Improvement of Company ABC's Inventory to determine the best safety stock to keep

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Executive Summary

Company ABC, is a retail company that buys and delivers its products to retailers. Deliveries are triggered by orders from retailers. Daily retailers' require stock from Company ABC and Company ABC has to make sure that it always has stock available for all their customers.

A thorough research was conducted to best identify the safety stocks that needs to be kept in the warehouse to ensure that Company ABC always has stock available for its customers. This project identified a system that will determine the re-ordering points, economic order quantity and the safety stock levels of the KVI (Known Value Items) to minimise the total inventory costs.

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Chapter 1

1.1. Introduction and background

The retail industry is one of the biggest and fast growing sectors in South Africa and it plays a vital role in fulfilling consumer needs. Inventory control is one of the toughest decisions to be made by management, it involves studying order management, which consists of how much to order, and when the actual order is placed with suppliers for delivery. Due to the vastness of products with different suppliers, the challenge that arises is the inability to strike a balance within the procurement process.

Every product has its own trend with regards to demand and supply as each product has a different product life cycle based on consumer requirements. Product behaviour varies based on seasonality and availability. The product trends may also differ according to LSM (living standard measures) and geographic locations.

As mentioned by Wild, (2002) inventory control is the process which organises the availability of products to customers. It coordinates the ordering and stockholding policy of products in a company to meet customer needs.

This project was conducted in a company which will be referred to as Company ABC. Company ABC is a distribution centre that stores and distributes millions of consumer goods a year, this company is one of the six distribution centres that is part of a larger company which will be referred to as Company Z for confidentiality purposes. Company Z is among the four leading retail Companies in South Africa and is one of the biggest companies in the retail industry. They distribute to approximately 6000 retail stores around South Africa and outside South Africa, into the following countries: Botswana, Namibia, Malawi, Zimbabwe, Zambia and Mozambique. Company ABC distributes all of its products to 146 retail stores in the northern part of South Africa and also in Botswana, Zimbabwe, Malawi and Zambia. From this, one can deduce the enormity of this company.

Company ABC‘s warehouse is divided into two sections being the perishable and dry goods facilities that are on one site. Perishable goods are all the goods with a short life cycle and dry goods are goods with a long life cycle. Examples of each cluster are also given, as shown in Figure 1. Most of the dry goods are bought and stored in Company ABC‘s warehouse then the retail stores place their orders and buy from Company ABC. This means that Company ABC has to make sure that there is enough inventory to supply to all their customers (retail Stores).

Company ABC has products that are referred to as KVI (known value items) which are all the brands that are in high demand. They are referred to as fast moving products and also as commodity products, for example these are products like 2kg*Tastic* rice and *Savemore* toilet paper, 10’s. Rice is a commodity because many houses buy rice but the fact that it is tastic 2kg makes it a KVI, because that is the fast moving line under the brand *Tastic*. This is the same for the ten pack *Savemore* toilet paper which is a KVI because it is a known item and consumed in high rates and it is a very important item to have.

Figure 1 shows a breakdown structure of the product cluster in Company ABC. It is important to note that dry products are divided into 7 categories and occupy a large amount of space in the warehouse, while perishable products occupy a small space. Under each category are two examples.

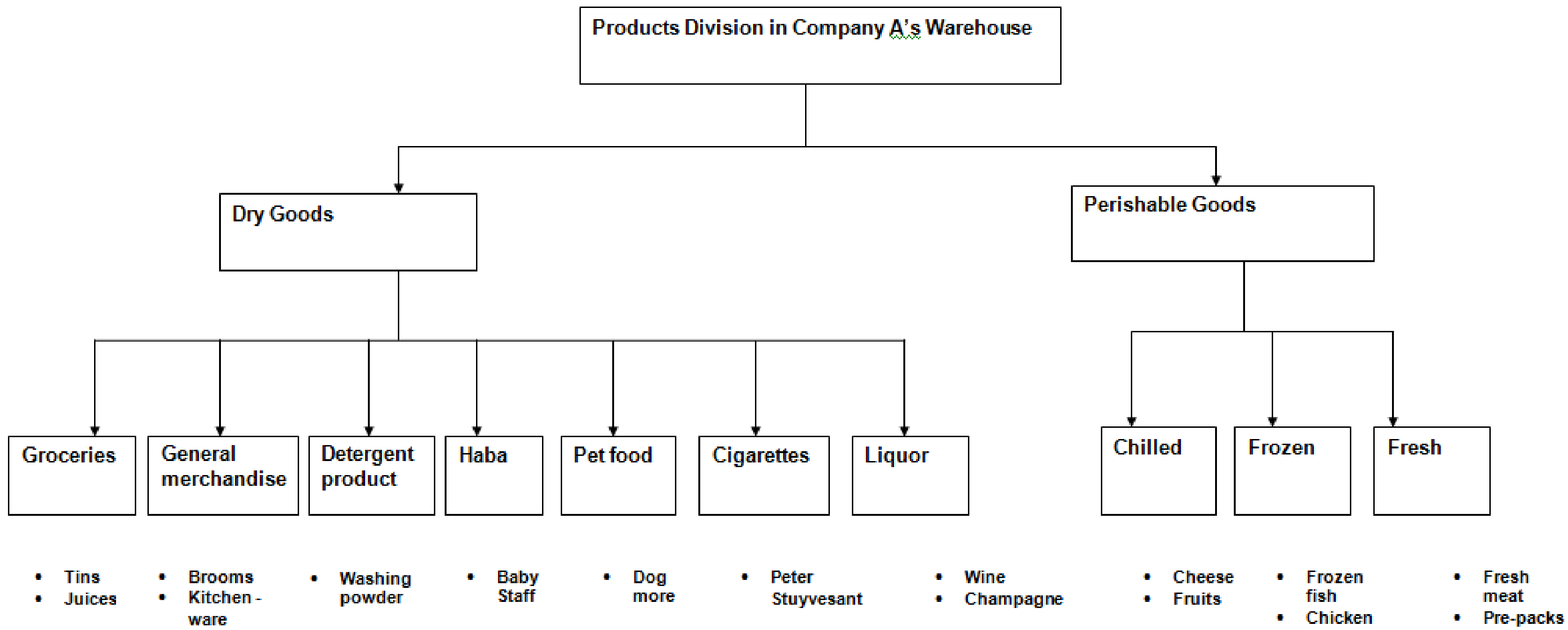

Figure 1: Illustration of Product division

Company ABC's activities can be divided into the following supply chain management process

- Order placing
- Receiving of orders
- Put away of stock into the warehouse
- Picking of stock for store orders
- Procurement on the warehouse management system
- Consolidation of orders
- Delivery to stores.

1.2. Problem Statement

So often companies all over the world ask themselves, "are we optimizing our maximum best?", and yet no one knows what the best is. Different companies have different ways of measuring their best. Continuous improvement of processes is a vital tool in any company that is working towards being the best in their industry.

As mentioned Company ABC orders and receives a vast number of products from their suppliers, which then gets delivered to their retailers according to the orders received from the retailers. Company ABC has a 30 day window period, within which Company ABC must receive orders and pay for this orders. The retailers are given a window period of 14 days to make their payments to Company ABC. This process is very important for Company ABC because within the 30 days Company ABC must receive payments from the retailers so that they can also pay their suppliers by the end of the 30^{th} day.

The challenge is to identify the correct safety stock to maintain, in order to have a correct in stock level to supply to customers. Hence it has been noticed that there is a possibility of stock-out in Company ABC.

1.3. Aim and Objectives

The aim of this project is to identify how much of each of the identified KVI should Company ABC order and the amount of safety stock to keep to ensure that there is always enough stock in the warehouse and minimize the levels of stock piling and hence save inventory costs.This will be done by analysing the AS-IS ordering policies of Company ABC’s inventory and ordering policy.

Listed below are the objectives of the study:

- To improve the replenishment process within the supply chain.
- To research and identify the different ordering policies
- To identify the best ordering policy

1.4. Project Scope

The scope of this project is to improve the ordering policy, re-order points and safety stock of selected KVI’s in Company ABC.

Company ABC has many KVI’s under dry products in their system but only a selected number of products, identified by management will be studied, and these products to be studied are known as commodity products, as mentioned in the introduction.

This investigation will also involve studying joint ordering which is also known as blanket ordering to make sure that products from the same supplier are included in the ordering policy. It is important to note that products from the same supplier will be considered in the calculations, whether they fall under KVI’s or not.

1.5. Project Plan

The project is divided into seven parts namely:

1. **Identification of the problem:** The first step is to identify the problem from the point of view of the customer, customer here being Company ABC.

2. **Definition of the problem:** After identifying what might be the problem from the customer and visiting the company, a clear definition of the problem is formulated. This includes identifying the scope, aim and objectives of the project.

3. **Do literature review:** The next step is to do literature study; this includes studying different models that can be implemented in solving the problem at hand.

4. **Data collection:** The fourth step is data collection, gathering all the data that is needed in solving the problem. Data collection is done through the analysis of past information, for example past sales data, interviews and studying the operations.

5. **Problem solving:** In this step a mathematical model is built with the help of excel. This model will minimise inventory costs and identify an ordering system.

6. **Solution and validation analysis:** The 6^{th} step is interpretation of the solution and validation, which checks how close to reality, is the solution. With the help of a sensitivity analysis, the model is checked on how it reacts to changes in the inputs of the model.

7. **Implementation and recommendations**: Lastly the solution is implemented and compared to the current situations in order to identify if they are any improvements to the problem, identified in steps one and two. Also recommendations are identified.

Chapter 2

Literature Review

2.1. Supply Chain Management

Supply Chain Management is a process through which customer needs are met by the design and management of seamless, value-added process organizational boundaries. It is also important to note that successful supply chain integration needs the integration of people and technological resources, (Leenders et al, 2006).

Langley et al, (2008) describes supply chain management as a journey, not a goal and he states that there are no "silver bullets" since all supply chains have been said to be different.

According to Scott et al, (1991) and New et al, (1995) supply chain management (SCM) is described as 'the chain that links each element of the manufacturing and supply processes from raw material to products for the end user, encompassing several organizational boundaries'. According to this definition supply chain management is integration between the entire value chain and materials and supply chain management from the extraction of raw materials to its end useful life, which is when it reaches the end user.

Nowadays the term supply chain management (SCM) is a key strategic factor that is used in increasing organisational effectiveness and also used in realization of organizational goals such as competitiveness, better customer care and increased profitability, (Gunasekaran et al, 2001).

2.2. Warehouse Management

According to Tompkins et al, (2010) warehouse management plays a critical role in the success of a company's supply chain. The main function of a warehouse is to effectively store products that are from one destination to the next in the supply chain without any damages or alterations to the product's basic form.

Warehouse management plays a vital role in distribution centres, especially at Company ABC. It houses most of the products that must be delivered to customers. The figure below shows the general warehouse process, (Coyle et al, 2003).

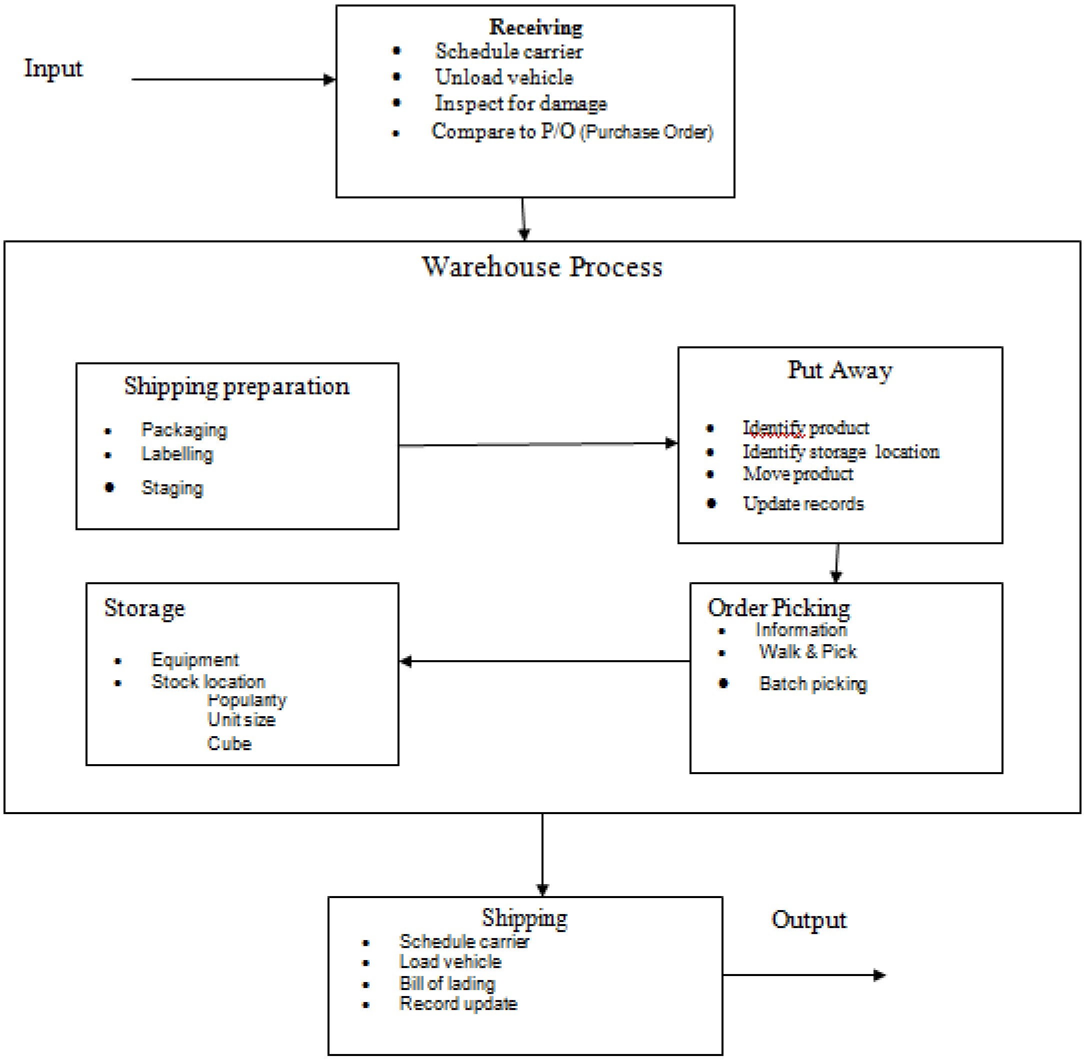

Figure 2: Warehouse process and activities.

(Bardi, Coyle, Langley2003:300)

As it has been mentioned in the introduction and from the figure 2, the processes that are part of Company ABC's warehouse are:

- Ordering
- Receiving
- Put Away

- Storage
- Order Picking
- Shipping preparation
- Shipping

Storage is the physical placement of products, when waiting to respond to demand. According to Tompkins et al, (2010) the form of storage isaffected by the size and quantity of the items in inventory and the product's container.

2.3. Demand Management

Blackwell et al, (1999) refers to demand management as a focused effort to estimate and manage customers' demand with the intention of using this information to shape operating decisions. Demand management allows a firm throughout the supply chain to collaborate on activities related to the flow of product, services, information and capital. It is important to note that any attention paid to demand management will increase the value of the supply chain because throughout the supply chain, from production of product to sale of the product to consumers or business buyers, there is demand satisfaction.

Here follows a list of a number of ways in which effective demand management will help in satisfying customer need and solving customer problems:

- Gather and analyse customer requirements
- Identify how and who will satisfy the requirements
- Sharing with other supply chain members' knowledge about consumers, customers and all other challenges.
- Providing service that meet customer requirements
- Developing and executing the best logistics, transportation, and distribution methods to deliver products and services to consumers in the desired format.

2.3.1. Problems associated with demand management

There are some problems that are associated with demand management such as:

- Lack of coordination between departments resulting in less coordination in the response to demand information.
- Too much effort placed on demand forecasts and less on collaborative efforts and the strategic and operational plans that need to be developed from the forecasts.
- Demand concentrates on operational and tactical purposes than on strategic purposes.

How Demand Management Supports Business strategies	
Strategy	Examples of how to use demand management
Growth Strategy	• Perform "what if" analyses on total industry volume to gauge how specific merger leverage market share. • Analyze industry supply/demand to predict changes in product pricing structure and market economics based on mergers. • Building staffing models for merged company using demand data.
Portfolio Strategy	• Manage maturity of products in current portfolio to optimally time overlapping life cycles. • Create new product development/introduction plans based on life cycle. • Balance combination of demand and risk or consistent "cash cows" with demand for new products. • Ensure diversification of product portfolio through demand forecast
Positioning Strategy	• Manage product sales through each channel each based on demand and product economics. • Manage positioning of finished goods at appropriate distribution centres to reduce working capital, based on demand.

	• Define capability to supply for each channel
Investment Strategy	• Manage capital investment, marketing expenditures, and research and development budgets based on demand forecasts of potential products and maturity of current products. • Determine whether to add manufacturing capacity.

Table 1: Demand management support business strategy.

(Langley, Coyle, Gibson, Novack & Bardi 2009:236)

2.3.2. Forecasting

Forecasting is a major tool of demand management; it determines the amount of output needed by the customer. It is a way of reducing variability, in terms of expected versus actual sales.

Different approaches to forecasting serve different purposes:

- Long term forecasts

  It covers more than three years and is used for long term planning and strategic issues.

- Midrange forecast

  It is between one to three years range and it addresses budgeting issues and sales plans.

- Short-term forecast

  It project demand into several months ahead and it focuses on shorter time intervals. Short-term forecasts are more important for the operational logistics planning.

2.4. Inventory Management

Inventory control and maintenance plays an important role in all sectors of the economy. Almost all organisations have to deal with inventory on a daily basis. Companies close down if inventory is not managed correctly, especially if customer satisfaction is an issue. As it has been mentioned, it is important to have balance when it comes to company stock. Inventory management deals with having enough stock when needed, and also making sure that a company does not run out of stock. Thus inventory management ensures constant availability of safety stock.

2.4.1. Definitions and Concepts

2.4.1.1. Definitions

- **Inventory**

It is defined as: 'stockpiles of raw materials, suppliers, components, work in process and finished goods that appear at numerous points throughout a firm's production and logistics channel' (Ballou, 2004). According to Chase et al, (2009), inventory is the stock of any item or any resource used in a firm, and he also describes inventory system as the guidelines of policies and regulations that monitor levels of inventory and helps in determining what levels should be maintained, when should stock be ordered and in what sizes should it be ordered.

'Inventory ties up capital, uses storage space, requires handling, deteriorates, and sometimes it's lost. Furthermore, inventory frequently compensates for sloppy and inefficient management, including poor forecasting, haphazard scheduling, and inadequate ordering processes'. This means that inventory can hide inadequacies and allow management not to notice (Fogarty et al, 1991).

Good customers can easily become irritated and take their business somewhere else if their demand is not immediately met. "The availability of the right items at the right time and in the right place supports the organisational objectives of customer service, productivity, profit and return on investment"(Fogarty et al, 1991).

- **Lead time**

It is the span of time between the reorder point and the receipt of products for sale. It consists of order preparation, release time, handling time from the supplier and shipping time from supplier to distribution centre. It plays a very important role in manufacturing performance and distribution of products. Lead time has an impact on work-in process and as well as finished goods, inventories, information requirements, quality management practices and customer service.

- **Repetitive Ordering**

It is the repetition of ordering decision in a regular fashion. For example a company ordering bearings assemblies will place an order, then see its inventory depleted, then place another order, and so on.

- **Continuous Ordering**

It is when an order is placed at any time. It deals with two types of models the continuous review models and periodic review model. Continuous review models are inventory models that allow orders to be placed at any time.

- **Ordering cost**

It is the fixed cost of placing an order. It refers to the managerial and clerical costs for preparing for the purchase. Ordering costs include details such as counting items and calculating order quantities, also the system that is used to track orders is part of cost of ordering.

- **Holding cost**

It is a variable cost of holding a unit of goods on stock during a period of time. It includes costs for storage facilities, handling, insurance, pilferage, breakage, obsolescence, taxes, and the opportunity cost of capital.

- **Handling cost**

The cost involved in handling inventory in a warehouse, it does not influence the minimization of the total inventory cost if all demand is satisfied. This cost is usually considered in the design and the control of warehouse.

- **Purchasing Cost**

It is the variable cost associated with purchasing a single unit of a product, includesvariable labour cost, variable overhead cost and raw material cost associated with producing or handling a single unit.Butfor goods ordered from an external supplier it includes shipping costs.

- **Shortage Cost**

It is the cost that is incurred when a product is out of stock; an order for that product must either wait for the product or be cancelled. In the case of backlog of demand it is the extra cost associated with the administration and later delivery of goods. In the case of lost sales it is the opportunity cost of lost profit on unsatisfied demand.

2.4.1.2. Inventory Concept

- **Inventory on hand**

It is the actual number of units presents at the stocking point, it is also known as physical stock and it plays a role in determining holding cost.

- **Net stock**

It is the inventory on hand minus the amount of backlog.

- **Safety stock**

Is the additional amount of stock carried in addition to the expected demand, it is used as protection against uncertainty in demand and against other irregularities like breakage.

- **Inventory position**

It is defined as the stock on-hand plus on-order minus backordered stock.

- **On- order inventory level**

It is the summation of inventory on hand and inventory that has been ordered.

2.4.2. Factors influencing Inventory Management

According to Fogarty, (1991) the nature of a situation determines the appropriateness of an inventory management system, even though one cannot examine all possible factors that define a unique situation and set of considerations, due to the vastness of inventory systems. Three factors that affect inventory management will be considered among all of them:

2.4.2.1. Demand Pattern

The nature of the demand pattern plays a role in the appropriateness of when to order decision rule and also on the inventory management system. Under demand pattern two types of demand are encountered; the independent demand that is characterised by gradual and steady state usage pattern.

- Independent Demand

In distribution inventory products usually experience stable demand. It is important to note that the demand that maybe affected by trends and seasonal patterns does not depend on other demand of other items. Different types of trends and how they affect inventory level is shown below in figure3.

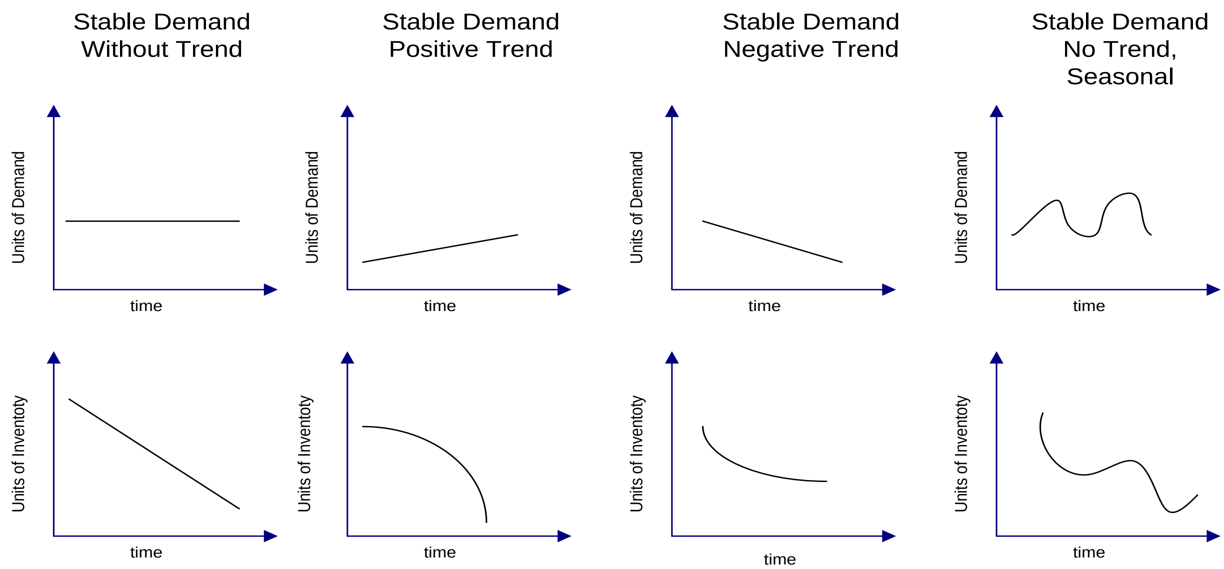

Figure 3: Relation of demand and product dissipation patterns overtime

- Dependent Demand

  Dependent demand is usually found in manufacturing, subassemblies, component parts, and raw materials. Raw materials have a demand that is dependent on the demand of the final products in which they are used. Also finished goods purchased in large quantities a few times a year by very few customers will likely exhibit an abrupt and irregular demand pattern which is similar to dependent demand, as shown in the figure 4, below.

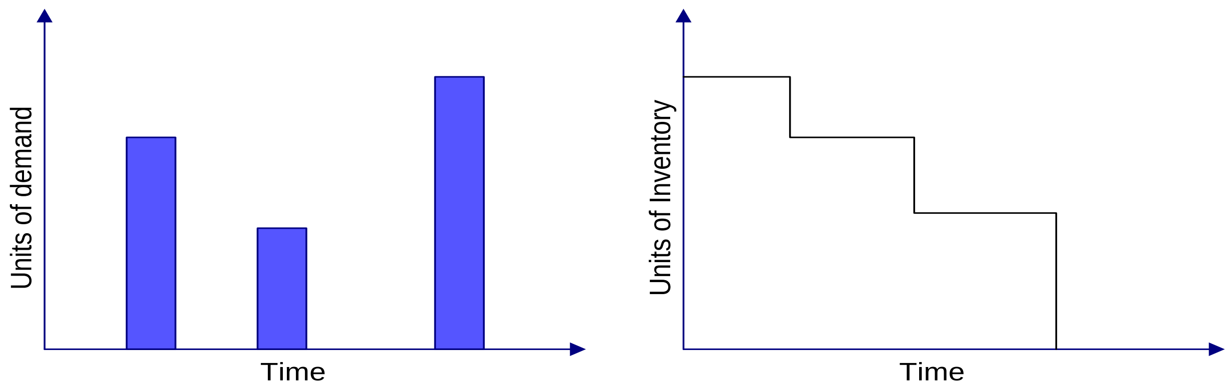

Figure 4: Relation of demand and inventory over time

2.4.2.2. Source: Common Supplier or Production Process

Products purchased from the same supplier are usually grouped together to facilitate joint purchase orders, joint product quantity discounts, transportation, as well as streamlining communications with suppliers.

2.4.2.3. Customer Requirements

When a single customer orders a group of items, purchase of these items may be grouped to enable concurrent delivery as well as grouped shipping and invoicing.

2.4.3. Reasons for holding inventory

Different companies hold inventory for different reasons. Chase, (2009) describes some of these reasons as:

2.4.3.1. Meet variation in product demand

Some companies accumulate inventory for seasonal demand, for example stationery demand increases in December, January and (or) February, then after that the demand is there but slower, but yet again if demand is known it may be easier to produce the exact amount though it is not economicallynecessary. Most of the time when demand is not stable it is safer to maintain safety or buffer stock for variation purposes.

2.4.3.2. Take advantage of economic purchase order size

A company can realise economies of scale in the manufacturing, purchasing and transportation sector by holding inventory. If a company buys in large amounts it has the advantage of getting quantity discounts as transport carries larger volumes.

2.4.3.3. Maintain independence of operations

There are costs involved in setting up machines for new production; therefore inventory allows the reduction of the number of setups.

2.4.3.4. Allow flexibility in production Scheduling

Most of the time there is pressure to deliver products on time. A stock of Inventory decreases the stress of not satisfying customers on time. This leads to longer lead times, which permit production planning for smoother flow and lower-cost operation through larger lot-size production.

2.4.3.5. Provide safeguard for variation in raw material delivery time

When a product is ordered from a supplier anything can happen that may cause a delay, for example: Product getting lost, variation in shipping time, strikes that occur at the supplier's plant, incorrect shipments or defective products.

2.4.4. Types of inventory

According to Leenders, (2006) inventory can be classified as follows:

2.4.4.1. Transit or pipeline inventories

These are products that are on the route from one destination to the other, they are usually considered to be part of the stock, even though they are still on the way.

2.4.4.2. Cycle inventories

It is inventory that is needed to meet predictable demand. It balances the decision concerning purchase, produce, or sell in lots rather than individual units.

2.4.4.3. Buffer or Uncertainty inventories

Safety stock exists because of variability in demand or supply. Purchase products or buffer stock give protection against the variability of supplier performance due to shutdowns, strikes, lead time variations, late deliveries, and poor quality products that cannot be accepted.

2.4.4.4. Anticipation or uncertainty inventories

Anticipation inventory is inventory that is kept for a well-defined future need. It is different from buffer stock because it has certainty and less risk attached to it, for example seasonal inventories.

2.4.5. Inventory Models

Inventory models to be studied in this section are divided into two types

1. Deterministic EOQ inventory model- which basically deals with known demand during any period of time, and
2. Probabilistic Inventory Models- which deals with unknown, uncertain or random demand. It also considers single-period inventory models. It highlights the importance of safety stock and service level.

2.4.5.1. Deterministic EOQ inventory Models

Assumption of EOQ Models

- Constant demand

It is when demand occurs at a known constant rate, for example if demand occurs at a rate of 3000 units per year, the demand at any t-month period will be$\frac{3000t}{12}$, (Winston, 2004).

- Constant lead time

Further Winston (2004) describesconstant lead time as the lead time for an order at a known constant.

2.4.5.2. EOQ Model Notations

For calculations the following notations will be used in the EOQ Model:

c = Unit cost

p = Purchasing cost

D = Demand per time unit

h = Holding cost for one unit in inventory for one unit of time

K = Setup or ordering cost

q= Order quantity

n = Number of orders per time unit

r = Rate of production per time unit (r > D)

s = Shortage cost of one unit for one unit of time

t = Time between orders

b = Point of price break

I = Inventory level

L = Lead time

Assumptions of the Basic EOQ Model

Winston (2004) describes the assumptions that must hold true for the basic EOQ model:

1. Demand must be fulfilled on time
2. Zero lead time for all orders
3. Demand is known and occurs at a constant rate
4. There's a setup cost K and a holding cost of h

From these assumptions based on the EOQ models, an ordering policy that minimise the yearly sum of ordering cost, purchasing cost, and holding cost is determined.

Derivation of basic EOQ Model

According to Winston (2004), the basic EOQ model involves placing an order when there are zero inventories. One should place the same quantity, to calculate the economic order quantity (q^*) that minimise annual cost (TC (q)).

TC (q) = annual purchasing cost + annual holding cost + annual cost of placing orders

Annual purchasing cost is given by:

$$\frac{Purchasing\ cost}{year} = \left(\frac{Purchaisng\ cost}{unit}\right)\left(\frac{Units\ purchased}{year}\right)$$

$$= pD$$

Annual holding cost is given by:

$$\frac{Holding\ cost}{year} = \left(\frac{holding\ cost}{cycle}\right)\left(\frac{cycles}{year}\right)$$

$$= \frac{hq}{2}$$

Annual ordering cost is given by:

$$\frac{Ordering\ cost}{year} = \left(\frac{ordering\ cost}{order}\right)\left(\frac{orders}{year}\right)$$

$$= \frac{KD}{q}$$

Therefore the annual total cost is given by:

$$TC = pD + \frac{hq}{2} + \frac{KD}{q}$$

Since the annual purchasing cost does not depend on order size, this means that the purchasing cost can be ignored when computing the annual cost. This can be written as;

$$TC = \frac{hq}{2} + \frac{KD}{q}$$

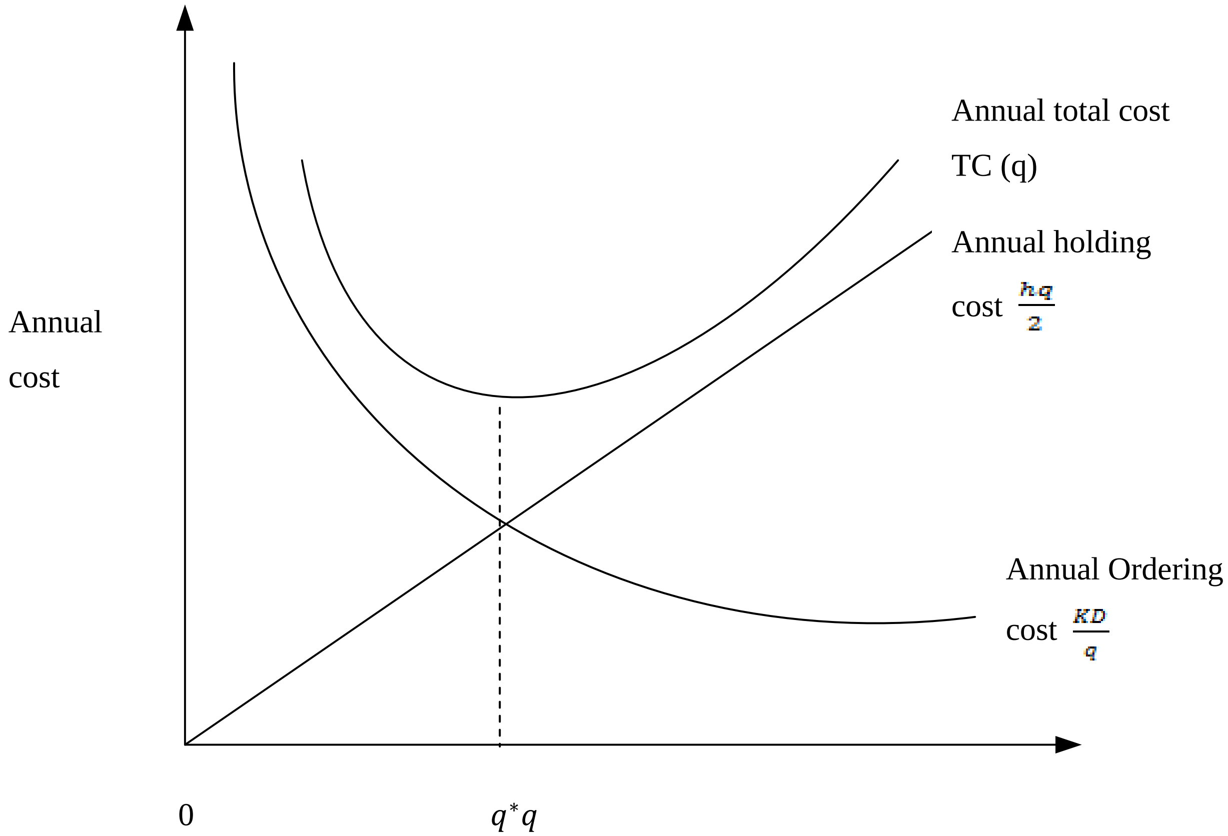

Figure 5: Graph showing the trade-off between holding cost and ordering cost
(Winston 2004:109)

2.4.6. Price break Models

Jacobs et al, (2009) states that the selling price of products varies with the order size of that product, the bigger the order size, the lesser the selling price. This is also known as quantity discount. Most of the time holding cost is a percentage of the product's purchasing cost, this means that holding cost will also decrease as the quantity increases.

A different approach is investigated when it comes to the order quantity different from the previous one, a graph will be used to describe this approach taken by Winston, (2004).Let q be the quantity ordered and $b_{i-1}, b_i, \ldots, b_{i+1}$ are price break points as shown in figure 6 below.

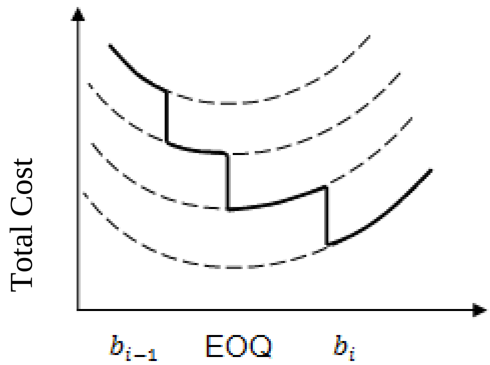

Figure 6: Modified graph showing three price break models

According to Jacobs et al, (2009) to determine the optimal quantity of any item, we have to solve the economic order quantity for each price and the point of price change. Winston, (2004) considers the following definitions:

TC (q)= Total annual cost

EOQ = Economic order quantity that minimizes total cost

EOQ is acceptable if $b_{i-1} \leq$ EOQ< b_i

The aim of these definitions is to find the value of q, minimizing TC (q)as shown in figure 4, the EOQ is allowable because b_{i-1} <EOQ< b_i. From this inequality Winston summarises by the following inequality

$$TC(EOQ) \leq TC(q)$$

The above observations are essential because they help in further understanding of optimal order quantity when numerous quantity discounts are allowed.

2.4.7. Probabilistic Inventory Models

2.4.7.1. Notations to be used in Probabilistic inventory models:

q= is the number of units ordered

q^*= is the optimal order quantity

p (d) = Probability of a demand units, d.

D= Random demand

c= Cost incurred

K=Ordering cost

h= Holding cost

L= lead time for each order

q=Quantity ordered

$E(D) =$ Average demand

2.4.7.2. Discrete Demand

According to Winston, (2004) companies usually face inventory problems because of:

1. The company makes their own decisions on how many units to order
2. A demand of d units occurs with probability p(d)
3. A cost of c (d, q) is incurred.

Such problems are referred to as news vendor problems, for example a vendor that must decide how many newspapers to buy in a day because if the vendor buys too much, he ends up with useless newspapers or if he buys less, he loses profit that he could have made. Basically the vendor must buy newspapers that will balance inventory costs.

2.4.7.3. Marginal analysis

The marginal analysis is usually used to solve news vendor problems when the demand is a discrete random variable and the cost c (d, q) is in the form:

$c(d, q) = c_0 q$ + (terms not involving q) $\quad d \leq q$

$c(d, q) = -c_u q$ + (terms not involving q) $\quad d \geq q + 1$

c_0 = overstocking cost

c_u= under stocking cost

If $d \leq q$ it means ordered quantity is more than the demand, it is overstocked. If the size of the order is increased from q to q +1, this means that the cost increases by c_o.

If $d \geq q + 1$ it means ordered quantity is less than the demand, this is known as under stocking and cost is reduced by c_u.

To derive the optimal order quantity, let E (q) be the expected cost if an order is placed for q units. The goal is to find the value q^* that minimizes E (q), the smallest value of q must be determined for which E (q+1) - E (q)≥ 0. To calculate E (q+1) - E (q) ≥0, two possibilities must be considered:

Case 1: d≤ q

Ordering q+1 units instead of q units causes an overstock by one units, it increases cost by c_o. The probability of this occurring is P (D≤ q)

Case 2: d≥ $q + 1$

Ordering q+1 units instead of q units causes an under stocking by one units, it reduces cost by C_u. There probability of case two occurring is P $(D \geq q + 1) = 1 - P(D \leq q)$.

Basically this means that:

P (D≤ q) of time, ordering q+1 units will cost c_o more than ordering q units.

1-P (D≤ q) of time, ordering q+1 units will cost c_u less than ordering q units. Hence ordering q+1 units will cost $c_o P(D \geq q) - c_u[1 - P(D \leq q)]$.

It was shown that: E (q+1)-E (q) =$c_o P(D \geq q) - c_u[1 - P(D \leq q)]$

$$=(c_o + c_u)P(D \leq q) - c_u$$

Then E (q+1) - E (q)≥ 0 will be true if

$$(c_o + c_u)P(D \leq q) - c_u \geq 0 \quad \text{Or} \quad P(D \leq q) \geq \frac{c_u}{c_o + c_u}$$

Let F (q) =P $(D \geq q)$ be the demand distribution function.

Therefore E (q) will be minimized by the smallest value q (let it be q^*) satisfying

$$F(q^*) \geq \frac{c_u}{c_o + c_u}$$

2.4.7.4. Continuous Demand

From the news vendor scenario when demand D is continuous random variable having density function $f(d)$. Based on the marginal analysis, one can see that the decision maker's expected cost is minimised by ordering q^* units and it is the smallest number satisfying:

$$(D \leq q) \geq \frac{c_u}{c_o + c_u}$$

The optimal order quantity can be determined by finding the value of q^* satisfying, from the below equation it can be seen that it is optimal to order units up to the point where the last unit ordered has a chance of being sold.

F $(D \leq q^*) = \frac{c_u}{c_o+c_u}$ or F $(D \geq q^*) = \frac{c_u}{c_o+c_u}$

2.4.8. Inventory Policies

2.4.8.1. The EOQ with uncertain Demand

In this section, consideration will be on the lead time and the demand. The lead time is nonzero and the demand during each lead time is random. Notations to be used:

K= ordering cost

h=holding cost/ unit/year

L=lead time for each time an order takes place

Q=quantity ordered each time an order takes place

D=random variable representing annual demand with mean E (D), variance varD, and standard deviation σ_D

c_B =cost incurred for each unit short, which does not depend on how long it takes to make up stock-out

OHI (t) =on-hand inventory (amount of stock on hand) at time t

B (t) = number of outstanding back orders at time t

I (t) = net inventory level at time t= OHI (t) -B (t)

r = inventory level at which order is placed (reorder point)

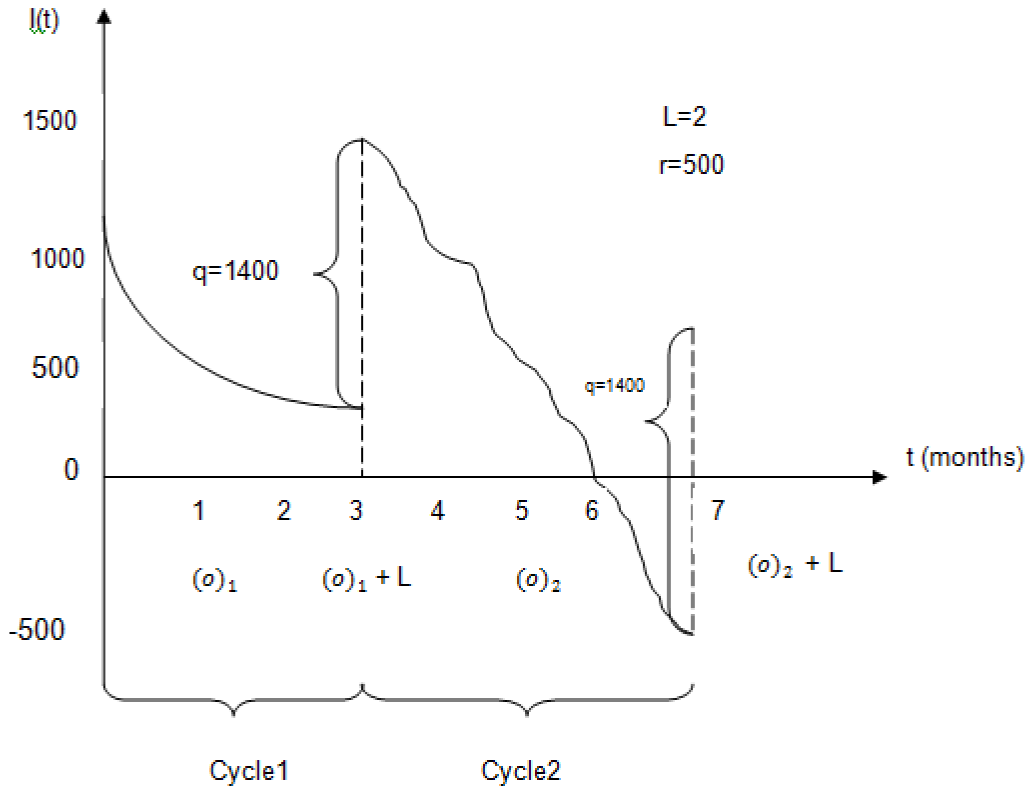

Figure 7: Inventory over with reorder point model

(Winston 2004:147)

Figure 5 above illustrates what happens in models with constant reorder point, for example in the above graph when r =500; whenever the inventory level drops to r, an order is placed for q units. Further, let X = random variable representing demand during lead time.

Assume that X is a continuous random variable with a density function f(x) and mean, variance, and standard deviation of E(x), var X, and σ_X ,respectively. Assuming that demands at different points in time are independent, then it can be said that the random lead time demand X satisfies

$$E(X) = LE(D), var\ X = L(var\ D), \sigma_X = \sigma_D\sqrt{L}$$

Assuming that D is normally distributed, then X is also normally distributed.

If the lead time, L is allowed to be a random variable, with E(L), variance var L, and standard deviation σ_L. If the length of the lead time is independent of the demand per unit time during the lead time, then:

$E(X) = E(L)E(D)$and $var\ X = E(L)(var\ D) + E(D)^2(var\ L)$

2.4.9. Inventory policies

2.4.9.1. Continuous Review (r, q) Policies

A continuous review (r, q) policy, is a policy in which one orders a quantity q, when stock in inventory reaches a reorder level r. it is also called a two-bin policy, because it can be easily likened to two bin containing stock for example as long as bin one has stock, its safe, until it gets empty then you must place an order.

2.4.9.2. Continuous Review (s, S) Policies

Concerns are raised when the inventory point is reached and is even less than the reorder point, because from (r, q) policy one can only place an order when the reorder point r is reached. Thus (s, S) policy addresses such shortcomings. It is when one places an order whenever the inventory level is less than or equal to s. the size of the order is sufficient to raise the inventory level to S. for example if a policy of (10,45) is being used, then suddenly inventory drop from 12 to 8, an order of 45-8=37 units will be placed immediately. Thus we may approximate the optimal(s, S) policy as S-s equal to the economic order quantity q.

2.4.9.3. Periodic Review (R, S) Policy

Periodic review (R, S) policy says that every R units of time, on hand inventory level must be reviewed and place an order to make sure that there is S inventory level. For example if a policy of (0.25, 250) is used, it means inventory should be reviewed at the end of each quarter. If $i < 250$ units were on hand, an order of $250 - i$ would be placed. This shows that an (R, S) policy will cost more because it incurs more holding cost than (r, q) policy. (R, S) is usually easier to maintain than a continuous review policy, with (R, S) policy, thus a company can establish with certainty the times when order will be placed.

2.4.10.Stock-outs Costs

Stock-out or shortages occur when desired quantities of products are required by a customer and these products are not available. When a seller is unable to satisfy demand with available inventory according to Langley et al, (2009), the following events may occur:

2.4.10.1. Backorder

These are the orders that you couldn't fulfil with the stock at hand and have to be fulfilled at a later stage. A firm having to back order an item that is out of stock will incur expenses for special order processing and transportation

2.4.10.2. Lost sale

Lost sale has implications on the profit, because if the product was available it would mean more profit gain. For lost sales it is assumed that all out of stock products will result in lost sales. The reorder point r of the lost sales can be estimated using the marginal analysis

2.4.11.Safety stocks

As mentioned before safety stock is extra stock kept to guard against variation in demand and lead time. Given the cent sales volumes and replenishment cycles, safety stock requirements can be calculated as:

$$\sigma_{ss} = \sigma_D * z * \sqrt{\bar{L}}$$

Where:

σ_{ss} = Units of safety stock needed to meet demand

$\bar{L}$ = Average lead time

σ_D = Standard deviation of daily demand

z =Number of standard deviations for a specified service probability.

2.4.11.1. Safety stock- Fixed order Quantity model

Jacobs et al, (2009) states that 'a fixed order quantity system monitors the inventory level and places a new order when stock reaches some level, R, an order is placed when inventory position drops to the reorder point, R'.

The amount of safety stock relatively depends on the service level desired. Q being the quantity to be ordered is calculated considering the demand, ordering cost, holding cost, and so on. Reorder point covers the expected demand during the lead time.Jacobs et al, (2009) 'further states that the difference between a fixed order quantity model where demand is known and one where demand is uncertain is in computing the reorder point'. The reorder point is:

$$\boldsymbol{R} = \overline{\boldsymbol{D}}\boldsymbol{L} + (\boldsymbol{z} * \sigma_{\mathrm{D}} * \sqrt{\mathrm{L}})$$

2.4.12.Service Level Measure

Most of the time managers control shortages in a firm by meeting a specified service level. According to Winston, (2004) two types of measures for service level sexist:

Service Level Measure 1,SLM_1: The expected fraction of all demand that is met on time.

Let SLM_1be the fraction of all demand met on time, then:

$$\frac{Expected\ shortages}{year} = \frac{E(B_r)E(D)}{q}$$

$E(D)$= the average daily demand

B_r= the number of stock-outs during a cycle if the reorder point is r.

E(X) = Mean of the lead time in demand.

The q, (order quantity) and r (reorder point), can be calculated as follows:

$$1 - SLM_1 = \frac{expected\ shortages\ per\ year}{Expected\ demand\ per\ year} = \frac{E(B_r)\frac{E(D)}{q}}{E(D)} = \frac{E(B_r)}{q}$$

A reorder point of r corresponds to holding:$y = \frac{r-E(X)}{\sigma_x}$ which will yieldan expected number of shortages $E(B_r)$, calculated as:

$$E(B_r) = \sigma_x NL(\frac{r - E(X)}{\sigma_x})$$

This leads to:

$$1 - SLM_1 = \frac{\sigma_x NL(\frac{r-E(X)}{\sigma_x})}{q}$$

$$NL\left(\frac{r - E(X)}{\sigma_x}\right) = \frac{q(1 - SLM_1)}{\sigma_x}$$

Service level measure 2, SLM_2: the expected number of cycles per year during which a shortage occurs. It assumes backlogging, when given $s_0 = the\ average\ of\ cycles\ per\ year$, the reorder point is the smallest value satisfying

$\frac{P(X>r)E(D)}{q} \leq s_0$or $P(X > r) \leq \frac{s_0 q}{E(D)}$

This leads to the reorder point to be:

$P(X \geq r) = \frac{s_0 q}{E(D)}orP(X > r) \leq \frac{s_0 q}{E(D)}$

E(X) = Mean of the lead time in demand.

2.5. Just in Time (JIT) Inventory Management

JIT is the principle that governs parts to arrive in time to be used at the appropriate work station and it discourages holding large quantities of inventory. Most of the time inventory is a management tool as described by Gourdin, (2001), no customer wants to face empty shelves and the marketing department want products to be always available. Due to increase in costs many firms have decided not to hold large amount of on-hand inventories. They rather have small, but frequent shipments exactly when needed by the customer.

2.5.1. Advantages of JIT

The advantages of Just in time inventory management, as described by Gourdin, (2001):

More inventory turns: Because of small amounts of inventory, maintenance of inventory is allowed to be for a short period of time. The issue with a high number of inventory turns is that there is high probability of being out of stock, while raising ordering costs as well.

Better quality: Quality is one of the biggest attributes of JIT products. Customers will do anything to receive the best quality for their products or services.

Less warehouse space needed: Small quantity of inventory means a smaller warehouse space is required.

2.5.2. Disadvantages of JIT

Risk of stock-outs: Elimination of inventory means more risk of being out of stock. Managers try to prevent this occurrence by demanding very high levels of service from the logistic service.

Increased transportation costs: Transportation costs are usually high due to the frequent shipments of small quantities.

Increased purchasing cost: Purchasing costs discounts are usually associated with buying large amounts of quantities, but because JIT concentrate on small quantities more frequently, this means more costs for the customer.

Environmental issues: JIT can affect traffic congestion and air pollution due to the additional transportation required to maintain customer needs.

2.6. Tools and method selection

The demand for the selected known value items (KVI) is unknown. A discrete demand problem is evident. To determine the reorder points and safety stocks of the products mentioned in this project the probabilistic uncertain demand EOQ will be used. The r, q policy will be used to determine when to reorder.

Chapter3

Problem Solving

To determine the reorder points and safety stocks for Company ABC, past data, meeting with management and inventory data was used to build the model for this project, which will be compared to the existing system used. Purchasing cost, ordering, holding costs, demand and lead times will be used to do the calculation for this policy.

Due to limitations to the system only twelve months demands was able to be retrieved from the system and was also used for the calculations which will have a big impact on the correctness of the result. Management was made aware of the flaw, and it was decided that the model that is being investigated in this study will be used as a tool for future reference for reviewing or comparing future systems in terms of ordering policy

3.1. Service level measurement

Company ABC as it has been mentioned it is a retail distribution centre and delivers its products to more than 130 stores. It is important that their customers' needs are fulfilled at all times, Company ABC strive to have a service level of 98%.Appendix A, table 12 shows the z value (number of standard deviations for a specified service probability) that is calculated usingNormsinv from excel.

3.2. Inventory Costs

3.2.1. Purchasing costs

Most of Company ABC's products are purchased in cases and only a few are purchased in units, because orders are made in cases, and these cases are in different sizes, some products are 12 in a cases; some are 8 products in a case, depending on the size of the products. Some products are stored in big boxes and some are stored in bailers but for this project it will all be referred to as cases, for uniformity purpose.

3.2.2. Set up cost per order

The ordering cost was hard to determine due to the fact that it is included in the purchasing cost. A system called SUGO is used by Company ABC, this system is linked to Company ABC's suppliers, and the suppliers use the system to place orders. This SUGO system was purchased and paid for a long time ago thus the cost to run the SUGO software cannot be included in the ordering cost. Because only a few products are being considered for this model, the percentage of the time spent ordering these production a daily basis, is very small when compared to the over-all items that they order daily. A few suppliers were called, and asked how they incorporate transportation costs or delivery costs in the purchasing costs, and it was said that it is calculated as 2% plus VAT of a full truckload of products costs. A full truckload is a truck with 32, 36 or 39 pallets; a pallet usually consists of 84 cases of a productor more depending on the size of the productand a case consists of a number of packs of the product.For example *Tasti*c rice comes in 36 pallets, with 40 cases and each case has 10 packs of2kg*Tastic*. Thus ordering costs is calculated as$(pallets * no\ of\ cases * case\ purchase\ cost * 0.0228)$ and the same for the 8% plus VAT, instead of multiplying by 0.0228 it is multiplied by 0.0912. The transportation cost varies according to the distance of the suppliers. Suppliers that have a lead time of one and half days, their transportation costs are calculated using 2% plus VAT of a full truckload. While suppliers with a lead time of 3 days, their transportation cost is 8% plus VAT of a full truck load.

3.2.3. Daily Holding cost

The holding cost of Company ABC includes storage cost, insurance cost, taxes, handling cost, labour work and electricity. Since Company ABC is a very big company the net operating cost constitutes of 3% of the total costs per month, It is important to note that this cost is used as an assumption, due to the fact that costs are not stable and they are subject to change, for example interest rate change, electricity rate also change and so on. A daily holding cost of 0.11% is calculated from the 3%, meaning that the holding cost is calculated by multiplying the 0.11% with the case purchasing cost, as shown in Appendix A, table 10.

3.2.4. Shortage cost

Shortage cost of Company ABC's products, considers lost sales. A lost sale happens whenever a costumer places an order and it is not available. For companies like Company ABC there is indirect loss of sale, because Company ABC must always have products in order to supply their customers who are retail stores and these stores must supply these products to consumers, therefore if a product is not available in Company ABC this means it won't be available in the stores for consumers and these consumers will have to look else for the products. It makes it difficult for Company ABC's costumers to measure that how many lost sales do they lose each day they are out of stock, thus Shortage cost won't be included in the calculations. Only the service level will be considered.

3.2.5. Lead time

The lead time of products from Company ABC depends on the distance of the suppliers; suppliers who are in Johannesburg have a lead time of one day and suppliers in Western Cape have a lead time of three days, while products from Mpumalanga have a lead time of one day. Average lead time and standard deviation of lead time in days will be considered for each product.

3.2.5.1. Average lead time

Appendix A , table 11 shows the average lead times in days, it is important to note the difference in the lead times as mentioned above due to the difference in their locations. Products from Western Cape have an average of 3 days while products from Gauteng and Mpumalanga have an average of 1.5 days.

3.2.5.2. Standard deviation of lead time

The standard deviation of lead time for products from Western Cape is 0.82 days and the products from around Gauteng and Mpumalanga has a standard deviation of 0.5 days. See Appendix A.

3.2.5.3. Standard deviation in leadtime demand

The random lead time is explained as satisfying $\sigma_x = \sigma_D * L^{\wedge}0.5$ if it is assumed that the demand is independent at different points in time, the calculations of the standard deviation in leadtime demand is shown in appendix A.

3.2.6. Demand

The demand of all the products is as follows:

3.2.6.1. Average daily demand

The daily demandwas gathered to calculate the average daily demand. Company ABC receives orders on a daily basis especially on the products that are being studied in this project, as seen in Appendix A.

3.2.6.2. Standard deviation of Demand

From the daily demand the standard deviation was calculated using a formula from excelcalled STDEV, as shown in appendix A.

3.2.7. Calculations

The calculations, which includes EOQ, safety stock and reorder point were done on excel. Excel was also used to calculate the average and standard deviation in demand and in lead time.

3.2.7.1. Excel Program

Excel is a Microsoft software program that is used in calculations. It was used to calculate the EOQ, reorder points and safety stocks. Inputs from the excel spreadsheet found in appendix A these are inputs such as average daily demand, average lead time and their respective standard deviations.

Chapter 4

Solutions

4.1. Economic order quantities, Reorder points and Safety stock levels

The solution part is divided into two parts, which are as follows:

4.1.1. Products delivered separately

Table 2 and table 3 shows the products' economic order quantity, safety stock, reorder point and all the other different costs. For example looking at the first KVI which is Spar Maize meal, 12.5kg, Company ABC should order a quantity of 6765, it must be reordered when the quantity reaches 935 and should keep safety stock of 386 maize meal 12.5kg and from table 3, maize meal has a holding cost of R122.51 per day, an ordering cost of R122.51 per order and it has a total inventory cost of R245.02 per day. The safety stock days are 2.5 days and the number of trucks is 2.2, these means that approximately 2.2trucks will last for2.5 days, Company ABC must buy 3 trucks to last 2and half days, then buy 2 trucks to last 2 and half days for the next four cycles, and repeat this cycle.

KVI Products	Size	Quantity per Case	EOQ	reorder point	safety stock
Spar maize meal	12.5kg	1	6772.64	935.68	386.83
Koo baked beans	410g	12	15008.78	2827.56	1396.56
Tastic Rice	2.5kg	10	4007.22	746.87	343.37
Tissue paper	10's	6	4343.21	799.00	325.00
Milk 2% cream	1L	6	26810.85	5959.07	2134.07
Milk full cream	1L	6	45935.64	17699.80	6471.61
Spar Flour	12.5kg	1	7425.77	1105.67	381.17
Sunflower	750ml	8	5030.16	559.45	278.95
sunflower	2L	8	6473.45	1103.29	374.29
Cremora	1kg	20	2695.47	262.04	101.54
Sunlight Washing powder	2kg	8	3240.87	263.07	56.07
Sunlight Liquid	750ml	25	3129.73	142.72	36.22
Selati White sugar	2.5kg	10	4542.36	919.12	370.16
Selati White sugar	10kg	1	2433.05	453.54	243.54
Selati brown sugar	5kg	1	7924.98	1704.81	869.31

Table 2: Summary of solutions

KVI Products	Size	Holding costs	Set up costs	New Total Daily Costs	Current Daily Costs	SS days	No of trucks
Spar maize meal	12.5kg	122.51	122.51	245.02	328.81	2.5	2.2
Koo baked beans	410g	455.58	455.58	911.17	1373.35	3.0	2.6
Tastic Rice	2.5kg	367.98	367.98	735.95	1156.23	2.8	2.8
Tissue paper	10's	157.66	157.66	315.32	527.79	2.5	3.0
Milk 2% cream	1L	611.81	611.81	1223.62	4902.04	4.7	7.9
Milk full cream	1L	1045.70	1045.70	2091.40	14205.34	4.7	13.5
Spar Flour	12.5kg	239.33	239.33	478.67	734.09	2.3	2.7
Sunflower	750ml	302.25	302.25	604.50	661.92	3.0	1.5
sunflower	2L	640.87	640.87	1281.74	2200.46	2.3	3.1
Cremora	1kg	663.57	663.57	1327.14	1495.21	2.4	1.6
Sunlight Washing powder	2kg	431.59	431.59	863.18	1006.34	1.9	1.8
Sunlight Liquid	750ml	681.07	681.07	1362.14	1364.71	2.0	0.9
Selati White sugar	2.5kg	452.57	452.57	905.13	1647.06	2.5	3.3
Selati White sugar	10kg	88.32	88.32	176.64	247.70	3.2	2.4
Selati brown sugar	5kg	142.97	142.97	285.93	465.62	3.1	2.9

Table 3: Summary or costs solutions, safety stock days and no of trucks

4.1.2. Orders Delivered jointly

Table 4 is divided into two parts below, which are all the products delivered in a mixed load. Part one shows the total demand of the products in a mixed load, set up cost, which is calculated in terms of the highest set up cost in the load. The holding cost is the sum of the holding costs, calculated as a fraction of demand times the holding cost of each individual product, and lastly the EOQ, which is the total quantity to be ordered. Basically the first table shows the aggregated demand and EOQ of the mixed load. The second table of table 4 shows EOQ the reorder points and safety stock of each item, separately.

Total Demand	Set up cost	EOQ	Total Holding Costs
260	5831	1536.22	1.2848169

Products In Joint Ordering	Size	Quantity per Case	Ratio to be ordered (EOQ)	Holding Costs Weighted	Total Pallets to be ordered	Reorder Point	Safety Stock
Selati White sugar	250g	50	35.4512	0.0297	0.7340	16.34	7.34
Selati White sugar	500g	15	124.0791	0.0542	8.9912	50.78	19.28
Selati White sugar	1kg	15	449.0480	0.3698	73.6017	232.99	118.99
Selati White sugar	5kg	4	242.2496	0.2481	20.5636	112.27	50.77
Selati White sugar	12,5kg	1	183.1643	0.1153	19.5931	82.87	36.37
Selati brown sugar	500g	25	206.7984	0.1303	24.9757	85.70	33.20
Selati brown sugar	1kg	25	224.5240	0.2705	29.4407	104.19	47.19
Selati brown sugar	2kg	10	35.4512	0.0335	0.7340	16.34	7.34
Selati brown sugar	10kg	1	35.4512	0.0335	0.6239	15.54	6.54
Total				**1.2848**		**717.03**	**327.03**

Table 4: Summary of the EOQ and the ratio of each product for the joint ordered product

Table 5 shows the reorder points, safety stock, no of trucks, safety sock days and the different costs. Basically this table means that Company ABC must keep an aggregate safety stock of 327, and place orders when stock reaches a quantity of717. The safety stock days of 1.3, this is approximately one and half a day and the number of trucks will also be approximated to 1.5 trucks. These can be interpreted as buying two trucks that will last for one and half daysand then buying one truck to last one day, and this cycle can be repeated like that. The total daily cost is R1045, 01 and the new calculated daily cost is R 998.74, which saves R1295.69on a monthly basis and R15 548.28on a year basis, also see Appendix B.

Safety Stock	Reorder point	No of Trucks	SS days	Set up Cost	Holding Cost	Total Daily current cost	New Daily Cost
327.03	717.03	1.4	1.3	499.37	499.37	1045.01	998.74

Table 5: Summary of the safety stock, ROP, no of trucks, safety stocks days and the costs.

4.2. Sensitivity Analysis

Sensitivity analysis is a critical part of the analysis of the results because it describehow sensitive is the model to changes intheinput data, it actually helps to identify the critical input data. For this case average daily demand was considered to be critical input.

We will look at two instances when the demand of maize meal is very low and when the demand is very high. These values were taken from Company ABC sales data, which are the smallest and the highest value Maize meal, has reached in the year of 210/2011. From table 7 and 9it ca be seen how a demand of 150, 365 and 732 react in termsof EOQ, ROP and safety stock. Firstly we capture the current values of maize meal:

	Value
Daily Demand	365
Daily Standard Deviation in Demand	153.79
Daily Lead Time in days	1.5
Daily Standard Deviation in Lead Time in days	0.5
Daily Holding Cost	0.035
Set up cost per order	2270.43
Daily Shortage Cost	6.07

Table 6: Current values of Maize meal

EOQ(Q)	6765
Safety Stock Level	387
Reorder Point(ROP)	934
Daily Holding Cost (R)	122.51
Set up cost per order (R)	122.51
Total Cost(R)	245.02

Table 7: Current Maize meal solution

Changing the demand into two different values, value 1 being the smaller demand and value 2 being the bigger demand:

	Value1	Value2
Daily Demand	150	732

Daily Standard Deviation in Demand	42.2721	298.9569
Daily Lead Time	1.5	1.5
Daily Standard Deviation in Lead Time	0.5	0.5
Daily Holding Cost	0.035	0.035
Set up Cost per Order	2270.43	2270.43

Table 8: Maize meal values with change in demand

The below solutions shows what happens to the EOQ, Reorder point and mostly to the safety stocks:

EOQ(Q)	4336.33	9579.27
Safety Stock Level	106	1850
Reorder Point(ROP)	331	752
Daily Holding Cost (R)	78.54	173.49
Set up cost (R)	78.54	173.49
Total Cost (R)	157.08	345.98

Table 9: Maize meal solution with change in demand

A graphical representation of what happens to the EOQ, safety stock and ROP (reorder point) is shown below, from the graph below it can be seen the importance of having enough in case the demand increases.

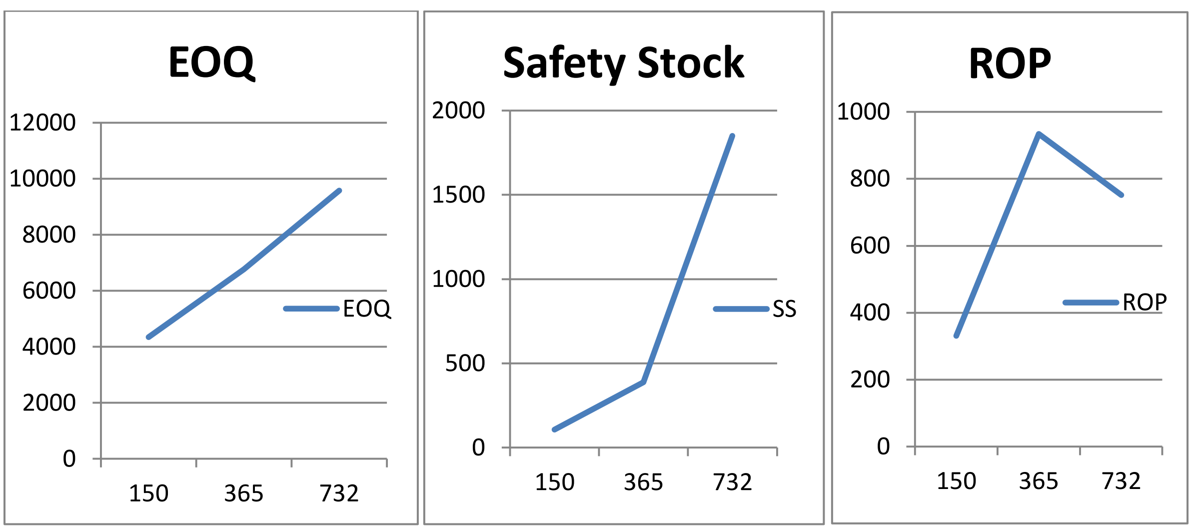

Figure 8: Graphs showing the trend of demand I terms of EOQ, safety stock and ROP

Chapter 5

5.1. Conclusion

The objective of the project was to find the best safety stock level to keep at Company ABC while saving inventory costs. The r, q policy was found to be the best ordering policy to use in establishing the safety stocks level in Company ABC. It is important to note that the findings are only true to the extent of the inputs, the calculations were calculated in such a way to allow any changes in the inputs, for instance if holding cost setup costs or demand changes one can easily change the inputs in the model.

It is suggested that Company ABC considers using bigger trucks, especially forthe products with very high consumption rate, for example Milk, these will help reduce the number of trucks that must deliver this product.

The proposed solution has proved to save a lot of money for Company ABC on a monthly basis, as shown in appendix B. Company ABC will gain a lot from the solution. The model can be used to calculate the EOQ, safety stock and reorder point of the entire products in the warehouse for better management.

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Appendix

Appendix A

The KVI's and their respective information used to calculate the safety stocks:

KVI Products	size	Quantity per Case	Daily Holding Cost	Set up Cost per order	Purchase Cost
Spar maize meal	12.5kg	1	0.362	2270.43	32.93
Koo baked beans	410g	12	0.607	7167.46	55.19
Tastic Rice	2.5kg	10	1.837	5481.63	166.96
Tissue paper	10's	6	0.726	2166.91	66.00
Milk 2% cream	1L	6	0.456	908.13	41.49
Milk full cream	1L	6	0.455	905.94	41.39
Spar Flour	12.5kg	1	0.645	3679.56	58.60
Sunflower	750ml	8	1.202	8130.30	109.25
sunflower	2L	8	1.980	8536.32	180.00
Cremora	1kg	20	4.924	16716.25	447.60
Sunlight Washing powder	2kg	8	2.663	10135.76	242.13
Sunlight Liquid	750ml	25	4.352	30022.05	395.66
Selati White sugar	2.5kg	10	1.993	5617.10	181.15
Selati White sugar	10kg	1	0.726	2046.53	66.00
Selati brown sugar	5kg	1	0.361	2034.12	32.80
Products In Joint Ordering					
Selati White sugar	250g	50	1.287	640.22	117.00
Selati White sugar	500g	15	0.671	1168.27	61.00
Selati White sugar	1kg	15	1.265	4981.80	115.00
Selati White sugar	5kg	4	1.573	3208.23	143.00
Selati White sugar	12,5kg	1	0.967	2485.11	87.90
Selati brown sugar	500g	25	0.968	2808.96	88.00
Selati brown sugar	1kg	25	1.851	5830.87	168.25
Selati brown sugar	2kg	10	1.452	722.30	132.00
Selati brown sugar	10kg	1	0.718	303.49	65.25

Table 10: The different costs.

KVI Products	Size	Average Daily Demand	Standard Deviation of Daily Demand	Average Lead Time in Days	Standard Deviation of Lead Time	Standard Lead time in Demand
Spar maize meal	12.5kg	365	153.79	1.5	0.5	188.353514
Koo baked beans	410g	954	555.22	1.5	0.5	680.002847
Tastic Rice	2.5kg	269	136.51	1.5	0.5	167.189922
Tissue paper	10's	316	129.21	1.5	0.5	158.249285
Milk 2% cream	1L	1275	599.93	3	0.82	1039.10924
Milk full cream	1L	3742.73	1819.30	3	0.82	3151.12003
Spar Flour	12.5kg	483	151.54	1.5	0.5	185.597838
Sunflower	750ml	187	110.90	1.5	0.5	135.824206
sunflower	2L	486	148.81	1.5	0.5	182.248161
Cremora	1kg	107	40.37	1.5	0.5	49.4429505
Sunlight Washing powder	2kg	138	22.29	1.5	0.5	27.2995632
Sunlight Liquid	750ml	71	14.40	1.5	0.5	17.6363261
Selati White sugar	2.5kg	366	147.16	1.5	0.5	448.226004
Selati White sugar	10kg	140	96.82	1.5	0.5	118.581023
Selati brown sugar	5kg	557	345.61	1.5	0.5	423.278809
Products In Joint Ordering						
Selati White sugar	250g	6	2.92	1.5	0.5	3.57625502
Selati White sugar	500g	21	7.67	1.5	0.5	9.39011893
Selati White sugar	1kg	76	47.31	1.5	0.5	57.9365561
Selati White sugar	5kg	41	20.19	1.5	0.5	24.7214752
Selati White sugar	12,5kg	31	14.46	1.5	0.5	17.7098108
Selati brown sugar	500g	35	13.20	1.5	0.5	16.1666323
Selati brown sugar	1kg	38	18.76	1.5	0.5	22.9762138
Selati brown sugar	2kg	6	2.92	1.5	0.5	3.57625502
Selati brown sugar	10kg	6	2.60	1.5	0.5	3.18433667

Table 11: The demands and lead time in days.

KVI Products	size	Purchase Cost	pallets	Total Truck load cost	Profit	SLM	z
Spar maize meal	12.5kg	32.93	3024.00	99580.32	8.45	0.98	2.05375
Koo baked beans	410g	55.19	5696.00	314362.24	9.72	0.98	2.05375
Tastic Rice	2.5kg	166.96	1440.00	240422.40	18.37	0.98	2.05375
Tissue paper	10's	66.00	1440.00	95040.00	14.34	0.98	2.05375
Milk 2% cream	1L	41.49	3400.00	141066.00	5.81	0.98	2.05375
Milk full cream	1L	41.39	3400.00	140726.00	5.79	0.98	2.05375
Spar Flour	12.5kg	58.60	2754.00	161384.40	9.07	0.98	2.05375
Sunflower	750ml	109.25	3264.00	356592.00	15.30	0.98	2.05375
sunflower	2L	180.00	2080.00	374400.00	25.20	0.98	2.05375
Cremora	1kg	447.60	1638.00	733168.80	37.37	0.98	2.05375
Sunlight Washing powder	2kg	242.13	1836.00	444550.68	16.73	0.98	2.05375
Sunlight Liquid	750ml	395.66	3328.00	1316756.48	55.39	0.98	2.05375
Selati White sugar	2.5kg	181.15	1360.00	246364.00	5.36	0.98	2.05375
Selati White sugar	10kg	66.00	1020.00	67320.00	10.23	0.98	2.05375
Selati brown sugar	5kg	32.80	2720.00	89216.00	2.46	0.98	2.05375
Products In Joint Ordering							
Selati White sugar	250g	117.00	240.00	28080.00	11.70	0.98	2.05375
Selati White sugar	500g	61.00	840.00	51240.00	5.48	0.98	2.05375
Selati White sugar	1kg	115.00	1900.00	218500.00	10.36	0.98	2.05375
Selati White sugar	5kg	143.00	984.00	140712.00	10.01	0.98	2.05375
Selati White sugar	12,5kg	87.90	1240.00	108996.00	5.80	0.98	2.05375
Selati brown sugar	500g	88.00	1400.00	123200.00	7.18	0.98	2.05375
Selati brown sugar	1kg	168.25	1520.00	255740.00	12.35	0.98	2.05375
Selati brown sugar	2kg	132.00	240.00	31680.00	9.24	0.98	2.05375
Selati brown sugar	10kg	168.25	204.00	26928.00	4.37	0.98	2.05375

Table 12: Truckload costs, the profit and the Service Level Measurements.

Appendix B

A comparison of the current cost incurred by Company ABC to the new costs calculated and how they impact on monthly costs.

KVI Products	size	New Daily cost	New Monthly costs	Current Daily Costs	Current Monthly Costs	Difference in Monthly Cots
Spar maize meal	12.5kg	346.99	9715.72	604.36	16922.02	7206.30
Koo baked beans	410g	911.17	25512.70	1373.35	38453.74	12941.05
Tastic Rice	2.5kg	735.95	20606.61	1156.23	32374.48	11767.87
Tissue paper	10's	315.32	8828.88	527.79	14778.09	5949.21
Milk 2% cream	1L	1223.62	34261.37	4902.04	137257.22	102995.84
Milk full cream	1L	2091.40	58559.31	14205.34	397749.43	339190.12
Spar Flour	12.5kg	478.67	13402.63	734.09	20554.47	7151.84
Sunflower	750ml	604.50	16925.99	661.92	18533.87	1607.88
sunflower	2L	1281.74	35888.81	2200.46	61612.99	25724.18
Cremora	1kg	1327.14	37160.00	1495.21	41865.82	4705.82
Sunlight Washing powder	2kg	863.18	24169.14	1006.34	28177.54	4008.40
Sunlight Liquid	750ml	1362.14	38139.92	1364.71	38211.89	71.97
Selati White sugar	2.5kg	905.13	25343.72	1647.06	46117.61	20773.89
Selati White sugar	10kg	176.64	4945.89	247.70	6935.54	1989.65
Selati brown sugar	5kg	285.93	8006.13	465.62	13037.24	5031.11

Table 13: The difference in monthly cost for separate delivery

Total Current Daily Cost	Current Monthly Cost	New Daily Cost	New Monthly Cost	Difference Monthly Cost (Saving)
1045.01	29260.40	998.74	27964.70	1295.69

Table 14: The difference in monthly cost for joint delivery.