Then

Cn.CommitTrans

MsgBox Fval1 & " Ordered Item(s) Updated!", vbInformation, "Update Successful"

Else

Cn.RollbackTrans

MsgBox "Unable to Update " & Fval1 & " Ordered Item(s)! Please Try Again",

vbInformation, "Update Failed"

End If

End If

ClearCtrls

End Sub

## APPENDIX C

```
Private Sub CmdOK_Click()
For Each Ctrl In Me.Controls
If Trim(Ctrl.Tag) <> "" Then
If Ctrl = "" Then
MsgBox "Please,Enter Or Select " & Ctrl.Tag, vbInformation, "Blank " & Ctrl.Tag
Ctrl.SetFocus: Exit Sub
End If
End If
Next
If sFlag = False Then
rs.Open "Select GeneralItems.*, WareHouseStocks.Description
,WareHouseStocks.ItemID from WareHouseStocks Inner Join GeneralItems On
WareHouseStocks.ItemID=GeneralItems.ItemID Where GeneralItems.ItemID= " &
Me.TxtItemCode & "Order By GeneralItems.ItemID Asc"
If rs.RecordCount > 0 Then
MsgBox Me.TxtDescription & " with size " & Me.CboSize & " and Manufacturer "
& Me.TxtBrand & " already exist.", vbInformation, "Duplicate Item Setup"
rs.Close: Me.TxtDescription.SetFocus: Exit Sub
End If
rs.Close
Cn.BeginTrans
Descript = TxtDescription
```



If Y > 0 Then

If Trim(CboBaseUnit) <> "" Then

Cn.Execute "Insert Into WarehouseItems

([ItemID],[Unit\_Type],[UserID],[Discount],[SCostPrice],[SCashPrice],[SCreditPrice])"

& \_

"Select "" & TxtItemCode & ""," & CboBaseUnit & ""," & UserCode & ""," &

Val(TxtDiscount) & ""," & Val(FindStringValue(Me.TxtUnitCost)) & ""," &

Val(FindStringValue(Me.TxtUnitPrice)) & ""," &

Val(FindStringValue(Me.TxtCreditPrice)) & """, Y

End If

End If

If Y > 0 Then

If Trim(CboPackUnit) <> "" Then

If Val(TxtNoofBoxes) > 0 Then

Cn.Execute "Insert into WarehousePacks

([ItemID],[Unit\_Type],[Packed],[No\_Per\_BaseUnit],[CashPrice],[CreditPrice],[UnitCost

],[UserID]) Select "" & TxtItemCode & ""," & CboPackUnit & "",'P'," &

Val(TxtQtyPerPack) & ""," & Val(FindStringValue(TxtPackPrice)) & ""," &

Val(FindStringValue(TxtCreditPackPrice)) & ""," & Val(FindStringValue(TxtPackCost))

& ""," & UserCode & """, Y

Else

Cn.Execute "Insert into WarehousePacks

([ItemID],[Unit\_Type],[No\_Per\_BaseUnit],[CashPrice],[CreditPrice],[UnitCost],[UserID

] Select "" & TxtItemCode & ""," & CboPackUnit & ""," & Val(TxtQtyPerPack) & "","

```

& Val(FindStringValue(TxtPackPrice)) & "," &
Val(FindStringValue(TxtCreditPackPrice)) & "," & Val(FindStringValue(TxtPackCost))
& "," & UserCode & """, Y
    End If
End If
End If
If Y > 0 Then
    Cn.CommitTrans
    MsgBox "Item Added Successfully!", vbInformation, "Addition of New Item"
Else
    Cn.RollbackTrans
    MsgBox "Sorry,Unable to Add Item:Please Try Again!", vbInformation, "Item
Addition Failed"
End If

Else
    Cn.BeginTrans
    Descript = TxtDescription '& " " & CboSize & " " & TxtBrand
    rs.Open "Select WareHousestocks.*,WareHouseItems.ItemID From WareHouseItems
Inner Join WareHousestocks on WareHouseItems.ItemID= WareHousestocks.ItemID
Where WareHousestocks.ItemID= '" & Me.TxtItemCode & ""'"
    If rs.RecordCount > 0 Then
        trs.Open "Select * From WareHousePacks Where ItemID= '" & Me.TxtItemCode &
"""

```

If trs.RecordCount > 0 Then

If trs.Fields!Packed = "P" Then

Cn.Execute "Update Warehousestocks Set [Quantity]= " &  
Val(rs.Fields!Quantity) + (Val(trs.Fields!No\_Per\_BaseUnit) \* Val(Me.TxtPackQuantity)  
\* Val(Me.TxtNoofBoxes)) & ",[QtyofBoxes]=" & Val(rs.Fields!QtyofBoxes) +  
Val(Me.TxtNoofBoxes) & ",[Description]=" & ChkQuotes(Descript) &  
",[StoreDescription]=" & TxtStoreDescription & " where ItemID = " &  
Trim(TxtItemCode.Text) & """, Y

Else

Cn.Execute "Update Warehousestocks Set [Quantity]= " &  
Val(rs.Fields!Quantity) + (Val(trs.Fields!No\_Per\_BaseUnit) \*  
Val(Me.TxtPackQuantity)) & ",[QtyofCrates]=" & Val(rs.Fields!QtyofCrates) +  
Val(Me.TxtPackQuantity) & ",[Description]=" & ChkQuotes(Descript) &  
",[StoreDescription]=" & TxtStoreDescription & " where ItemID = " &  
Trim(TxtItemCode.Text) & """, Y

End If

End If

trs.Close

Else

trs.Open "Select

Warehousestocks.\*, WarehousePacks.ItemID, WarehousePacks.Packed From

```

WareHousePacks Inner Join WareHousestocks on WareHousePacks.ItemID=
WareHousestocks.ItemID Where WareHousestocks.ItemID= "" & Me.TxtItemCode & ""

If trs.RecordCount > 0 Then
    If trs.Fields!Packed = "P" Then
        Cn.Execute "Update WareHousestocks Set[QtyofBoxes]=" &
Val(trs.Fields!QtyofBoxes) + Val(Me.TxtNoofBoxes) & ",[Description]=" &
ChkQuotes(Descript) & ",[StoreDescription]=" & TxtStoreDescription & " where
ItemID = "" & Trim(TxtItemCode.Text) & "", Y
    Else
        Cn.Execute "Update WareHousestocks Set[QtyofCrates]=" &
Val(trs.Fields!QtyofCrates) + Val(Me.TxtPackQuantity) & ",[Description]=" &
ChkQuotes(Descript) & ",[StoreDescription]=" & TxtStoreDescription & " where
ItemID = "" & Trim(TxtItemCode.Text) & "", Y
    End If
End If
trs.Close
End If
rs.Close
If Y > 0 Then
    If Trim(CboBaseUnit) <> "" Then
        rs.Open "select * from WarehouseItems Where ItemID="" & Me.TxtItemCode & ""
        If rs.RecordCount > 0 Then
            Cn.Execute "Update WarehouseItems Set [SCostPrice]=" &
Val(FindStringValue(TxtUnitCost)) & ",[SCashPrice]=" &

```

```

Val(FindStringValue(TxtUnitPrice)) & ",[SCreditPrice]=" &
Val(FindStringValue(TxtCreditPrice)) & ",[Discount]=" & Val(Me.TxtDiscount) & "
where ItemID = " & Trim(TxtItemCode.Text) & "", Y

Else

Cn.Execute "Insert Into WarehouseItems
([ItemID],[Unit_Type],[UserID],[Discount],[SCostPrice],[SCashPrice],[SCreditPrice])"
& _
"Select " & TxtItemCode & ", " & CboBaseUnit & ", " & UserCode & ", " &
Val(TxtDiscount) & ", " & Val(FindStringValue(Me.TxtUnitCost)) & ", " &
Val(FindStringValue(Me.TxtUnitPrice)) & ", " &
Val(FindStringValue(Me.TxtCreditPrice)) & "", Y

End If

rs.Close

End If

End If

If Y > 0 Then

Cn.Execute "Update WarehousePacks Set [CashPrice]=" &
Val(FindStringValue(TxtPackPrice)) & ",[No_Per_BaseUnit]=" & Me.TxtQtyPerPack
& ",[UnitCost]=" & Val(FindStringValue(TxtPackCost)) & ",[CreditPrice]=" &
Val(FindStringValue(TxtCreditPackPrice)) & ",[Unit_Type]=" & CboPackUnit & "
where ItemID = " & Trim(TxtItemCode.Text) & "", Y

End If

If Y > 0 Then

Cn.CommitTrans

```

MsgBox "Item Edited Successful!", vbInformation, "Edit Successful"

Else

Cn.RollbackTrans

MsgBox "Sorry,Unable to Edit Item:Please Try Again!", vbInformation, "Item Edit

Failed"

End If

End If

ClearFields

End Sub