Improved Inventory Management Policies for Exclusive Home Fashions (PTY) Ltd.

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Executive Summary

This is a report on an inventory management system at Exclusive Home Fashions.

Exclusive Home Fashions, the sister company of Capri linen, specialises in high quality linen, and is based in Randburg with a nationwide network of representatives. Exclusive Home Fashions' products consist of two divisions namely their Open range and Standard range collections. This project focuses on the T230 Percale Standard range items.

The current inventory management system at Exclusive Home Fashions shows potential for improvements with the use of modern inventory control techniques. The aim of the project is to use a modern inventory modelling approach to determine an improved balance between under- and overstocking costs as well as shortage costs. This project will focus a Probabilistic Inventory Modelling approach to estimate the economic order quantities, reorder points and safety stock levels. By balancing the economic order quantities, reorder points and safety stock levels to obtain an improved inventory management policy, Exclusive Home Fashions will not only benefit financially but also have better control over their inventory.

This report consists of the study of relevant literature on inventory and inventory management techniques, as well as the proposed improved inventory policies.

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1. Introduction and Background

Capri linen was founded in 1966 by Mr. GN Brits. With the help of his wife and a single employee, Mr. Brits built the Capri group into the successful businesses it is today. Mr Brits started his company by selling household items from door to door. The expansion of Capri linen was inevitable as more specialised products were requested by clients. Capri linen expanded into a group of companies namely: Capri Linen (Pty) Ltd, T&G Exclusive Creations (Pty) Ltd., Hollywood Household Supplies (Pty) Ltd, V.I.P. Imports, as well as Exclusive Home Fashions (Pty) Ltd. In 1996, Exclusive Home Fashions was established as a company specialising in luxury linen and homeware. The Capri group of companies are situated in Randburg.

Exclusive Home Fashions (EHF) is situated adjacent the other Capri companies in Naaf Street, Randburg. Their facility consists of a storage warehouse, offices and a show room. Strict Quality Control Measures are implemented to ensure they meet the high standard of quality set by management. Exclusive Home Fashions' percale products are of SABS and international (Intertek) Recognized Inspection Standards.

Exclusive Home Fashions has 2 types of products namely, their Open range collection and their Standard range collection. The Open range collection consists of products that are replaced each year. These products follow fashion trends and are chosen by skilled professionals at international trade fairs. The second types of products are the Standard range or Hotel range collection. These products form the backbone of the company. The Standard range of product consists of products that are typically found in hotels, lodges, guesthouses and spas. These products come in standard sizes, up to three different colours and three different quality types, but clients do have various options to personalise the products such as embroiding logos and company names.

The products arrive at Exclusive Home Fashions made to specification and pre-packaged. The products are ordered on a regular basis. The order quantities vary and economic order quantities, reorder points and safety stock levels are not taken into consideration with the current policy.

This project aims to implement an improved inventory policy at Exclusive Home Fashions that makes use of Economic Order Quantities (EOQ), reorder points and safety stock levels.

This will allow Exclusive Home Fashions to improve their inventory management and apply better control.

2. Project Aim

The project aim to design and implement an improved inventory management policy that minimises the total cost associated with inventory and warehousing, while ensuring a minimum standard of service is delivered to their customers, and allow inventory policies to operate at improved levels. The preposed inventory management policy allows Exclusive Home Fashions to utilize improved inventory levels and, create a foundation to control inventory sufficiently and economically.

3. Project Scope

This project focuses on an improved inventory management policy at Exclusive Home Fashions. The aim is to lower the total inventory and warehousing cost while ensuring a minimum standard of service is delivered to Exclusive Home Fashions' customers. Optimal inventory ratios will be calculated by making use of modern inventory theories and calculations to balance the under- and overstocking cost as well as shortage cost. A detailed model is constructed with the use of modern probabilistic inventory models. This includes a study of all external factors that influence inventory on all levels. It is important to build a model that will be applicable to the range of economic conditions that Exclusive Home Fashions could face with the passage of time. It is important to remember that the aim is to lower the total cost, while ensuring customer satisfaction, and this could imply that not all products are ordered in optimal quantities.

By processing current inventory data, a better understanding and control over inventory will be implemented and supply Exclusive Home Fashions with the necessary knowledge to ensure a policy that will improved and simplify the inventory system.

A probabilistic inventory model approach ensures accurate calculations, since demand at Exclusive Home Fashions is not constant. The model will allow shortage costs. The lead-time is also probabilistic variable to add further realism to the calculations.

4 Literature analysis and method identification

4.1 Inventory

4.1.1 Definition of Inventory

Jacobs, Chase, Aquilano (2009, p. 547) describe inventory as the stock of any item or resource used in an organisation. An inventory system is the set of policies and controls that monitor levels of inventory and determine which levels should be maintained, when stock should be replenished, and how large orders should be.

Inventory has many advantages, but can influence a company tremendously if it is not managed correctly. Inventory can help any business run efficiently with advantages such as improved customer satisfaction and better product control. Inventory could also have negative effects on a business, such as additional cost involved with holding inventory and possible loss of control.

4.1.2 Basic Inventory Decisions

The basic inventory decisions described by WL Winston(2004, p. 103) are on *how much* inventory should be ordered and at *what time* the inventory should be ordered.

These factors play a critical role in the optimal management of inventory on hand. The aim of an inventory system is to satisfy all the demand of the inventory system at a minimum cost. This not only includes Exclusive Home Fashions but their customers as well.

4.1.3 Purpose of Inventory

Jacobs, Chase, Aquilano (2009, p. 548) describe inventory to have the following purpose, and all firms (including Just-In-Time (JIT) operations) keep a supply of inventory for the following reasons:

4.1.3.1 To Maintain Independence of Operations

A supply of materials at a work centre allows the centre flexibility of operation. For example, since there are costs for each new production setup, this inventory allows management to reduce the number of setups.

4.1.3.2 To Meet Variation In Product Demand

If the demand for the product is known, it may be possible (though not necessarily economical) to produce or buy the product to meet the exact demand. Usually, however, demand is not constant and a safety or buffer stock must be maintained to absorb variation.

4.1.3.3 To Allow Flexibility In Production Scheduling

A stock of inventory relieves the pressure on the production system. This causes longer lead times, which permits production planning for smoother flow and lower-cost operation through larger lot size production.

4.1.3.4 To Provide A Safeguard Against Variation In Raw Material Delivery Time

When material or products are ordered from a vendor, delays can occur for a variety of reasons: a normal variation in shipping time, a shortage of material at the vendor's plant causing backlogs, unexpected strike at vendor's plant or at one of the shipping companies and lost order or a shipment of incorrect or defective material. These reasons could all delay delivery and having inventory on hand can absorb the delay to an extent.

4.1.3.5 To Take Advantage Of Economic Purchase Order Size

Labour, phone calls, typing and postage are some of the costs involved with placing an order. Therefore, the larger each order is, the fewer orders have to be placed (Inman). Also shipping cost favours larger orders – the larger the shipment the lower the per-unit cost.

4.1.4 Objective of Inventory Control

T Wild (2002, p. 7) describes the purpose of inventory control functions, in supporting business activities, is to optimise three targets:

- Customer service
- Inventory costs
- Operating costs

He describes the most profitable policy as one that does not optimise one activity at the expense of another. The most important policy is to optimise the external or customer service, and to then look at internal problems.

4.1.5 Types of Inventory

R. Anthony Inman (Inman,2009) defines inventory as the stock or store of goods. It describes that all inventory fall within the following categories:

4.1.5.1 Raw Materials

Raw materials are inventory items that are used in the process to produce components, subassemblies, or finished products. They may also be objects or elements that the firm has purchased from outside the organization. Even if the item is partially assembled or is considered a finished good to the supplier, the purchaser may classify it as a raw because it is not yet transformed into the final product.

4.1.5.2 Work-In-Progress

Work-in-process (WIP) is made up of all the materials, parts (components), assemblies, and subassemblies that are being processed or waiting to be processed within the system. This generally includes all material, from raw material that has been released for initial processing up to material that has been completed and is awaiting final inspection and acceptance before inclusion in finished goods.

4.1.5.3 Finished Goods

A finished good is a completed part that is ready for a customer order. Therefore, finished goods inventory is the stock of completed products. Such goods have passed final inspection requirements so that they can be transferred out of work-in-progress into finished goods inventory. From this point, finished goods can be sold directly to their final user, sold to retailers and wholesalers, sent to distribution centres, or held in anticipation of a customer order.

Inventories can be further classified according to the purpose they serve. These types include transit inventory, buffer inventory, anticipation inventory, decoupling inventory, cycle inventory, and maintenance, repairs and operations (MRO) inventory. Some of these also are know by other names, such as speculative inventory, safety inventory, and seasonal inventory. (Inman)

4.1.5.4 Anticipation Inventory

Often firms will purchase and hold inventory that is in excess of their current need in anticipation of a possible future event. Such events may include a price increase, a seasonal increase in demand, or an impending labour strike. This tactic is commonly used by retailers, who routinely build up inventory months before the demand for their products will be unusually high.

An excellent example is the anticipation of increased demand due to the Soccer World Cup 2010. This event will increase the demand for linen throughout South Africa. Hotels, lodges, guesthouses and spas wish to prepare for the flood of tourists that will visit our shores.

These establishments also aim to improve their AA star ratings in order to increase their tariffs and profits by adhering to certain quality prerequisites for the respected AA ratings.

4.1.5.5 Cycle Inventory

Cycle inventories, also called lot-size inventories, result from the EOQ process. Usually, excess material is ordered and, subsequently, held in inventory in an effort to reach the cost minimisation point. Hence, cycle inventory results from ordering in batches or lots rather than ordering material strictly as needed.

An aim of the project is to determine the improved cycle inventory quantities. By improving these quantities more efficient inventory policies can be established.

4.1.6 Inventory Costs

When an optimal inventory policy is considered, it is important to take all costs involved with inventory into consideration. Jacobs, Chase, Aquilano (2009, p. 549) give the following costs to be considered when making any decision that may affect inventory size.

4.1.6.1 Holding (or Carrying) Cost

This broad category includes the cost for:

- Storage facilities
- Handling
- Insurance
- Breakage
- Depreciation
- Opportunity cost of capital

High holding costs tend to favour low inventory levels and frequent replenishment.

This cost can be described as the cost to store or hold one unit of inventory per unit of time. The unit of time is typically chosen to be one year. It is important to accurately calculate the holding cost for each item since the economic order quantities are directly related to the holding cost.

4.1.6.2 Setup Costs

Making different product involves obtaining the necessary materials, arranging specific equipment setups, filling out the required documents, appropriately charging time and materials, and moving out previous stock or equipment. This cost can be associated with all

the cost involved to order or make the inventory. This cost can typically be the cost to setup a machine to produce a product. Jacobs, Chase, Aquilano (2009, p. 549)

This cost will not be a major factor in this project since most of the products are previously finished goods. However, Exclusive Home Fashions does have a division that can alter and create linen to customer specifications. Special products will not be discussed in this project.

4.1.6.3 Ordering Cost

These costs refer to the managerial and clerical cost to prepare the purchase or production order. Ordering cost includes all the detail, such as counting items and calculating order quantities. The costs associated with maintaining the system and tracking orders are also included in ordering costs. Jacobs, Chase, Aquilano (2009, p. 549)

Ordering cost will apply to this project. Ordering cost at Exclusive Home Fashions includes the following:

- Labour
- Freight
- Fixed orders costs

4.1.6.4 Shortage Cost

When stock of an item is depleted, an order for that item must either wait until the stock is replenished or cancelled. There is a trade-off between carrying stocks and to satisfy demand or the cost resulting from a stock out. This balance is often difficult to obtain. Jacobs, Chase, Aquilano (2009, p. 549)

Shortage cost at Exclusive Home Fashions includes the following:

- Delivery costs
- Labour cost
- Freight cost
- Lost sales cost

4.1.6.5 Unit Purchasing Cost

WL Winston (2004, p. 103) describes unit purchasing cost as the variable cost associated with purchasing a single unit. Typically, the unit purchasing cost includes the variable labour cost, variable overhead cost, and raw material cost associated with purchasing or producing a single unit.

The unit cost for each item is known by Exclusive Home Fashions. The unit cost is fairly stable and price increases occur at fixed intervals. The main influence on the unit cost it the variation of the US Dollar. With all the products imported, all transactions are made in US Dollars. The variation of the dollar plays a major role in the purchasing cost and can be linked to other costs, such as the opportunity cost and holding cost.

4.1.7 Types of demand

As described by Jacobs, Chase, Aquilano (2009, p. 550), independent demand is the demand for items that are independent of each other. This is typical when a demand for a product is not related to another product such as, products that are classified as finished products. For example: the demand for sheets is independent of each other. This is typical where the product is not a component of another product or assembly.

Dependant demand can be described as the demand for a product that is used in the assembly of another product. To illustrate dependant demand, one can look at the demand for the thread used in special alterations to the linen. If the demand for alterations increases, the demand for thread will increase. Thus, the demand for components such as tread is dependant on the demand for the special products.

4.1.8 Service Level Measurement

Service levels measurement (SLM) described by W L Winston (2004, p. 155) is the expected fraction (usually expressed as a percentage) of all demand met on time. This is important to all inventory policies. The service level measurement is often used to control shortages. One must remember that there is a cost associated with every percentage of demand met on time. This could be illustrated by considering that a company have a 98% SLM, thus 98% of all orders are met on time. If the company wishes to increase that percentage to 99% additional inventory must be kept. This leads to higher inventory costs. There is a fine balance between the shortage cost and the inventory cost of the company. Thus, it must be financially feasible to keep extra inventory to increase the SLM to 99%. Every company desires to have a 100% SLM, but the return on investment should carefully be calculated.

4.1.9 ABC Inventory Classification Systems

WL Winston (2004, p. 168) describes the ABC classification, devised by General Electric during the 1950's, as the classification to help a company identify the small percentage of items that contribute to the large amount of annual turnover. This helps a company to decide which items are important in terms of inventory policies. When one can optimise these items a large part of the inventory is optimised. To identify these products, T Wild (2002, p. 34) suggests that one draws a Pareto cause and effect curve. This curve visually demonstrates the contribution of the products.

There are three types, or subgroups, an item can be classified as:

4.1.9.1 Type A Items

These 5% - 20% of inventory items typically contribute 55%-65% of the annual turnover of a company. These items can be seen as the core items of a business.

The Service Levels Measurement of type A items are typically set at 85-85%. Tight management control over ordering procedures is essential for Type A items. Individual demand forecast should be made for each type A item. Every effort should be made to lower the lead-time of orders. WL Winston (2004, p. 168)

4.1.9.2 Type B Items

These 20%-30% of inventory items contributes to 20%-40% of the annual turnover. These items are important to give customers a variety of products and services to choose from.

The Service Levels Measurement for Type B items are typically set at 95%. These inventory items can be reviewed less often than Type A items. WL Winston (2004, p. 168)

4.1.9.3 Type C Items

These 50%-70% of inventory items contribute 5%-25% of the company's annual turnover. These items are slow moving inventory. The SLM is recommended at 98%-99%. Little extra investment will be necessary to maintain these high service levels'. Winston (2004, p. 168)

4.10 Safety Stock Levels

Jacobs, Chase, Aquilano (2009, p. 558) describes safety stock as the amount of inventory carried in addition to the expected demand. This inventory is a buffer zone for abnormal events that influence inventory levels. It is a level of inventory that is used to absorb the variation of demand and delivery times. The safety stock has a great influence on your Service Levels Measurement and visa versa. The safety stock level will be determined by the chosen service level measurement Exclusive Home Fashions wishes to achieve and the feasible Service Levels Measurement range.

5 Economic Order Quantity Inventory Models

5.1 Basic EOQ Models

For the basic EOQ models described by WL Winston (2004, p. 105), certain assumptions are required.

- Demand is deterministic and occur at a constant rate
- If any order of any size, say *q*, is placed an ordering and a setup cost of *k* is incurred
- The lead time for each order is zero
- Shortages are not allowed
- The cost per unit-year of holding inventory is *h*
- *D* is defined as the number of units demanded each year

W L Winston (2004, pp. 105-115) derives various formulas to help determine the EOQ. These formulas are the following

5.1.1 Optimal Order Quantity

To determine the optimal order quantity one must have the following:

- Demand (D) per unit time
- Holding cost per unit(h)
- Order or setup cost (k) per order

The formula used to determine the optimal order quantity (q*) is :

$$q^* = \sqrt{\frac{2kD}{h}}$$

This formula gives the optimal order quantity to ensure that all demand is met at a minimum cost.

5.1.2 Cycle Time

Cycle time represents the time between inventory refills. This cycle time, inventory I and time t is illustrated by the following figure :

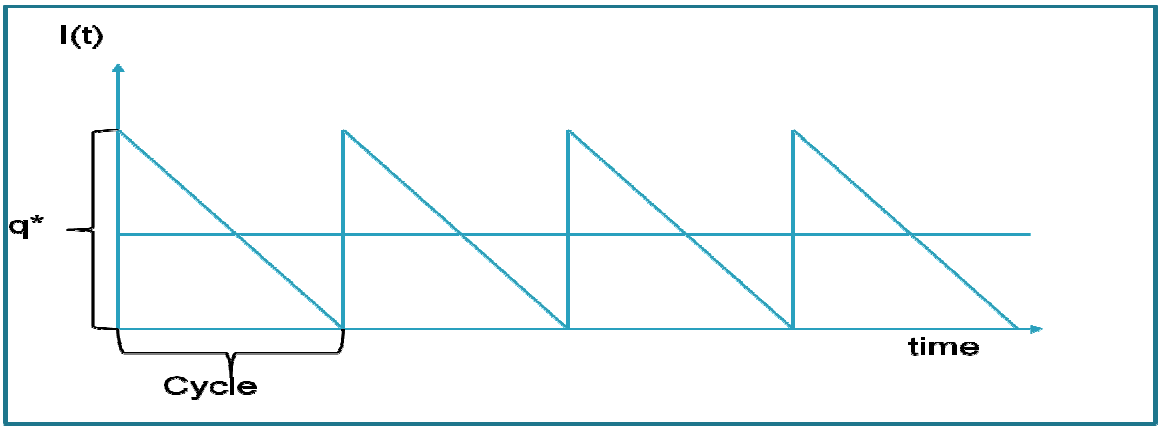

Figure 1: Behaviour of I(t) in basic EOQ model. WL Winston (2002, p.107)

5.1.3 Total Annual Holding Cost

The holding cost per year represents the cost of holding inventory for one year. The formula to determine total holding cost is

$$HC(q^*) = \frac{1}{2}(q^*)h$$

This formula gives the optimal holding cost. One can use this formula to determine the improvement of an optimised inventory policy by comparing any current order quantity HC(q) with HC (q*).

The formula uses the average inventory, $\frac{1}{2}q^*$, and multiplies that by the holding cost per unit per unit-time.

5.1.4 Total Annual Ordering Cost

The annual ordering cost, OC (q*), is equal to the number of orders per annum times the cost of placing an order.

$$OC(q^*) = \frac{D}{q^*}k$$

EOQ does not depend on unit purchasing price, since the size of each order does not change the unit purchasing cost.

5.1.5 Total Annual Cost

The total annual cost for holding inventory can be determined with the following formula

$$TC(q^*) = HC(q^*) + OC(q^*)$$

This formula does not include the total purchasing cost of the inventory.

5.1.6 The Effect of Non-Zero Lead Time

WL Winston (2004, p. 111) illustrates that the effect of non-zero lead time leaves the annual holding and ordering cost unchanged. The EOQ still minimises the total costs. To prevent shortages, the lead-time of the model must be taken into consideration. Orders must be placed when inventory levels reach a certain level. The level is called the reorder point or reorder level. The reorder point is critical in ensuring the smooth running of an EOQ system. To determine the reorder point one determines the lead-time and deducts it from the cycle time.

There are two possible reorder point scenarios. In the first scenario the lead time is shorter than cycle time and the reorder point will be in the current cycle. In the second scenario the lead time is longer than the cycle time and the reorder point will be in the cycles before the current cycle time.

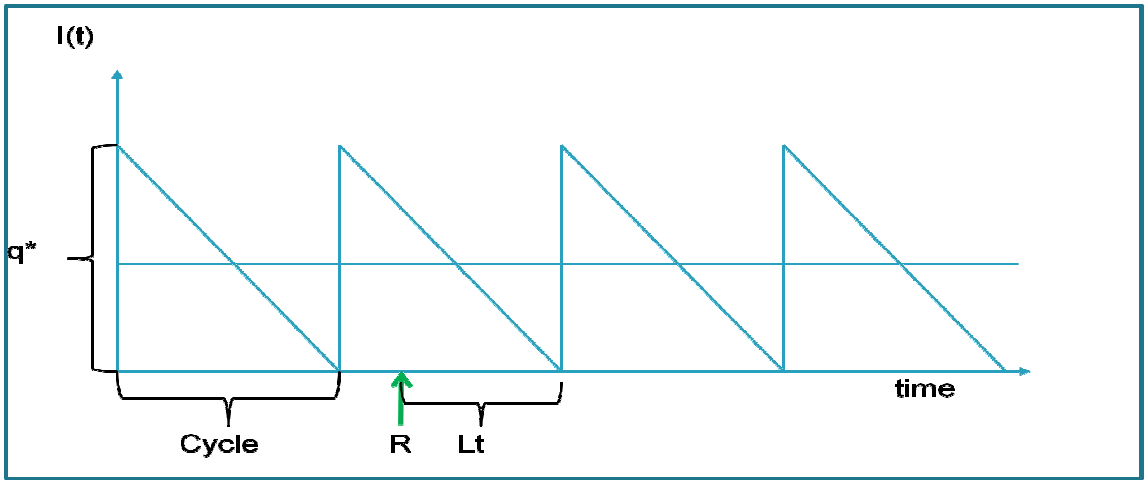

Figure 2 : Illustration of the lead-time (Lt) and a reorder point(R). WL Winston (2002, p.107)

5.1.7 Computing Optimal Order Quantity When Discounts Are Allowed

WL Winston (2004, p. 116) illustrates the methods used to determine EOQ when discounts are applicable. The discounts are referred to as quantity discounts. If a supplier gives quantity discount the annual purchasing cost will depend on the number of products ordered. Since the annual purchasing cost depends on order quantity it can not be ignored.

To solve the EOQ with discount or price breaks, Jacobs, Chase, Aquilano (2009, p. 566) suggests the following two steps:

Sort the prices from lowest to highest and then, beginning with the lowest price, calculate the EOQ for each price level until a feasible EOQ is found. Feasible means that the price is in the corresponding range.

If the first feasible EOQ is for the lowest price, this order quantity is the most economical. Otherwise, calculate the total cost for the first feasible EOQ and also calculate the total cost at which price break is lower than the price associated with the first EOQ. This is the lowest order quantity at which one can take advantage of the price break. The optimal order quantity is the one with the lowest cost.

5.1.8 Economic Order Quantity with Back Orders Allowed

WL Winston (2004, p. 125) illustrates the importance of taking back orders into consideration. Many situations can affect an inventory model that can lead to situations where demand is not met on time and shortages occur. This shortage cost(s), as discussed in section 4.1.6.4, plays an important role in determining the EOQ. To determine the optimal order policy define:

- q= order quantity
- q-M= maximum shortage that occurs under an ordering policy

Thus, a firm will be q-M units short each time an order is placed. This cost must be taken into consideration when the total inventory cost (TC (q)) is computed.

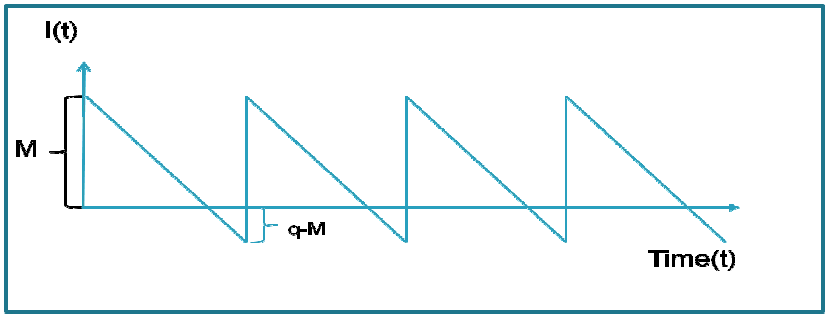

Figure 3: Evolution of inventory over time for EOQ model with back orders allowed. WL Winston (2004, p. 126) Figure 12

The formula for the maximum shortage cost per cycle is:

$$SC(q)=(\frac{shortage\ cost}{cycle})x(\frac{Cycles}{year})$$

$$SC(q)=\frac{(q-M)^2 s}{2D}$$

The total cost of inventory with back order and shortage cost is:

$$TC(q,M)=\frac{M^2 h}{2q}+\frac{(q-M)^2 s}{2q}+\frac{KD}{q}$$

5.2 The Economic Order Quantity with Uncertain Demand

Economic order quantity models with uncertain demand is a more applicable to Exclusive Home Fashions.

WL Winston (2004, p. 147) define the following variables

- K = Ordering cost
- h = Holding cost/unit/year
- L = Lead time for each order
- q = Quantity ordered
- D = Random variable representing demand with mean E(D),variance var D, and standard deviationσ_D
- c_B = Cost incurred for each unit short
- OHI(t) = On hand inventory 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 orders are placed(reorder point)
- X = A random variable representing demand during lead time

X is assumed to be a continuous random variable having a density function *f(x)* with a mean variance, and standard deviation of E(X), var X and σ_x. We want to calculate q and r to minimize the expected total annual cost.

5.2.1 Determining the EOQ with Uncertain Demand

Winston (2004, p. 150) states that the EOQ, with demand equal to the mean of several previous demands, will adequately approximate the optimal EOQ. This is true when EOQ $\leq \sigma_x$. If the standard deviation of the model is larger than the EOQ Winston suggest that LINGO software is used to determine the EOQ that balances under-, overstocking and shortage costs.

5.2.2 Determining the Reorder Point

To determine the reorder point (r) for an EOQ with uncertain demand WL Winston (2004, p. 148) determined the following.

TC (q, r) = (expected annual holding cost) + (expected annual ordering cost) + (expected annual cost due to shortages)

To determine the optimal reorder point it is assume that the average number of back orders is relatively small in relation to the average on-hand inventory level. Then I(t)=OHI(t)-B(t) yields

$$\textit{Expected value of I(t)} \cong expected\ value\ of\ OHI(t)$$

5.2.3 The Expected Annual Holding Cost

Expected value of I(t) during a cycle= $\frac{1}{2}$ [(expected value of I(t) at beginning of cycle) + (expected value of I(t) at end of cycle)

At the end of a cycle, the inventory level will equal the level at the reorder point (r) less the demand X during lead time. The expected value of I(t) at end of a cycle = r-E(X). And the expected value of I(t) at beginning of a cycle = r-E(X) +q.

The expected value of I(t) during a cycle is:

$$I(t)=\frac{q}{2} + r - E(X)$$

$$\textit{The expected annual holding cost} \cong h\left(\frac{q}{2} + r - E(X)\right)$$

5.2.4 Expected Annual Shortage Cost

Let B_r= random variable representing the number of stock outs or backorders during a cycle if the reorder point is *r.*

The expected annual shortage cost is:

$$\textit{Expected annual shortage cost} = \left(\frac{expected\ shortage\ cost}{cycle}\right) x \left(\frac{expected\ cyles}{year}\right)$$

Then by definition of B_r, the expected shortage cost per cycle = c_BE(B_r), and an average of $\frac{E(D)}{q}$ orders will be placed each year.

$$\textit{Expected annual shortage cost} = \frac{c_B E(B_r) E(D)}{q}$$

5.2.5 Expected Annual Order Cost

$$\textit{Expected annual order cost} = K\left(\frac{expected\ annual\ demand}{yearorder\ quantity}\right)$$

$$\textit{Expected annual order cost} = \frac{KE(D)}{q}$$

5.2.6 Total Annual Cost

WL Winston (2004, p. 149) describe the total annual cost for inventory with uncertain demand as

$$TC(q, r) = h\left(\frac{q}{2} + r - E(X)\right) + \frac{c_B E(B_r) E(D)}{q} + \frac{KE(D)}{q}$$

This formula includes all the cost involved with inventory per annum. To determine the EOQs, reorder points and safety stock levels this formula will be used in LINGO to minimise the total cost with various combinations of EOQs, reorder points and safety stock levels.

6 Inventory Policies

Three inventory policies are described by WL Winston (2004, p. 153) . These policies describe how one should react when certain inventory levels are reached.

6.1 Continuous Review (r, q) Policies

If *q* units are ordered when inventory level *r* is reached, an (r,q) policy is followed. This policy is also called a two-bin policy, since it can easily be implemented by using two bins. One order q units when the first bin is empty. The second bin will have r units to ensure no shortages. Thus when bin one is empty the reorder point *r* is reached.

6.2 Continuous Review (s, S) Policies

This policy differs from the (r, q) policy since it allows inventory levels to drop below the reorder point. This is typical in situations where inventory items are not depleted singly. The policy implies that the company order units to fill inventory levels up to *S,* whenever inventory is equal or below *s.*

6.3 Periodic Review*(R, S)* Policy

The periodic review policy as described by WL Winston (2004, p. 164) follows a predetermined time schedule to replenish inventory. A review period R is determined and all stock is adjusted up to *S* when that period occurs.

7 Determining of the Reorder Point and Safety Stock Levels for Service Measure Levels

WL Winston (2004, p. 156) describes that given the desired service level measurement, we can determine a reorder point that provides that service level measurement.

$$\textit{Expected shortages per cycle} = E(B_r)$$

$$\textit{Expected shortages per year} = E(B_r)\left(\frac{E(D)}{q}\right)$$

E(D) is the average annual demand. And let SLM_1 be the percentage of all demand met on time, then for given values of *q* and *r* we have:

$$1 - SLM_1 = \frac{E(B_r)}{q}$$

This equation can be used to determine the reorder point that yields a desired service level with the help of the Normal Loss Function.

8 Methods and Tool Selection

The method to be used at Exclusive Home Fashions will be a probabilistic inventory model type with a Continuous Review (s, S) policy. The reason for this is that Exclusive Home Fashions experience a probabilistic demand and orders of any size can be placed. The model will allow Exclusive Home Fashions to improve their inventory management system by using an appropriate inventory technique.

8.1 Data Gathering

To determine all the variables needed to improve the system, the following data for each product is collected.

- Monthly demand for each product for the 12 months
- Unit cost
- Sales cost
- Shipping cost
- Insurance cost
- Storage and handling cost
- Overhead cost

Exclusive Home Fashions has sufficient records of all the costs and decisions regarding inventory on a database called Softline ACCPAC. ACCPAC is used for all transactions and every day operations. The system allows for annual report and support inventory control functions. All the data will be gathered by using ACCPAC reports.

The filtered data will be filed accordingly for the use in calculations in an EXCEL spreadsheet.

Holding costs will be determined by considering the following:

- Storage facilities
- Handling
- Insurance
- Opportunity cost

All the above factors will influence the cost of holding inventory.

A further important calculation will be to determine the annual demand for the products. The demand will be determined with a mean and standard deviation for each product. These values will be used in all relevant calculations.

The ordering cost will include freight cost

The lead-time for each product is calculated by studying the time of order placed to the time of order received. ACCPAC provides the ability to record order placement dates as well as order arrival date. The corresponding order number will be used to determine the average lead-time for products. All the orders are shipped to Exclusive Home Fashions. These containers are filled with various items, and thus product will have fairly constant order times.

The following will be determined with all the gathered data.

9. Proposed Solution

Exclusive Home Fashions have a wide variety of products. This project focuses on the T230 Percale Cotton range, products that are typically found in accommodation providers. The T230 is a description for the thread count per square inch. The higher the threads count per square inch, the better the quality. The minimum thread count for linen to be classified as Percale is 180 threads per square inch and must be comprised of 100% pure cotton. Exclusive Home Fashions have the following range of percale linen T180, T230, T600. All the studies and calculations are based on the T230 range.

The first step in finding a solution is to analyse the turnover contribution of the T230 product range. This information is critical for all the relevant calculations.

9.1 Performing the ABC-Analyses

To identify the products with the greatest monthly contribution to turnover, an ABC analysis is done. This analysis is carried out by comparing the average sales quantities of each product for the past 12 months and multiplying that with the average sales price. The data is captured on an EXCEL spreadsheet and sorted according to greatest monthly contribution to turnover. The following table is an extraction of the sorted data; this example is of the Oxford Satin stitch T230 Duvet Covers.

Product Description : Oxford Satin Stitch Duvet Covers							
Product description	Size	Product code	Average Monthly Sales	Standard Deviation	Weight	Bulk Price	Average Monthly Contribution to Turnover
Oxford Satin Stitch Duvet	Single	003882	29.23	31.91	1.42	202.00	5904.62
Oxford Satin Stitch Duvet	3 Quarter	003883	48.08	35.63	1.50	223.00	10721.15
Oxford Satin Stitch Duvet	Double	003884	22.83	20.36	1.80	316.00	7215.33
Oxford Satin Stitch Duvet	Queen	003885	45.08	23.19	2.00	340.00	15326.15
Oxford Satin Stitch Duvet	King	003886	47.31	34.45	2.50	346.00	16368.46
Oxford Satin Stitch Duvet	S/King	003887	28.00	18.07	2.75	354.00	9912.00

Table 1 Sales Data: Oxford Stitch Duvet Covers

All 64 products in the T230 Percale Cotton range are tabulated as illustrated in Table 1. These products are sorted according to average monthly contribution to turnover.

Exclusive Home Fashions does not wish to make their profit margin public, but it was taken into consideration with all calculations where relevant. See Appendix A, Table 6 for the full, sorted product range information. With the information of the average contribution, the ABC Analysis is performed and the following table illustrates the findings.

Product Category	No Of Units	Percentage Of Total Product Range	Percentage of Turnover
A	15	23.44%	55.81%
B	16	24.49%	24.99%
C	33	52.07%	19.20%
Total	64	100	100

Table 2: ABC Analysis for T230 Range

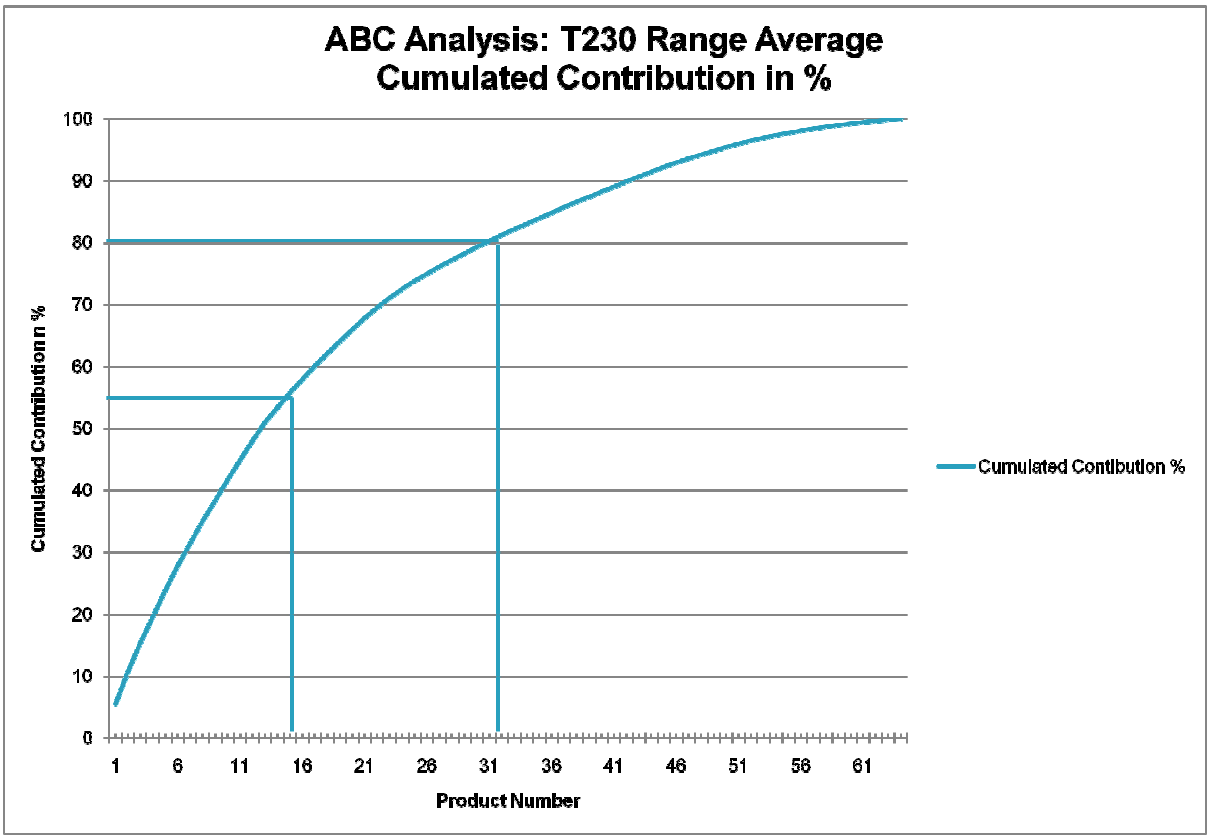

Figure 4: Pareto Diagram Illustrating the ABC Analyses

The Pareto diagram in Figure 4 gives a clear illustration of the cumulated contribution, in percentage, of the 64 products to the monthly turnover. It is clear that Category A items contribute the most to average monthly turnover. Table 2 illustrates the number of products and their contributions to each category of the T230 Range. Table 2 also indicates the Category A items. WL Winston ((2004, p. 168) describes these items as the 5%-20% of the products that are responsible for 55%-65% of the sales. With this information the following 15 type A items became the focus of the project.

No	Product description	Product Size	No	Product description	Product Size
1	Oxford Satin Stitch Duvet	King	9	Fitted Sheets: Standard	Queen
2	Oxford Satin Stitch Duvet	Queen	10	Oxford Satin Stitch Duvet	S/King
3	Flat Sheet	Queen	11	Fitted sheets: Standard	Single
4	Pillowcase	Oxford Satin Stitch	12	Pillowcase	Oxford
5	Flat Sheet	King	13	Flat Sheet	Single
6	Pillowcase	Standard	14	Oxford Satin Stitch Duvet	Double
7	Oxford Satin Stitch Duvet	3 Quarter	15	Fitted sheets: Standard	King
8	Fitted Sheet: XL XD	King			

Table 3 : Category A Product Names

By optimising the category A products, a great deal of the inventory will be optimised. The method discussed in the previous sections will be followed.

10. Determining the Inventory Costs

10.1 Holding (or Carrying) Cost

High holding costs tend to favour low inventory levels and frequent replenishment. The holding cost can be seen as the balancing factor of the order quantities. If the cost to hold inventory is high, a point will occur where it is not economically feasible to hold one more item in inventory. This balancing point is applicable for each product in inventory.

Holding cost can be described as the cost to store or hold one unit of inventory per unit of time. The unit of time is chosen to be one month, since most of the data is sorted according to monthly contribution or sales. This value can easily be converted to year by multiplying by twelve. It is important to calculate the holding cost accurately for each item since the economic order quantities, reorder points and safety stock levels are directly related to the holding cost

This category includes al the costs associated with the holding or storing of inventory, namely:

10.1.1 Storage Facility Cost

Exclusive Home Fashions owns the warehouse and offices they are based in. The potential income that Exclusive Home Fashions can earn for leasing the facility to another organisation must be taken into consideration. The loss of potential income is as follows:

Average costs per m² for a similar property in Randburg per month.	R 65 /m² ex VAT
Size of factory	936 m²
Total potential loss of income	R60 840

The rate of R65/m² per month is the average rate per square metre in the Strydom Park Industrial Area for property that includes a show room, offices and a warehouse. The total potential loss of income is allocated to a product in the facility by the following method:

(Total Storage Facility Cost) ÷ (No of Inventory Units in Factory)

The cost is allocated according to the number of units in the warehouse and not according to the monetary value of each product. Products are stored in similar boxes and the value of a product does not necessarily mean that it occupies more space in the warehouse.

10.1.2 Handling Cost

The monthly cost of the labour that is employed in the factory and used for material handling and picking of orders are:

No of personnel in warehouse	19
Total cost	R 69000

The personnel are a direct cost to inventory handling. Without inventory Exclusive Home Fashions will not need the 19 workers.

The monthly handling costs are allocated to each product as follows:

(Total Labour Cost) ÷ (No of Inventory Units In Factory)

The handling cost is allocated to the number of inventory units in the warehouse and not according to the monetary value of each product. The same actions are followed to move and pick inventory for all items in the warehouse. The mass ranges from 0.217kg for a pillowcase to 2.75kg for a Super King Satin Stitch Duvet Cover. With all linen products, the weight range of 2.533kg will not affect the handling cost per product dramatically.

10.1.3 Insurance

The monthly insurance cost for Exclusive Home Fashions for the inventory is

Monthly insurance cost	R 3700

This is relatively low, but Exclusive Home Fashions have taken the necessary precautions to ensure all inventory exposure to possible theft, fire and water damage is minimised.

10.1.4 Opportunity Cost of Capital

Each inventory item can also be described as capital in material form. With all the advantages of inventory, one major disadvantage is the fact that inventory does not gain value. Inventory does not provide the possible opportunity gains that Exclusive Home Fashions could earn if they invested the capital in other projects. A simple but effective way to measure this is to take the potential interest that the capital could earn, if it was invested with a financial institution. The minimum guaranteed amount that capital could earn would be the current prime interest rate. The following information is given on the website of the South African Reserve Bank (SARB)

Prime Interest Rate as of 14 August 2009	10.5%

The shipping cost used in the following calculations is determined by calculating the average cost per kilogram for 4 previous orders. This breaks down to R3.60 per kilogram. The mass of each product is known and the estimated shipping cost is determined as

(Product mass) x (Average Cost per Kilogram)

It is necessary to determine this estimated value since, this value is used to determine the Opportunity cost.

See Appendix A for detailed breakdown of previous shipments.

For the category A items the following monthly Opportunity cost of capital is calculated.

Opportunity Cost of Capital : Category A Items										
	Product description	**Size**	**Product code**	**Mass**	**$/Unit**	**R/unit**	**Customs**	**Shipping**	**Landed Cost**	**Opportunity cost(R) at 10.5% per month**
1	Oxford Satin Stitch Duvet	King	003886	2.50	23.65	192.55	50.61	9.00	252.16	**2.21**
2	Oxford Satin Stitch Duvet	Queen	003885	2.00	22.40	182.37	47.94	7.20	237.51	**2.08**
3	Flat Sheet	Queen	000647	1.24	7.39	60.17	15.81	4.46	80.44	**0.70**
4	Pillowcase	OSS	003888	0.22	2.43	19.78	5.20	0.78	25.77	**0.23**
5	Flat Sheet	King	000648	1.31	7.79	63.42	16.67	4.72	84.81	**0.74**
6	Pillowcase	Standard	000635	0.22	1.49	12.13	3.19	0.78	16.10	**0.14**
7	Oxford Satin Stitch Duvet	3 Quarter	003883	1.50	14.43	117.48	30.88	5.40	153.76	**1.35**
8	Fitted Sheet: XL XD	King	000668	1.21	9.03	73.52	19.32	4.36	97.20	**0.85**
9	Fitted Sheets: Standard	Queen	000652	0.97	6.40	52.11	13.70	3.48	69.29	**0.61**
10	Oxford Satin Stitch Duvet	S/King	003887	2.75	23.75	193.36	50.83	9.90	254.09	**2.22**
11	Fitted Sheets: Standard	Single	000649	0.70	4.84	39.40	10.36	2.52	52.28	**0.46**
12	Pillowcase	Oxford	000636	0.22	2.10	17.10	4.49	0.78	22.37	**0.20**
13	Flat Sheet	Single	000644	0.86	5.10	41.52	10.91	3.11	55.54	**0.49**
14	Oxford Satin Stitch Duvet	Double	003884	1.80	20.53	167.14	43.93	6.48	217.56	**1.90**
15	Fitted sheets: Standard	King	000653	1.08	7.15	58.2117	15.30	3.89	77.40	**0.68**
	Rand/Dollar	8.14	2009/08/14 Reserve Bank(SARB)							
	Average freight cost(R) per kg	3.60								

Table 4: Opportunity Cost of Capital: Category A Items

The Opportunity cost per month for the category A items was calculated as follows:

(Landed Cost) x [(Interest rate per year)/12]

The Landed Cost includes the Cost Price, Customs and shipping cost. The landed cost is multiplied by the current interest rate of 10.5% per year and divided by 12 to provide the monthly opportunity cost for each product.

10.1.5 Total Holding Cost for Category A Products

Opportunity Cost of Capital : Category A Items								
	Product description	**Size**	**Product Code**	**Storage Cost**	**Handling Cost**	**Insurance Cost**	**Opportunity Cost(R) at 10.5% per month**	**Total Holding Cost**
1	Oxford Satin Stitch Duvet	King	003886	1.11	1.25	0.07	**2.21**	4.63
2	Oxford Satin Stitch Duvet	Queen	003885	1.11	1.25	0.07	**2.08**	4.51
3	Flat Sheet	Queen	000647	1.11	1.25	0.07	**0.70**	3.13
4	Pillowcase	OSS	003888	1.11	1.25	0.07	**0.23**	2.65
5	Flat Sheet	King	000648	1.11	1.25	0.07	**0.74**	3.17
6	Pillowcase	Standard	000635	1.11	1.25	0.07	**0.14**	2.57
7	Oxford Satin Stitch Duvet	3 Quarter	003883	1.11	1.25	0.07	**1.35**	3.77
8	Fitted Sheet: XL XD	King	000668	1.11	1.25	0.07	**0.85**	3.28
9	Fitted Sheets: Standard	Queen	000652	1.11	1.25	0.07	**0.61**	3.03
10	Oxford Satin Stitch Duvet	S/King	003887	1.11	1.25	0.07	**2.22**	4.65
11	Fitted sheets: Standard	Single	000649	1.11	1.25	0.07	**0.46**	2.89
12	Pillowcase	Oxford	000636	1.11	1.25	0.07	**0.20**	2.62
13	Flat Sheet	Single	000644	1.11	1.25	0.07	**0.49**	2.91
14	Oxford Satin Stitch Duvet	Double	003884	1.11	1.25	0.07	**1.90**	4.33
15	Fitted sheets: Standard	King	000653	1.11	1.25	0.07	**0.68**	3.11
	Rand/Dollar	8.14	2009/08/14 Reserve Bank(SARB)					
	Storage cost	60 840.00						
	Handling Cost	69 000.00						
	Insurance	3 700.00						
	Average Units in Warehouse	55000						

Table 5: Holding Cost Category A items

10.2 Ordering Cost

Ordering cost includes all the costs associated with placing an order which excludes the actual cost of the products.

10.2.1 Freight Cost

Freight cost accounts for the total shipping cost to ship a package from the supplier, in China, to the warehouse in Randburg. Exclusive Home Fashion's inventory is shipped in

containers of 6 and 12-metre lengths. All the shipment documentation, cartage and customs clearing are outsourced to Kintetsu World Express, specialists in freight forwarding. Kintetsu World Express charges a flat rate per order and additional cost calculated as a percentage of the total value of the shipment. A critical assumption with EOQ models is that it is assumed that the ordering cost is constant. In order to do the calculation of the EOQ models an estimated freight cost was determined through inspection. This estimated cost is compared to the actual costs to ensure an accurate estimation is used for all calculations in section 11.1.2. The estimated shipping cost assumes that only the 15 Category A products are shipped in a 6 metre container. The total container cost is divided by 15 to determine the individual cost per order per item. The estimated and actual cost is not determined according to the monetary contribution of the total shipping cost of each product, since this makes the EOQ models difficult to solve. These values are based on the assumption that the container does not ship any other products than the Category A products in the container. The EOQ model becomes unwieldy since all calculations are dependant on these values. The estimated shipping cost is R1350 per type of item in the container.

10.3 Shortage Cost

Shortage cost is the cost of being one unit short of an item when a customer orders that item regardless of the time it takes to provide that item to the customer. This cost can be divided into three scenarios at Exclusive Home Fashions.

Scenario A

The customer acquires the same product from another supplier. This will cost Exclusive Home Fashions the profit of that product and possible loss of income due to the customer making all future transactions with the new supplier. This is difficult to determine and only the loss of profit will be taken into consideration.

Scenario B

The customer demands that Exclusive Home Fashions acquire the products via airfreight. The cost associated with airfreight is approximately the same cost as the product price. Thus, if the product is not sold at 100% profit a loss is incurred with the transaction. Exclusive Home Fashions have met with such scenarios but it is very unusual.

Scenario C

The Customer waits for the stock to arrive. Customers are willing to wait if only a minority of the products are not in stock. The reason for this is that the same items from different suppliers may have slight variations. Customers typically require that their products all have the same characteristics such as the same stitch, shade of colour and quality. It is very seldom that all the products a customer requires are not in stock and customers will wait for orders to be completed.

A weight is allocated to each scenario and an average calculated for each product.

The weighted average shortage cost for the Oxford Satin Stitch Duvet King Size is:

Oxford Satin Stitch Duvet	Probability	Cost to Exclusive Home Fashions (R)	Total cost (R)
Scenario A	84.00%	95.03	79.82
Scenario B	1.00%	192.55	1.93
Scenario C	15.00%	0	0
Total Shortage Cost			81.75

Table 6: Average Shortage - Oxford Satin Stitch Duvet King Size.

The cost of being one unit short for the Oxford Satin Stitch King Duvet is R81.75.The following table illustrates the shortage cost for the 15 Category A products.

	Product description	Size	Shortage Cost
1	Oxford Satin Stitch Duvet	King	81.72
2	Oxford Satin Stitch Duvet	Queen	87.58
3	Flat Sheet	Queen	38.53
4	Pillowcase	Oxford Satin Stitch	11.78
5	Flat Sheet	King	43.24
6	Pillowcase	Standard	5.90
7	Oxford Satin Stitch Duvet	3 Quarter	58.18
8	Fitted Sheet: XL XD	King	46.17
9	Fitted Sheets: Standard	Queen	31.57
10	Oxford Satin Stitch Duvet	S/King	85.72
11	Fitted sheets: Standard	Single	20.93
12	Pillowcase	Oxford	10.21
13	Flat Sheet	Single	25.21
14	Oxford Satin Stitch Duvet	Double	80.91
15	Fitted Sheets: Standard	King	36.71

Table 7: Shortage Cost for Category A Products

11 Determining the Economic Order Quantities, Reorder Points and Safety Stock Levels

To determine the economic order quantities, reorder points and safety stock levels all the information from the previous sections is used. The economic order quantities for deterministic models are based on minimising the following formula:

TC (q, r) = (expected annual holding cost) + (expected annual ordering cost) + (expected annual cost due to shortages)

This formula represents the total annual cost for an inventory item if q units are ordered at a reorder point of r. The aim is to minimise the total annual cost of inventory. The EOQ, reorder point and safety stock levels are determined by using LINGO to minimise the total annual cost for each item. The reason LINGO is used is because the basic EOQ formula does not take the shortage cost into consideration. The following section will explain each component that is used in LINGO in determining the EOQ, safety stock levels and reorder points for each product.

11.1 Components Used In Determining the EOQ, Reorder Point and Safety Stock Levels.

11.1.1 Average Demand (D) and Standard Deviation in Demand (SDD) Per Year.

The data that was available for these calculations was for the previous twelve months. The data was captured in EXCEL and the Mean and Standard deviation for each product was determined with the use of EXCEL Functions. The data was used to determine the average demand and the average standard deviation per year with the use of statistical formulas. The average demand per year is calculated by multiplying the average demand per month by 12. The average standard deviation is determined with the following formula described by WL Winston (2004, p. 148) :

$$(\text{Average Monthly Standard Deviation}) \times \sqrt{12}$$

This equation delivers the annual standard deviation. These calculations are done for each product.

See Appendix A for full description of average demand and standard deviation.

11.1.2 Estimated Fixed Shipping Cost (K)

As discussed in section 10.3.1 the shipping cost is determined by inspection. This cost is based on an estimated cost for shipping the 15 products. It is important to note that the EOQ calculations assume that the fixed shipping cost is equal for each product. The estimated shipping cost is R1350 per item type. The actual shipping cost is determined by dividing the actual cost for shipping the determined EOQ quantities of each product. The following table illustrates the actual shipping cost for the EOQ's for the 15 Category A products:

Actual shipping cost for all 15 EOQ	
Description	**Cost**
Cargo Dues	1942.23
Release Charges	3636.90
Degroup Charges	650.00
CTO	120.00
Cartage	6500.00
Communication fee	50.00
Documentation	355.00
Facility Fee	2781.56
Agency fee	4337.71
Total(Rand)	**20373.41**

Table 8: Actual Shipping Cost for EOQ Quantities

All the costs are fixed except the Facility Fee and the Agency Fee. The Facility Fee is equal to 0.855% of the total value, in South African Rand, of the goods shipped, and the Agency Fee is equal to 1.333% of the total value, in South African Rand, of the goods shipped. The actual cost is determined to compare the estimated cost to the actual cost to ensure accuracy with the EOQ, reorder point and safety stock level calculations.

The following table illustrates the estimated and actual shipping cost for the 15 category A products

	Product description	**Size**	**Estimated Fixed Shipping cost K (R)**	**Actual Shipping Cost (R)**
1	Oxford Satin Stitch Duvet	King	1350.00	1358.23
2	Oxford Satin Stitch Duvet	Queen	1350.00	1358.23
3	Flat Sheet	Queen	1350.00	1358.23
4	Pillowcase	Oxford Satin Stitch	1350.00	1358.23
5	Flat Sheet	King	1350.00	1358.23
6	Pillowcase	Standard	1350.00	1358.23
7	Oxford Satin Stitch Duvet	3 Quarter	1350.00	1358.23
8	Fitted Sheet: XL XD	King	1350.00	1358.23

9	Fitted Sheets: Standard	Queen	1350.00	1358.23
10	Oxford Satin Stitch Duvet	S/King	1350.00	1358.23
11	Fitted Sheets: Standard	Single	1350.00	1358.23
12	Pillowcase	Oxford	1350.00	1358.23
13	Flat Sheet	Single	1350.00	1358.23
14	Oxford Satin Stitch Duvet	Double	1350.00	1358.23
15	Fitted Sheets: Standard	King	1350.00	1358.23

Table 9: Estimated Shipping Cost Compared to Actual Shipping Cost.

It is clear that the estimated shipping cost of R1350 is close to the actual shipping cost due to trial and error estimates. The error is R123.41 between the actual total and the estimated total shipping cost. This translates into a deviation of 0.006%

11.1.3 The Total Holding Cost Per Item Per Year (H)

This is calculated by multiplying the monthly holding cost as determined in section 10.2 by 12. See Appendix A for total holding cost per item per year.

11.1.4 Shortage Cost (SC)

See section 10.3.2 for the full description of the calculation of the shortage cost for each item.

11.1.5 Lead Time in Years (L) and Standard Deviation in Mean Lead-Time (SDL) In Years.

The average lead-time is 3 months.(0.25 years). The standard deviation for lead-time is 3 weeks.(0.0577 years)

11.1.6 Mean Lead Time Demand (E(X)) and the Lead Time Standard Deviation (δx)

This is the expected number of orders that will be placed during lead times. This is calculated as:

(Expected demand per year) ÷ (lead times per year)

The standard deviation during lead-time is calculated with the following statistical formula, WL Winston (2004, p. 148):

(Standard deviation per year) x $\sqrt{lead\ time\ in\ years}$

The following table gives the demand (E(X)) and the standard deviation during lead times:

	Product description	Size	E(X)= E(D)x L expected order quantity during lead times - MLD	δx=δDxsqrt(L)-SLD
1	Oxford Satin Stitch Duvet	King	141.92	59.67
2	Oxford Satin Stitch Duvet	Queen	135.23	40.16
3	Flat Sheet	Queen	328.25	79.59
4	Pillowcase	Oxford Satin Stitch	928.85	326.47
5	Flat Sheet	King	278.25	119.75

6	Pillowcase	Standard	1443.46	478.17
7	Oxford Satin Stitch Duvet	3 Quarter	144.23	61.71
8	Fitted Sheet: XL XD	King	205.62	47.10
9	Fitted Sheets: Standard	Queen	281.31	110.16
10	Oxford Satin Stitch Duvet	S/King	84.00	31.30
11	Fitted Sheets: Standard	Single	356.50	63.08
12	Pillowcase	Oxford	765.25	240.69
13	Flat Sheet	Single	301.25	86.50
14	Oxford Satin Stitch Duvet	Double	68.50	35.26
15	Fitted Sheets: Standard	King	172.36	55.44

Table 10: Mean lead-time demand and lead time standard deviation.

11.1.7 Service Level Measurement (SLM1)

As explained in section 4.1.8 and section 7, SLM1 is the expected fraction (usually expressed as a percentage) of all demand met on time. Given the competitive nature of the industry and the long lead-time, Exclusive Home Fashions desire to supply 99% of orders on time. All calculations are based on an SLM1 of 99%. In the sensitivity analyses section a study will be done on the effect of the SLM1 on the EOQ, reorder points, safety stock levels and all relevant costs.

11.2 Calculating the EOQ, Reorder Points and Safety Stock Levels

All the foregoing information is used in LINGO to determine the required EOQs, reorder points and safety stock levels. LINGO is used rather than the EXCEL solver due to the fact that LINGO uses more suitable methods to solve the variables of Q, R and S. See appendix B for the LINGO programming code. A code with corresponding values for each product was constructed to find the Q, R and S. The code instructs the LINGO mathematical capabilities to find the optimal solution for the order quantity (Q) , reorder point (R) and safety stock levels (S) for each item. LINGO runs iterations with variable combinations of Q, R and S to minimise the total annual cost. The total annual cost consists of the following three parts:

11.2.1 Order Cost

The order cost as explained in section 5.2.5 is calculated by the following formula;

$$\textit{Expected annual order cost} = K\left(\frac{expected\ orders}{year}\right)$$

$$\textit{Expected annual order cost} = \frac{KE(D)}{q}$$

This formula calculates the amount of order per year by dividing the mean yearly demand by the order quantity. This is multiplied by the fixed shipping cost per order.

11.2.2 Holding Cost

The holding cost as explained in section 5.2.3 is calculated by the following formula:

$$\textit{The expected annual holding cost} \cong h\left(\frac{q}{2} + r - E(X)\right)$$

This formal calculates the average amount of inventory in the warehouse throughout the year and multiplies it by the holding cost per unit per year. The formula includes safety stock.

11.2.3 Shortage Cost

The expected annual shortage cost is calculated by the following formula:

$$\textit{Expected annual shortage cost} = \frac{c_B \mathrm{E}(B_r)\mathrm{E}(\mathrm{D})}{q}$$

Where c_B, or shortage cost, is also represented as SC in the LINGO code. SC represents the calculated values of section10.3.

$\mathrm{E}(B_r)$ represent the expected number of shortages during an inventory cycle. To compute this value the following must be explained.

Normal Loss Function

To quote WL Winston (2004, p. 156) :"*The normal loss function, NL(y), is defined by the fact that δxNL(y) is the expected number of shortages that will occur during a lead-time. In short, if we hold y standard deviations (in term of lead-time demand) of safety stock, then NL(y) δx is the expected number of shortages occurring during lead-time demand.*"

WL Winston (2004, p. 156) also illustrates that a larger reorder point leads to fewer shortage so NL(y) is a non-increasing function of y with a maximum value of 0.3989. For example NL(0) = 0.3989 means if the reorder point equals the expected lead-time, demand and the standard deviation is δx, then an average of 0.3989δx shortages will occur .The normal loss function is calculated by LINGO by using the @PSL function.

However, with a predetermined SLM1 value the reorder point and safety stock levels are calculated so that the NL(y) function adheres to a predetermined constraint that 99% of all orders must be met on time.

This information makes it capable to determine the annual shortage cost.

11.2.4 Other Constraint Used in Lingo

SLD

SLD represents the standard deviation in lead-time demand taking into consideration the standard deviation in lead-time. This is calculated by the following formula (LINDO Systems, 2006, p. 509):

$$SLD=\sqrt{SDD * SDD * L + D * D * SDL * SDL}$$

Where the variables represent the following:

- SDD = Standard Deviation in Demand
- L = Lead-time
- D = Demand
- SDL = Standard Deviation in Lead-time

Q+SAFETYSTOCK>R

This constraint means that the order quantity plus the safety stock levels must be larger than the reorder points. This constraint ensures that the solution is feasible.

Q>= (2*K*D/H) ^0.5;

This constraint only hastens up the calculation process.

EOQCALC= (2*K*D/H) ^0.5;

This constraint is not a binding constraint, it is only used to check the accuracy of the program. The solutions are compared to the similar calculations in EXCEL to ensure the variables' such as demand and lead-time are correctly entered into LINGO.

Q>MLD;

This constraint means that the order quantity must at least be larger than the expected mean lead-time demand, and that all demand is met accordingly.

11.3 Calculated EOQ's, Reorder Points and Safety Stock Levels.

The following table give the values of each product as calculated in LINGO.

	Product description	Size	EOQ	Reorder point r=s	Safety Stock Levels
1	Oxford Satin Stitch Duvet	King	**198.44**	**244.18**	**104.24**
2	Oxford Satin Stitch Duvet	Queen	**189.05**	**206.12**	**72.78**
3	Flat Sheet	Queen	**359.68**	**487.69**	**163.04**
4	Pillowcase	Oxford Satin Stitch	**928.85**	**1549.94**	**630.38**
5	Flat Sheet	King	**348.00**	**490.48**	**215.68**
6	Pillowcase	Standard	**1443.46**	**2360.12**	**931.09**
7	Oxford Satin Stitch Duvet	3 Quarter	**219.06**	**247.44**	**105.40**
8	Fitted Sheet: XL XD	King	**270.32**	**296.23**	**93.32**
9	Fitted Sheets: Standard	Queen	**349.56**	**476.98**	**199.17**
10	Oxford Satin Stitch Duvet	S/King	**145.46**	**134.28**	**51.74**
11	Fitted sheets: Standard	Single	**383.85**	**501.20**	**148.53**
12	Pillowcase	Oxford	**765.25**	**1230.42**	**472.82**
13	Flat Sheet	Single	**358.35**	**462.97**	**165.31**
14	Oxford Satin Stitch Duvet	Double	**137.99**	**123.05**	**55.93**
15	Fitted sheets: Standard	King	**256.72**	**267.09**	**97.30**

Table 11: Calculated EOQ, Reorder Points and Safety stock Levels

This table illustrates the EOQs, reorder points and safety stock levels for the 15 Category A products computed as illustrated in section 11.2. These calculations were done with a 3-month lead-time for deliveries and a SLM1 of 99%. For the complete LINGO report of each product, see APPENDIX C, and see APPENDIX B for the LINGO programming code.

11.4 Total Cost for EOQ, Reorder Point and Safety Stock Levels

The following table illustrates the cost of section 11.2 for the EOQ, reorder point and safety stock levels calculated in LINGO and represented in section 11.3:

	Product description	Size	Total Cost	Ordering Cost	Holding Cost	Shortage Cost
1	Oxford Satin Stitch Duvet	King	**15558.80**	**3861.95**	**11216.54**	**482.31**
2	Oxford Satin Stitch Duvet	Queen	**13287.21**	**3862.57**	**8950.90**	**473.74**
3	Flat Sheet	Queen	**18214.79**	**4928.13**	**12780.77**	**505.98**
4	Pillowcase	Oxford Satin Stitch	**40411.53**	**5400.00**	**34573.86**	**438.67**
5	Flat Sheet	King	**19485.35**	**4351.07**	**14653.03**	**481.26**
6	Pillowcase	Standard	**56252.22**	**5400.00**	**50511.56**	**340.66**
7	Oxford Satin Stitch Duvet	3 Quarter	**13530.07**	**3555.46**	**9638.95**	**335.65**

8	Fitted Sheet: XL XD	King	**13376.05**	**4107.32**	**8889.02**	**379.72**
9	Fitted Sheets: Standard	Queen	**18196.65**	**4345.28**	**13496.14**	**355.23**
10	Oxford Satin Stitch Duvet	S/King	**10279.12**	**3118.36**	**6872.75**	**288.01**
11	Fitted Sheets: Standard	Single	**16974.41**	**5015.16**	**11660.79**	**298.46**
12	Pillowcase	Oxford	**32409.59**	**5400.00**	**26697.07**	**312.52**
13	Flat Sheet	Single	**16767.95**	**4539.46**	**11924.71**	**303.78**
14	Oxford Satin Stitch Duvet	Double	**9329.35**	**2680.47**	**6427.18**	**221.69**
15	Fitted sheets: Standard	King	**12195.56**	**3625.54**	**8316.92**	**253.097**
	Total Cost Per Year		**306268.65**			

11.5 Graphical representation of the Total Cost for Oxford Satin Stitch King Duvet

The total cost, holding cost, order cost and shortage cost were analysed for a range of order quantities in EXCEL to provide graphical representations of these values. The values were calculated with the same formulas that were used in the LINGO program. The results had a slight variation due to limited EXCEL capabilities to compute the reorder point and safety stock levels for a certain SLM level. The results obtained in EXCEL were based on the minimum total cost and did not take a SLM of 99% into consideration, the reorder point and safety stock levels were also calculated according to the order quantity and not the minimum annual cost. The EXCEL formulas were verified by manually entering the LINGO EOQ, reorder point and safety stock level into the EXCEL sheet. The total, holding, order, and shortage cost were the same as the results of LINGO. The following graph illustrates the costs for a range order quantities of [100,500]. The graph clearly illustrates the relationship between the costs and the order quantities.

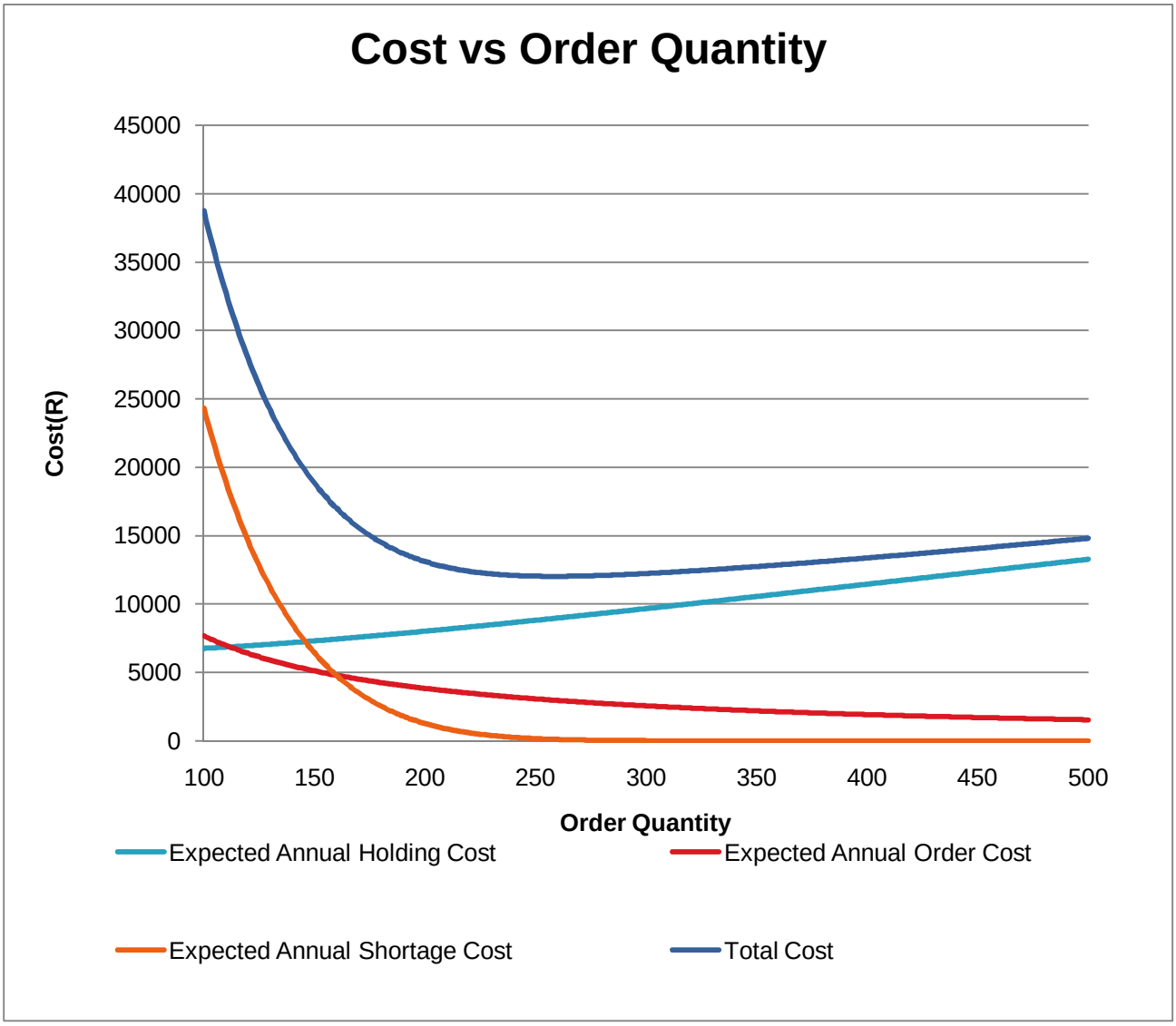

Table 12: Cost vs. Order Quantities [100-500]

11.4 Shipping Container Utilisation

The amount of units per item per shipping box is known to Exclusive Home Fashions. This means that it is possible to determine the container utilisation since the containers can accommodate the following number of boxes:

Container Size	Capacity
6 metre	Average of 300
12 metre	Average of 600

Table 13: Container Size and Capacity

This information makes it possible to determine the utilisation of the container. Using the EOQ's it is possible to determine the number of boxes shipped in an order.

	Product Description	Size	No of Units Per box - Shipping	EOQ	No of Boxes Used
1	Oxford Satin Stitch Duvet	King	10.00	**198.44**	**20.00**
2	Oxford Satin Stitch Duvet	Queen	10.00	**189.05**	**19.00**
3	Flat Sheet	Queen	22.00	**359.68**	**17.00**
4	Pillowcase	Oxford Satin Stitch	60.00	**928.85**	**16.00**
5	Flat Sheet	King	22.00	**348.00**	**16.00**
6	Pillowcase	Standard	60.00	**1443.46**	**25.00**
7	Oxford Satin Stitch Duvet	3 Quarter	10.00	**219.06**	**22.00**
8	Fitted Sheet: XL XD	King	14.00	**270.32**	**20.00**
9	Fitted Sheets: Standard	Queen	14.00	**349.56**	**25.00**
10	Oxford Satin Stitch Duvet	S/King	8.00	**145.46**	**19.00**
11	Fitted Sheets: Standard	Single	20.00	**383.85**	**20.00**
12	Pillowcase	Oxford	60.00	**765.25**	**13.00**
13	Flat Sheet	Single	22.00	**358.35**	**17.00**
14	Oxford Satin Stitch Duvet	Double	12.00	**137.99**	**12.00**
15	Fitted sheets: Standard	King	14.00	**256.72**	**19.00**
	Total				**280**

Table 14: Number of Boxes Uses to Ship EOQ

The utilisation of the containers is 93.3%, there is space for an additional 20 boxes in the container.

It is important to remember that the cycle times of all these products are different and the probability that these products are ordered at the same time is relatively small. However, the information is relevant since it confirms the accuracy of the fixed shipping cost. The fixed shipping cost is determined in two portions, explained in section 10.2.1, the fixed portion and the variable portion, determined according to the value of the contents of the container. If

only half of the container is utilised the estimated shipping cost would be misleading as other products of Exclusive Home Fashions would also account for half of the fixed shipping cost. Thus, the higher the utilisation of the EOQ's of the category A products in the 6 metre container the more accurate the calculations.

11.5 Converting r,Q policy to s,S policy

It is important to realize that Exclusive Home Fashions does not sell their product one-at-a-time. This implies that it is possible for inventory to fall below the reorder point. If the r,Q policy is followed, Q units will be ordered once the inventory reaches r, this is not a problem if exactly r units are left in inventory. If the inventory level is less than r, when an order of multiple units is received, and only Q units are ordered the order will not include the additional units of safety stock used when the inventory level falls below r. Safety stock will be used because mean lead-time demand is greater than order quantity. This implies that the units used from the safety stock will not be replenished by the order, resulting in the safety stock shrinking each time the situation occurs.

The s,S policy as explained in section 6.2 includes the units of safety stock used to complete the order. This implies that the safety stock will be replenished by the new order. According to WL Winston (2004, pp. 153,154) the s,S policy is determined by setting :

$$s = r$$

$$S = r + q$$

The following table illustrates the s,S values.

	Product description	Size	Reorder point r=s	S
1	Oxford Satin Stitch Duvet	King	**244.18**	**443.00**
2	Oxford Satin Stitch Duvet	Queen	**206.12**	**396.00**
3	Flat Sheet	Queen	**487.69**	**848.00**
4	Pillowcase	Oxford Satin Stitch	**1549.94**	**2479.00**
5	Flat Sheet	King	**490.48**	**839.00**
6	Pillowcase	Standard	**2360.12**	**3804.00**
7	Oxford Satin Stitch Duvet	3 Quarter	**247.44**	**467.00**
8	Fitted sheet: XL XD	King	**296.23**	**567.00**
9	Fitted Sheets: Standard	Queen	**476.98**	**827.00**
10	Oxford Satin Stitch Duvet	S/King	**134.28**	**280.00**
11	Fitted Sheets: Standard	Single	**501.20**	**886.00**

12	Pillowcase	Oxford	**1230.42**	**1996.00**
13	Flat Sheet	Single	**462.97**	**822.00**
14	Oxford Satin Stitch Duvet	Double	**123.05**	**262.00**
15	Fitted Sheets: Standard	King	**267.09**	**524.00**

Table 15: s,S Policy Values

With this policy the S-i units are ordered when inventory (i) drops below s. This takes the s-I units into consideration when an order is placed.

12 Sensitivity Analyses

The following section will evaluate the effect of change in demand, lead-times, service level measurement and the rand-dollar value have on the EOQs, reorder points and safety stock levels. These analyses will be done on the Oxford Satin Stitch King Duvet.

12.1 Changes in Demand

If demand changes the EOQ, reorder point and the safety stock levels will also adjust to accommodate the change in demand. With the basic EOQ model where:

$$q^* = \sqrt{\frac{2kD}{h}}$$

It is clear that any change in demand will have an impact on the order quantity. This section investigates the effect of change in demand on the EOQ, reorder points and safety stock levels.

The demand range of [400; 750] for product one, the Satin Stitch King Duvet, was investigated in LINGO. These values were tabulated in EXCEL and the following graph illustrates the relationship between the average demand and the EOQ, reorder points and safety stock levels.

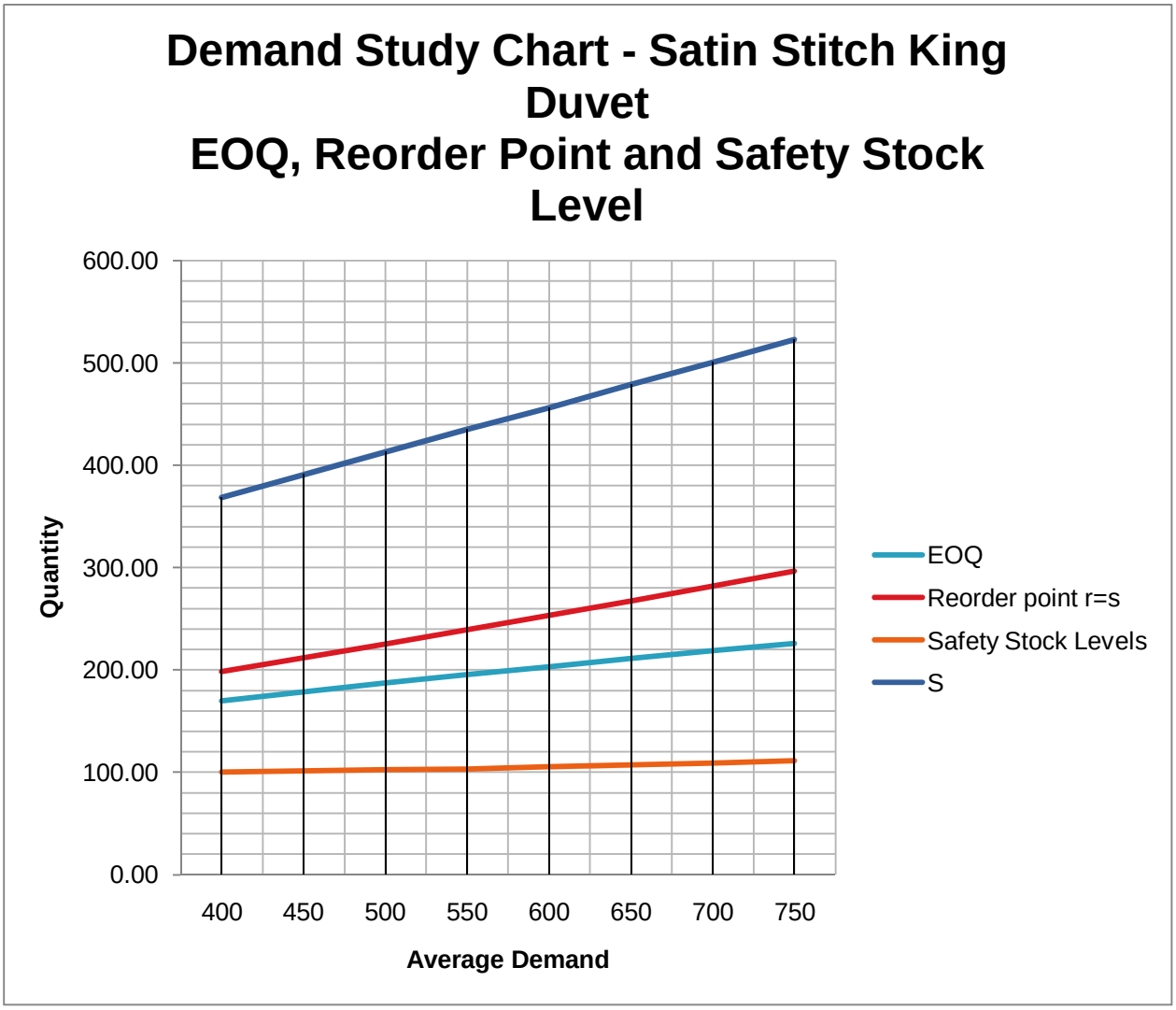

Figure 5 : Demand Change Chart - Satin Stitch King Duvet.

This chart illustrates the relationship between the average demand and the EOQ, reorder point, safety stock level and S. This chart also provides valuable information for Exclusive Home Fashions, the information on this chart can easily be used to adjust EOQs, reorder points, safety stock levels and S if the current demand average of 576 per year changes. The EOQs, reorder points, safety stock levels and S for average demand ranging from 400 up to 750 units per year can be determined by inspecting the data from the chart.

See Appendix D for demand range for all 15 category A products.

12.2 Change in Exchange Rates

The exchange rate has an effect on the holding cost of all products. The holding cost influence the EOQs, reorder points, safety stock levels and S of all products because the holding cost is present in all these calculations. The effect of the dollar on the holding cost will be illustrated with product one, the Satin Stitch King Duvet, with the current demand.

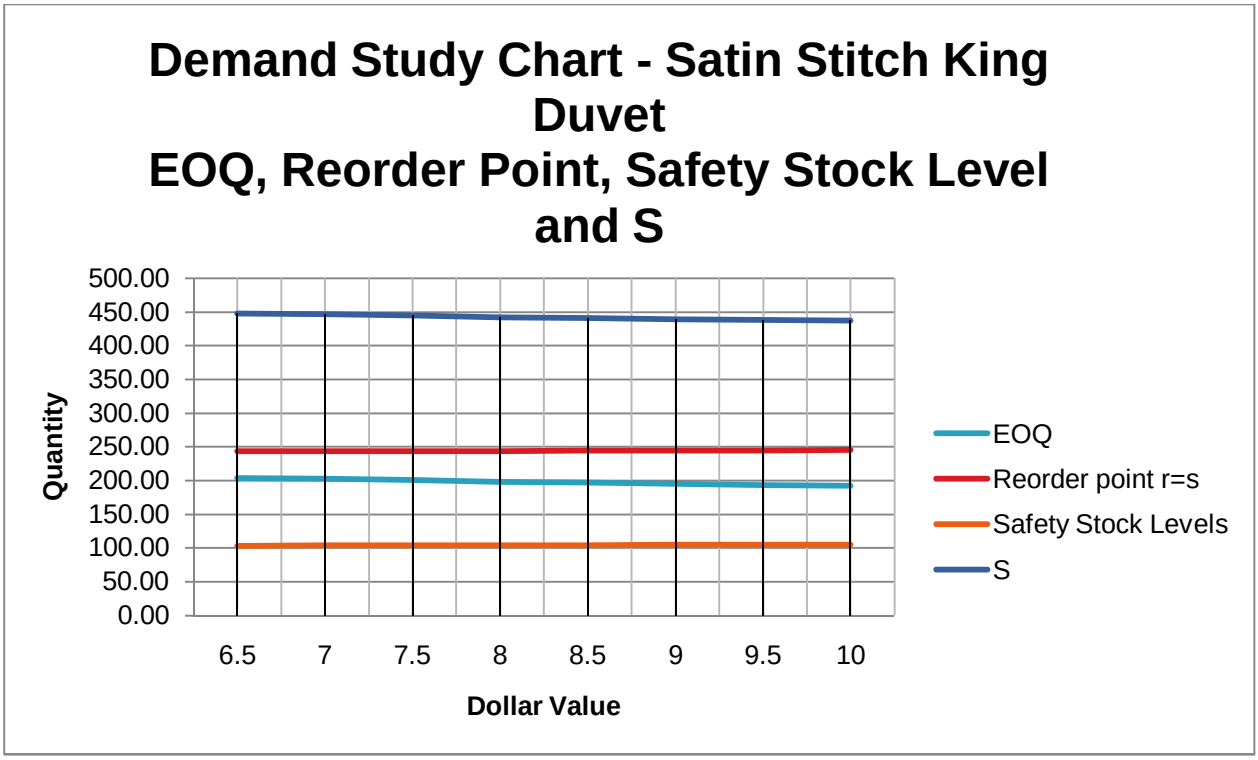

Figure 6 : Demand Study Chart - Satin Stitch King Duvet

It is clear that the effect of the fluctuating dollar does not affect any of these values enough to make it feasible to change the EOQs, reorder points, safety stock levels and S accordingly for these dollar ranges.

12.3 Change in Lead Time

Change in lead-time would affect the amount of inventory that has to be kept as safety stock, and would have an effect on the reorder points. The cost of change in lead-time is illustrated in the following figure. This figure illustrate the total and holding cost for Product one,the Satin Stitch King Duvet ,for assorted lead times.

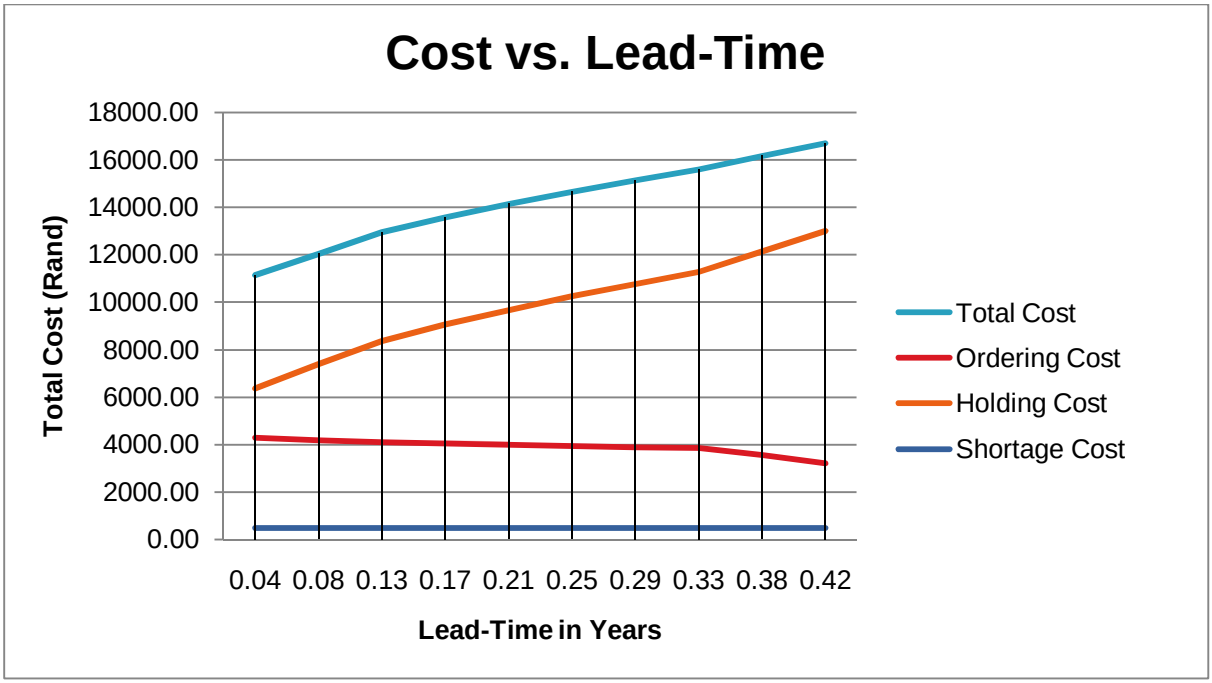

Figure 7: Cost vs. Lead-Time.

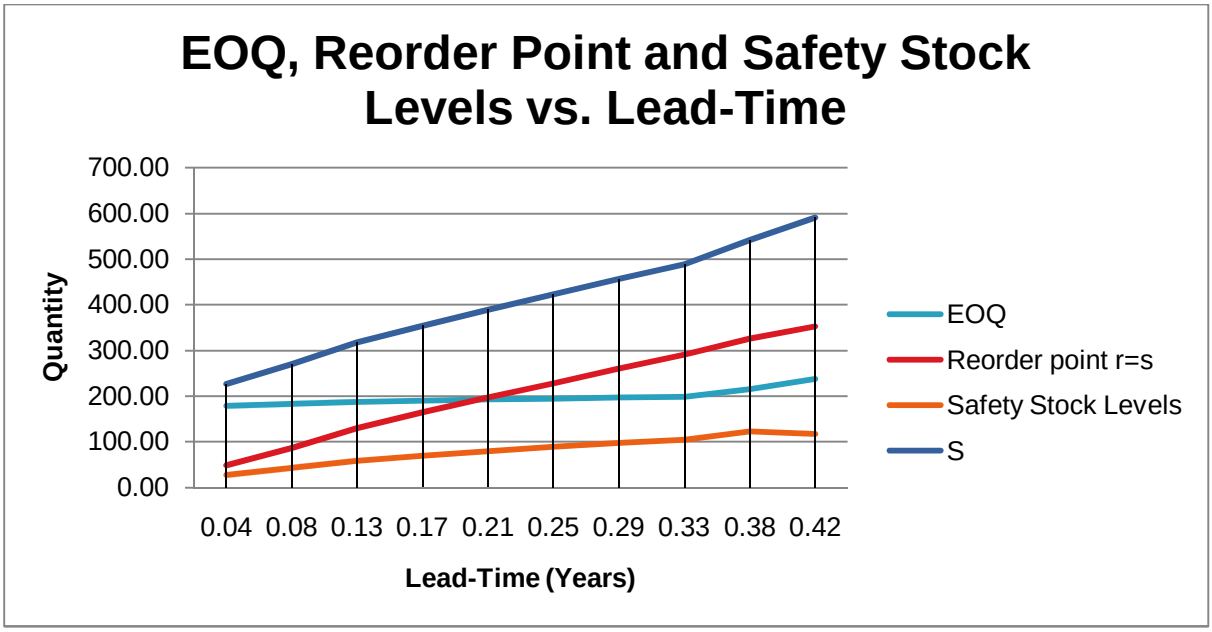

Figure 8:EOQ, Reorder Point and Safety Stock Levels vs. Lead-Time

It is clear in figure 8 that the longer the lead-time, the more inventory must be kept. This increases the annual inventory expenditure. Figure 7 illustrate the direct relationship between the holding cost, total cost and the lead-time. The shortage cost stays constant because LINGO computes the safety stock levels according to the chosen SLM1 level of 99%. The ordering cost decreases with longer lead-times, because fewer orders are placed during a year. It is very important that Exclusive Home Fashions investigate ways to lower their lead-times; even an improvement of a week can have a major impact on the total expenditure over the entire range of products.

Placing more frequent orders may result in larger ordering cost, and careful consideration must be made before this approach is followed. The ordering cost consists of a fixed and variable ordering cost and more frequent will reduce the variable cost, but the fixed cost will remain the same. This can be very costly.

12.4 Change in Service Level Measure (SLM1)

A change in the SLM1 level can influence the number of units that are kept in safety stock. This can have a major impact on the annual holding cost. The higher the SLM1 the more customer orders are fulfilled on time. This leads to more inventory being kept to absorb variation in lead-time demand and lead-time variation. The higher levels of inventory increase the annual holding cost, but it also decreases the annual shortage cost. The following figure illustrates the relationship between cost and various SLM1's.

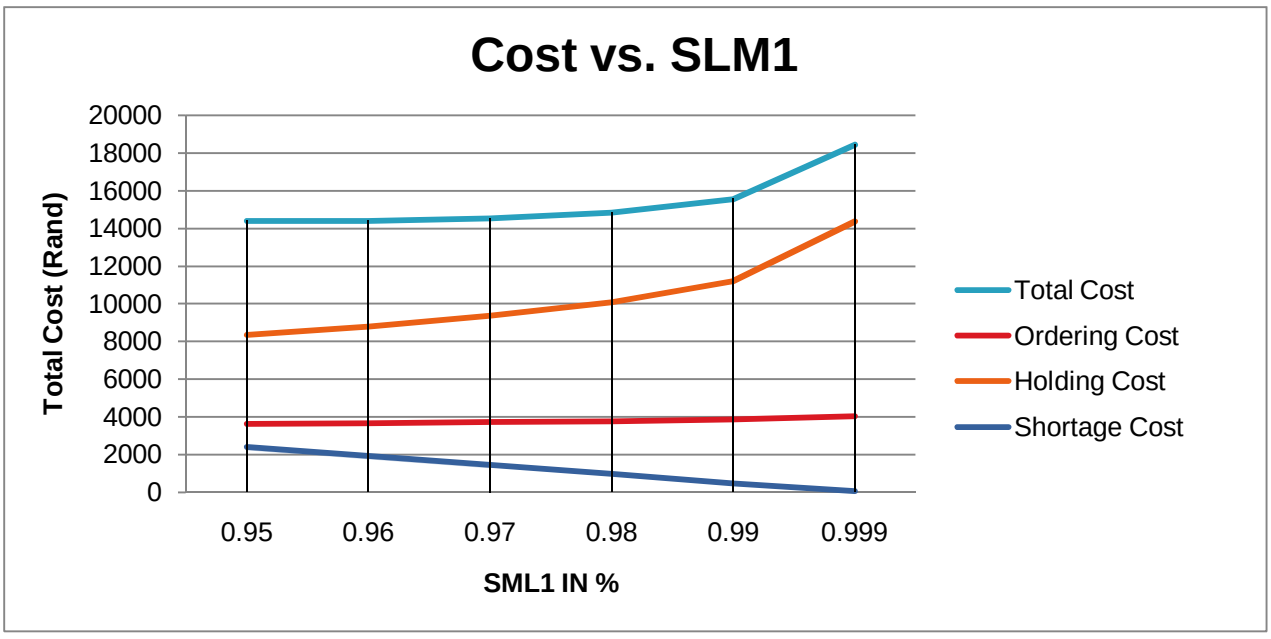

Figure 9: Cost vs. SLM1

It is clear that the holding cost increases due to the larger quantities of inventory being kept to satisfy customer demand. This results into a larger total annual cost. The shortage cost decreases because more orders are completed on time. The following figure illustrates the relationship between the EOQs, reorder points and safety stock levels according the various SLM1 levels.

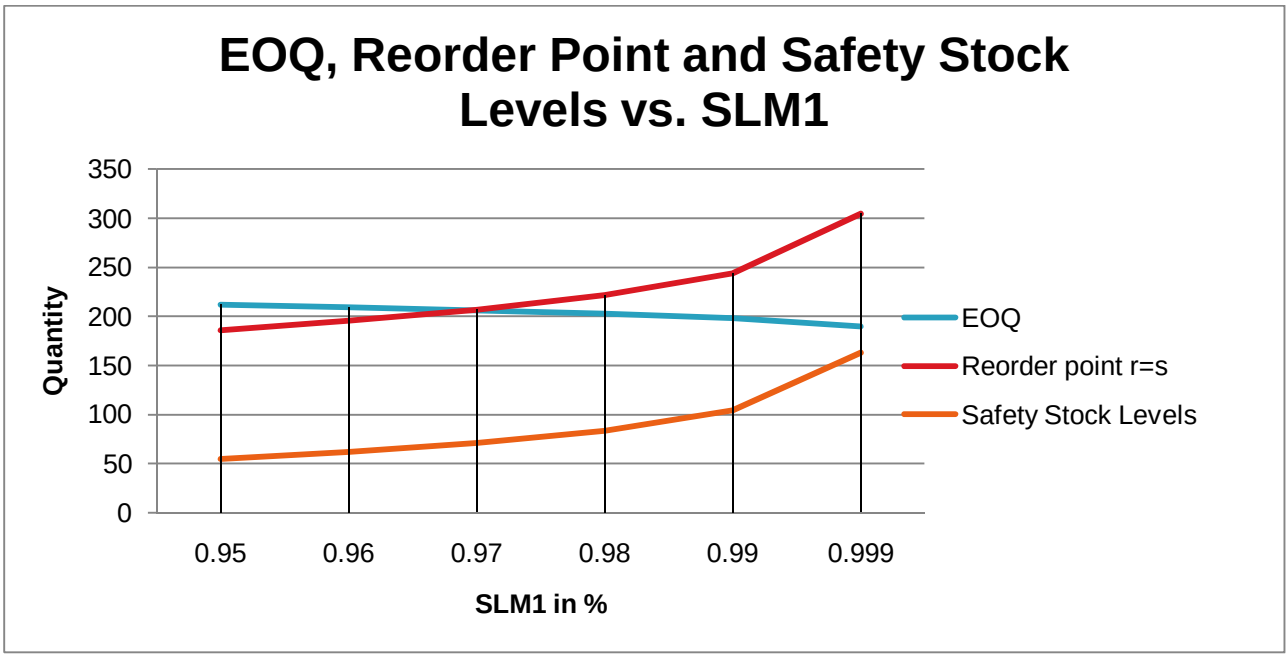

Figure 10: EOQ, Reorder Point and Safety Stock Levels vs. SLM1.

Figure 10 clearly indicate the relationship between the EOQs, reorder points and safety stock levels and the SLM1 levels. The higher the SLM1 level the more safety stock is kept and the sooner products are reordered. This results in a smaller probability that a customer order cannot be fulfilled.

With the competitive market that Exclusive Home Fashions trade in it is of utmost importance for them to keep their customers loyal and satisfied. This is the main reason why Exclusive Home Fashions have chosen a 99% SLM1. Exclusive Home Fashions may be spending more than what is necessary on holding costs, but with these long lead-times, they can be sure that at least 99% of all their customer orders are met on time. This will allow Exclusive Home Fashions to stay competitive and provide good quality service.

13 Conclusion

Exclusive Home Fashions showed potential for improved inventory policies. The aim of this project was to investigate methods to improve inventory policies that would allow Exclusive Home Fashions to reduce the annual costs associated with inventory, and will allow better control of inventory and ultimately better customer satisfaction.

With demand and lead-time probabilistic, a probabilistic inventory model was identified as the most appropriate method to improve the inventory policies. Probabilistic inventory models focus on products with uncertain demand and makes use of statistical and mathematical formulas to improve the control and expenditure regarding inventory.

All relevant information required for the calculations were gathered and tabulated. This data was used to identify the 15 products with the accumulated turnover contribution of 55.81% for the product range. These 15 products were identified as the Category A products and the EOQs, reorder points and safety stock levels were calculated for these products using LINGO.

The LINGO results made it clear that Exclusive Home Fashions will befit if these recommended inventory policies were to be followed. With a chosen SLM1 level of 99%, Exclusive Home Fashions can be sure that at least 99% of customer orders will be filled. This is an excellent contribution to improve inventory control and customer satisfaction. The second significant finding of the project is information regarding the EOQs, reorder points and safety stock levels for the 15 category A products. This information allows Exclusive Home Fashions to have better control over the inventory, and reduce cost associated with inventory while maintaining a high customer service.

All the results in this report makes it clear that Exclusive Home Fashions will benefit from these preposed inventory policies. These policies will allow better control and reduce inventory costs, while ensuring excellent customer service.

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Appendix A

General Information

	Product description	Size	Average demand per year D	std dev per year SDD	Estimated Fixed Shipping cost K	Actual Shipping cost	Holding cost/unit / year H	No of units per box - Shipping	Shortage Cost	EOQ	Total product cost	No of boxes used
1	Oxford Satin Stitch Duvet	King	567.69	119.34	1350.00	1358.23	55.66	10.00	81.72	**198.44**	**38208.92**	**20.00**
2	Oxford Satin Stitch Duvet	Queen	540.92	80.32	1350.00	1358.23	54.11	10.00	87.58	**189.05**	**34476.97**	**19.00**
3	Flat Sheet	Queen	1313.00	159.17	1350.00	1358.23	37.61	22.00	38.53	**359.68**	**21640.39**	**17.00**
4	Pillowcase	OSS	3715.38	652.95	1350.00	1358.23	31.85	60.00	11.78	**928.85**	**18376.13**	**16.00**
5	Flat Sheet	King	1113.00	239.50	1350.00	1358.23	38.07	22.00	43.24	**348.00**	**22070.96**	**16.00**
6	Pillowcase	Standard	5773.85	956.34	1350.00	1358.23	30.83	60.00	5.90	**1443.46**	**17510.38**	**25.00**
7	Oxford Satin Stitch Duvet	3 Quarter	576.92	123.43	1350.00	1358.23	45.31	10.00	58.18	**219.06**	**25735.00**	**22.00**
8	Fitted Sheet: XL XD	King	822.46	94.20	1350.00	1358.23	39.37	14.00	46.17	**270.32**	**19873.32**	**20.00**
9	Fitted Sheets: Standard	Queen	1125.23	220.31	1350.00	1358.23	36.43	14.00	31.57	**349.56**	**18214.03**	**25.00**
10	Oxford Satin Stitch Duvet	S/King	336.00	62.59	1350.00	1358.23	55.87	8.00	85.72	**145.46**	**28126.24**	**19.00**
11	Fitted Sheets: Standard	Single	1426.00	126.17	1350.00	1358.23	34.64	20.00	20.93	**383.85**	**15125.56**	**20.00**
12	Pillowcase	Oxford	3061.00	481.37	1350.00	1358.23	31.49	60.00	10.21	**765.25**	**13083.59**	**13.00**
13	Flat sheet	Single	1205.00	173.01	1350.00	1358.23	34.98	22.00	25.21	**358.35**	**14879.28**	**17.00**
14	Oxford Satin Stitch duvet	Double	274.00	70.51	1350.00	1358.23	52.02	12.00	80.91	**137.99**	**23064.34**	**12.00**
15	Fitted sheets: Standard	King	689.45	110.88	1350.00	1358.23	37.28	14.00	36.71	**256.72**	**14944.11**	**19.00**
	Total										**325329.2**	**280**

Table 16: Category A General Information.

	Product description	Size	Lead Time in Months (L)	E(X)= E(D)x L Expected Order Quantity During Lead Times	δx=δDxsqrt(L)	Reorder point r=s	Safety Stock Levels	Max Inventory Level	SLM1	No Of Shortages Per Cycle	S
1	Oxford Satin Stitch Duvet	King	**0.25**	**141.92**	**59.67**	**244.18**	**104.24**	**302.68**	**0.99**	**1.95**	**443.00**
2	Oxford Satin Stitch Duvet	Queen	**0.25**	**135.23**	**40.16**	**206.12**	**72.78**	**261.83**	**0.99**	**1.84**	**396.00**
3	Flat Sheet	Queen	**0.25**	**328.25**	**79.59**	**487.69**	**163.04**	**522.72**	**0.99**	**3.46**	**848.00**
4	Pillowcase	OSS	**0.25**	**928.85**	**326.47**	**1549.94**	**630.38**	**1559.23**	**0.99**	**9.288**	**2479.00**
5	Flat Sheet	King	**0.25**	**278.25**	**119.75**	**490.48**	**215.68**	**563.68**	**0.99**	**3.38**	**839.00**
6	Pillowcase	Standard	**0.25**	**1443.46**	**478.17**	**2360.12**	**931.09**	**2374.55**	**0.99**	**14.43**	**3804.00**
7	Oxford Satin Stitch Duvet	3 Quarter	**0.25**	**144.23**	**61.71**	**247.44**	**105.40**	**324.45**	**0.99**	**2.15**	**467.00**
8	Fitted Sheet: XL XD	King	**0.25**	**205.62**	**47.10**	**296.23**	**93.32**	**363.64**	**0.99**	**2.6**	**567.00**
9	Fitted Sheets: Standard	Queen	**0.25**	**281.31**	**110.16**	**476.98**	**199.17**	**548.73**	**0.99**	**3.41**	**827.00**
10	Oxford Satin Stitch Duvet	S/King	**0.25**	**84.00**	**31.30**	**134.28**	**51.74**	**197.20**	**0.99**	**1.43**	**280.00**
11	Fitted Sheets: Standard	Single	**0.25**	**356.50**	**63.08**	**501.20**	**148.53**	**532.38**	**0.99**	**6.35**	**886.00**
12	Pillowcase	Oxford	**0.25**	**765.25**	**240.69**	**1230.42**	**472.82**	**1238.07**	**0.99**	**7.65**	**1996.00**
13	Flat sheet	Single	**0.25**	**301.25**	**86.50**	**462.97**	**165.31**	**523.66**	**0.99**	**3.47**	**822.00**
14	Oxford Satin Stitch duvet	Double	**0.25**	**68.50**	**35.26**	**123.05**	**55.93**	**193.92**	**0.99**	**1.36**	**262.00**
15	Fitted sheets: Standard	King	**0.25**	**172.36**	**55.44**	**267.09**	**97.30**	**354.02**	**0.99**	**2.51**	**524.00**

Table 17: Category A General Information Continues.

Opportunity Cost of Capital

Opportunity Cost of Capital : Category A Items										
	Product description	Size	Measurement	Product code	Weight	$/Unit	R/unit	Customs	Unit Cost+ Customs Cost	Opportunity cost(R) at 10.5%
1	Oxford Satin Stitch duvet	King	230x220	003886	2.50	23.65	192.55	50.61	243.16	2.13
2	Oxford Satin Stitch duvet	Queen	230x200	003885	2.00	22.40	182.37	47.94	230.31	2.02
3	Flat sheet	Queen	250x270	000647	1.24	7.39	60.17	15.81	75.98	0.66
4	Pillowcase	Oxford Satin Stitch	45x70	003888	0.22	2.43	19.78	5.20	24.98	0.22
5	Flat sheet	King	270x270	000648	1.31	7.79	63.42	16.67	80.09	0.70
6	Pillowcase	Standard	45x70	000635	0.22	1.49	12.13	3.19	15.32	0.13
7	Oxford Satin Stitch duvet	3 Quarter	150x200	003883	1.50	14.43	117.48	30.88	148.36	1.30
8	Fitted sheet: XL XD	King	182x200x40	000668	1.21	9.03	73.52	19.32	92.84	0.81
9	Fitted sheets: Standard	Queen	152x190x30	000652	0.97	6.40	52.11	13.70	65.80	0.58
10	Oxford Satin Stitch duvet	S/King	260x230	003887	2.75	23.75	193.36	50.83	244.19	2.14
11	Fitted sheets: Standard	Single	91x190x30	000649	0.70	4.84	39.40	10.36	49.76	0.44
12	Pillowcase	Oxford	45x70	000636	0.22	2.10	17.10	4.49	21.59	0.19
13	Flat sheet	Single	160x270	000644	0.86	5.10	41.52	10.91	52.44	0.46
14	Oxford Satin Stitch duvet	Double	200x200	003884	1.80	20.53	167.14	43.93	211.08	1.85
15	Fitted sheets: Standard	King	182x190x30	000653	1.08	7.15	58.21	15.30	73.51	0.64
	Rand/Dollar	8.14	2009/08/14 Reserve Bank(SARB)							
	Average Landed Cost per kg	R 3.79								

Table 18: Opportunity Cost of Capital: Category A Items

Average Calculated Freight Cost per Kilogram

Invoice number	**476138**		**476137**		**475880**		**475879**	
Total weight of container(Kg)	**10402.00**		**11892**		**3200**		**5863**	
Description	Cost(R)	Cost/kg	Cost(R)	Cost/kg	Cost(R)	Cost/kg	Cost(R)	Cost/kg
Cargo Dues	3884.44	0.37	3884.44	0.33	1942.23	0.61	1942.23	0.33
Release Charges	2148.60	0.21	2148.00	0.18	3636.90	1.14	3636.90	0.62
Empty Return	4500.00	0.43	4500.00	0.38	0.00	0.00		0.00
Degroup Charges	650.00	0.06	650.00	0.05	650.00	0.20	650.00	0.11
CTO	120.00	0.01	120.00	0.01	120.00	0.04	120.00	0.02
Cartage	8360.00	0.80	8360.00	0.70	6500.00	2.03	6500.00	1.11
Communication fee	50.00	0.00	50.00	0.00	50.00	0.02	50.00	0.01
Documentation	360.00	0.03	365.00	0.03	350.00	0.11	355.00	0.06
Facility Fee	5570.61	0.54	4947.44	0.42	1779.36	0.56	2929.43	0.50
Agency fee	8689.42	0.84	7717.36	0.65	2775.57	0.87	4569.52	0.78
Total(Rand)	**34333.07**	**3.30**	**32742.24**	**2.75**	**17804.06**	**5.56**	**20753.08**	**3.54**
Average cost per kilogram(R)	R 3.79							

Table 19: Average calculated freight cost per kilogram.

Appendix B- LINGO Optimisation Code

The values for each product in Table 17 and Table 18 were substituted into this LINGO code for each category A product.

Product 1: Oxford Satin Stitch King Duvet

```
!EOQ MODEL : ITEM 1 SS KING DUVET ;
Data:
D=567.69          ;!MEAN DEMAND PER YEAR;
SDD =119.34       ;!STANDARD DEVIATION IN DEMAND PER YEAR;
H =55.66          ;!HOLDING COST PER UNIT PER YEAR;
SC =84.96         ;!PENALTY COST OR SHORTAGE COST;
L = 0.25          ;!LEAD TIME IN YEARS;
SLD = 59.67       ;!STANDARD DEVIATION IN LEAD TIME DEMAND;
K = 1350          ;!FIXED ORDER COST;
SDL = 0.0577      ;!STANDARD DEVIATION IN LEAD TIME IN YEARS;


END DATA
!THE Q,R EOQ INVENTORY MODEL;
MLD = L*D; !MEAN LEAD TIME DEMAND;

MIN = ECOST;
ECOST = ORDERINGCOST + HOLDINGCOST + SHORTAGECOST;
ORDERINGCOST= (K * D/Q);
HOLDINGCOST = H*(Q/2+R-MLD);
SHORTAGECOST = SHORTAGES * SC*D/Q;
SAFETYSTOCK= (R-MLD+SHORTAGES);

@PSL((R-MLD)/SLD) = ((Q*(1-SLM))/SLD);
SLM = .99;

Z=(R-MLD)/SLD;
!EXPECTED AMOUNT OF SHORTAGE COST/CYCLE. @PSL() IS = STANDARD NORMAL
LOSS FUNCTION;
SHORTAGES = SLD*@PSL(Z);
Q+SAFETYSTOCK>R;
!Q>=(2*K*D/H)^0.5;
EOQCALC=(2*K*D/H)^0.5;
Q+SAFETYSTOCK>MLD;
Q>MLD;
```

Appendix C: LINGO Reports

Product 1: Oxford Satin Stitch King Duvet

```
 Local optimal solution found at iteration:              32
Objective value:                                  15558.80
```

Variable	Value	Reduced Cost
D	567.6900	0.000000
SDD	119.3400	0.000000
H	55.66000	0.000000
SC	84.96000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	141.9225	0.000000
SLD	68.06942	0.000000
ECOST	15558.80	0.000000
ORDERINGCOST	3861.955	0.000000
HOLDINGCOST	11214.54	0.000000
SHORTAGECOST	482.3094	0.000000
Q	198.4439	0.000000
R	244.1835	0.000000
SHORTAGES	1.984439	0.000000
SAFETYSTOCK	104.2454	0.000000
SLM	0.9900000	0.000000
Z	1.502304	0.000000
EOQCALC	165.9457	0.000000

Product 2: Oxford Satin Stitch Queen Duvet

```
Local optimal solution found at iteration:              29
Objective value:                                  13287.21
```

Variable	Value	Reduced Cost
D	540.9200	0.000000
SDD	80.32000	0.000000
H	54.11000	0.000000
SC	87.58000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	135.2300	0.000000
SLD	50.86214	0.000000
ECOST	13287.21	0.000000
ORDERINGCOST	3862.574	0.000000
HOLDINGCOST	8950.899	0.000000
SHORTAGECOST	473.7377	0.000000
Q	189.0558	0.000000
R	206.1225	0.000000
SHORTAGES	1.890558	0.000000
SAFETYSTOCK	72.78309	0.000000
SLM	0.9900000	0.000000
Z	1.393817	0.000000
EOQCALC	164.2894	0.000000

Product 3: Flat sheet Queen

```
Local optimal solution found at iteration:            37
Objective value:                                18214.79
```

Variable	Value	Reduced Cost
D	1313.000	0.000000
SDD	159.1700	0.000000
H	37.67000	0.000000
SC	38.53000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	328.2500	0.000000
SLD	109.8789	0.000000
ECOST	18214.79	0.000000
ORDERINGCOST	4928.126	0.000000
HOLDINGCOST	12780.77	0.000000
SHORTAGECOST	505.8989	0.000000
Q	359.6803	0.000000
R	487.6923	0.000000
SHORTAGES	3.596803	0.000000
SAFETYSTOCK	163.0391	0.000000
SLM	0.9900000	0.000000
Z	1.451073	0.000000
EOQCALC	306.7725	0.000000

Product 4: Pillowcase Oxford Satin Stitch

```
Local optimal solution found at iteration:            36
Objective value:                                40411.53
```

Variable	Value	Reduced Cost
D	3715.380	0.000000
SDD	652.9500	0.000000
H	31.85000	0.000000
SC	11.78000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	928.8450	0.000000
SLD	390.5683	0.000000
ECOST	40411.53	0.000000
ORDERINGCOST	5400.000	0.000000
HOLDINGCOST	34573.86	0.000000
SHORTAGECOST	437.6718	0.000000
Q	928.8450	0.000000
R	1549.944	0.000000
SHORTAGES	9.288450	0.000000
SAFETYSTOCK	630.3874	0.000000
SLM	0.9900000	0.000000
Z	1.590244	0.000000
EOQCALC	561.2144	0.000000
MAXSTOCK	1559.232	0.000000

Product 5: Flat Sheet King

Local optimal solution found at iteration: 40
Objective value: 19485.35

Variable	Value	Reduced Cost
D	1113.000	0.000000
SDD	239.5000	0.000000
H	38.07000	0.000000
SC	43.24000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	278.2500	0.000000
SLD	135.8833	0.000000
ECOST	19485.35	0.000000
ORDERINGCOST	4351.066	0.000000
HOLDINGCOST	14653.03	0.000000
SHORTAGECOST	481.2612	0.000000
Q	345.3292	0.000000
R	490.4823	0.000000
SHORTAGES	3.453292	0.000000
SAFETYSTOCK	215.6856	0.000000
SLM	0.9900000	0.000000
Z	1.561871	0.000000
EOQCALC	280.9558	0.000000

Product 6: Pillowcase Standard

Local optimal solution found at iteration: 36
Objective value: 56252.22

Variable	Value	Reduced Cost
D	5773.850	0.000000
SDD	956.3400	0.000000
H	30.83000	0.000000
SC	5.900000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	1443.463	0.000000
SLD	582.7832	0.000000
ECOST	56252.22	0.000000
ORDERINGCOST	5400.000	0.000000
HOLDINGCOST	50511.56	0.000000
SHORTAGECOST	340.6571	0.000000
Q	1443.463	0.000000
R	2360.121	0.000000
SHORTAGES	14.43462	0.000000
SAFETYSTOCK	931.0934	0.000000
SLM	0.9900000	0.000000
Z	1.572898	0.000000
EOQCALC	711.0954	0.000000

Product 7: Oxford Satin Stitch Duvet 3 Quarter

Local optimal solution found at iteration: 31
Objective value: 13530.07

Variable	Value	Reduced Cost
D	576.9200	0.000000
SDD	123.4300	0.000000
H	45.31000	0.000000
SC	58.18000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	144.2300	0.000000
SLD	70.12026	0.000000
ECOST	13530.07	0.000000
ORDERINGCOST	3555.462	0.000000
HOLDINGCOST	9638.957	0.000000
SHORTAGECOST	335.6521	0.000000
Q	219.0551	0.000000
R	247.4360	0.000000
SHORTAGES	2.190551	0.000000
SAFETYSTOCK	105.3966	0.000000
SLM	0.9900000	0.000000
Z	1.471843	0.000000
EOQCALC	185.4141	0.000000

Product 8: Fitted Sheet: XL XD King

Local optimal solution found at iteration: 28
Objective value: 13376.05

Variable	Value	Reduced Cost
D	822.4600	0.000000
SDD	94.20000	0.000000
H	39.37000	0.000000
SC	46.17000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	205.6150	0.000000
SLD	66.86162	0.000000
ECOST	13376.05	0.000000
ORDERINGCOST	4107.318	0.000000
HOLDINGCOST	8889.002	0.000000
SHORTAGECOST	379.7298	0.000000
Q	270.3275	0.000000
R	296.2323	0.000000
SHORTAGES	2.703275	0.000000
SAFETYSTOCK	93.32061	0.000000
SLM	0.9900000	0.000000
Z	1.355297	0.000000
EOQCALC	237.4961	0.000000

Product 9: Fitted Sheets: Standard Queen

Local optimal solution found at iteration: 37
Objective value: 18196.65

Variable	Value	Reduced Cost
D	1125.230	0.000000
SDD	220.3100	0.000000
H	36.43000	0.000000
SC	31.57000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	281.3075	0.000000
SLD	127.8651	0.000000
ECOST	18196.65	0.000000
ORDERINGCOST	4345.275	0.2383368E-07
HOLDINGCOST	13496.14	0.000000
SHORTAGECOST	355.2351	0.000000
Q	349.5890	0.000000
R	476.9807	0.000000
SHORTAGES	3.495890	0.000000
SAFETYSTOCK	199.1691	0.000000
SLM	0.9900000	0.000000
Z	1.530310	0.000000
EOQCALC	288.7839	0.000000

Product 10: Oxford Satin Stitch Duvet S/King

Local optimal solution found at iteration: 34
Objective value: 10279.12

Variable	Value	Reduced Cost
D	336.0000	0.000000
SDD	62.59000	0.000000
H	55.87000	0.000000
SC	85.72000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	84.00000	0.000000
SLD	36.81359	0.000000
ECOST	10279.12	0.000000
ORDERINGCOST	3118.357	0.000000
HOLDINGCOST	6872.747	0.000000
SHORTAGECOST	288.0192	0.000000
Q	145.4612	0.000000
R	134.2826	0.000000
SHORTAGES	1.454612	0.000000
SAFETYSTOCK	51.73718	0.000000
SLM	0.9900000	0.000000
Z	1.365870	0.000000
EOQCALC	127.4272	0.000000

Product 11: Fitted Sheets: Standard

Local optimal solution found at iteration: 42
Objective value: 16974.41

Variable	Value	Reduced Cost
D	1426.000	0.000000
SDD	126.1700	0.000000
H	34.64000	0.000000
SC	20.93000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	356.5000	0.000000
SLD	103.6810	0.000000
ECOST	16974.41	0.000000
ORDERINGCOST	5015.155	0.000000
HOLDINGCOST	11660.79	0.000000
SHORTAGECOST	298.4618	0.000000
Q	383.8565	0.000000
R	501.1997	0.000000
SHORTAGES	3.838565	0.000000
SAFETYSTOCK	148.5383	0.000000
SLM	0.9900000	0.000000
Z	1.395625	0.000000
EOQCALC	333.3901	0.000000

Product 12: Pillowcase Oxford

Local optimal solution found at iteration: 36
Objective value: 32409.59

Variable	Value	Reduced Cost
D	3061.000	0.000000
SDD	481.3700	0.000000
H	31.49000	0.000000
SC	10.21000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	765.2500	0.000000
SLD	298.5361	0.000000
ECOST	32409.59	0.000000
ORDERINGCOST	5400.000	0.000000
HOLDINGCOST	26697.07	0.000000
SHORTAGECOST	312.5281	0.000000
Q	765.2500	0.000000
R	1230.420	0.000000
SHORTAGES	7.652500	0.000000
SAFETYSTOCK	472.8225	0.000000
SLM	0.9900000	0.000000
Z	1.558170	0.000000
EOQCALC	512.3034	0.000000

Product 13: Flat Sheet Single

```
  Local optimal solution found at iteration:            37
  Objective value:                                16767.95

                      Variable           Value        Reduced Cost
                             D        1205.000            0.000000
                           SDD        173.0100            0.000000
                             H        34.98000            0.000000
                            SC        25.21000            0.000000
                             L       0.2500000            0.000000
                             K        1350.000            0.000000
                           SDL   0.5770000E-01            0.000000
                           MLD        301.2500            0.000000
                           SLD        110.9835            0.000000
                         ECOST        16767.95            0.000000
                  ORDERINGCOST        4539.465            0.000000
                   HOLDINGCOST        11924.71            0.000000
                  SHORTAGECOST        303.7805            0.000000
                             Q        358.3572            0.000000
                             R        462.9721            0.000000
                    SHORTAGES        3.583572            0.000000
                   SAFETYSTOCK        165.3056            0.000000
                           SLM       0.9900000            0.000000
                             Z        1.457173            0.000000
                        EOQCALC        304.9759            0.000000
```

Product 14: Oxford Satin Stitch Duvet Double

```
  Local optimal solution found at iteration:            35
  Objective value:                                9329.354

                      Variable           Value        Reduced Cost
                             D        274.0000            0.000000
                           SDD        70.51000            0.000000
                             H        52.02000            0.000000
                            SC        80.91000            0.000000
                             L       0.2500000            0.000000
                             K        1350.000            0.000000
                           SDL   0.5770000E-01            0.000000
                           MLD        68.50000            0.000000
                           SLD        38.63761            0.000000
                         ECOST        9329.354            0.000000
                  ORDERINGCOST        2680.477           0.7529024E-
07
                   HOLDINGCOST        6427.184            0.000000
                  SHORTAGECOST        221.6934            0.000000
                             Q        137.9978            0.000000
                             R        123.0533            0.000000
                    SHORTAGES        1.379978            0.000000
                   SAFETYSTOCK        55.93324            0.000000
                           SLM       0.9900000            0.000000
                             Z        1.411921            0.000000
                        EOQCALC        119.2537            0.000000
```

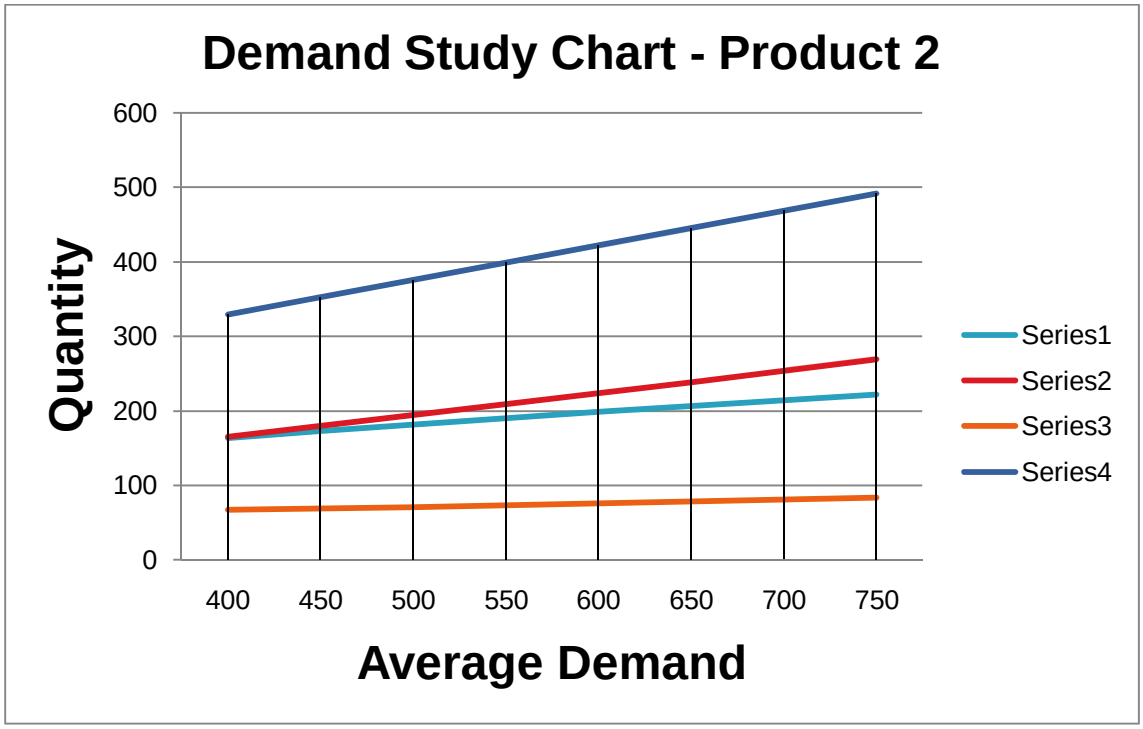
Product 15: Fitted Sheet Standard

Local optimal solution found at iteration: 30
Objective value: 12195.56

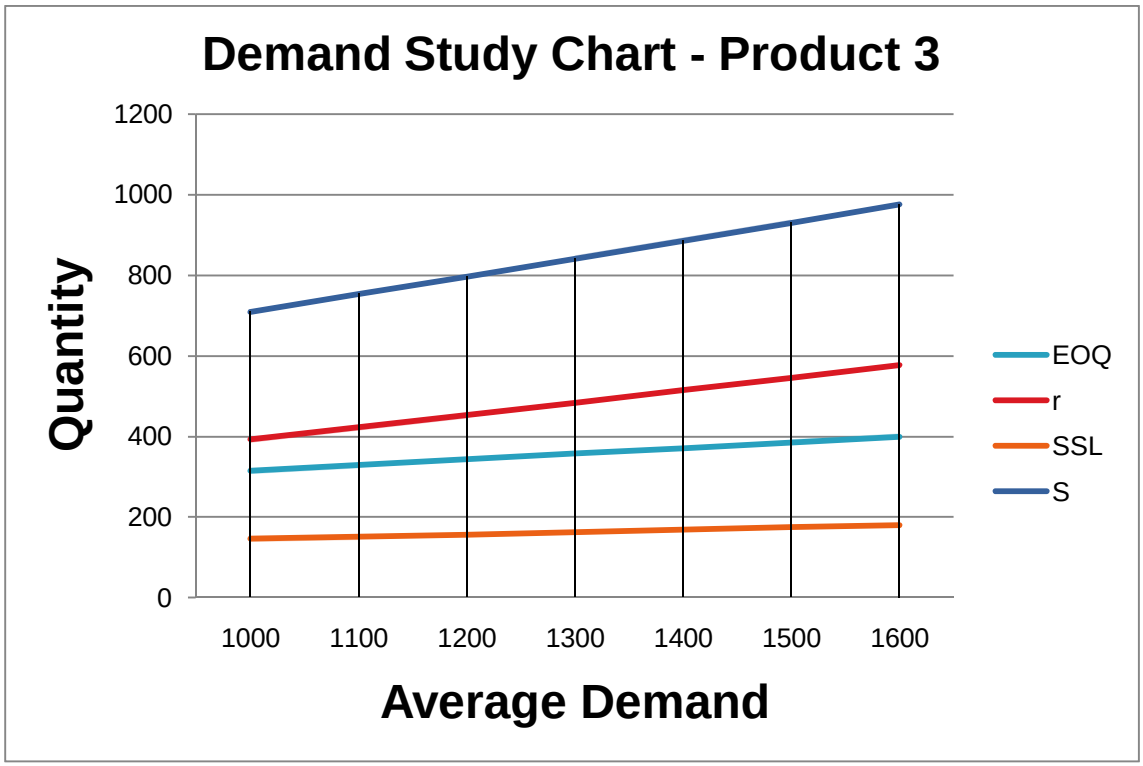
Variable	Value	Reduced Cost
D	689.4500	0.000000
SDD	110.8800	0.000000
H	37.28000	0.000000
SC	36.71000	0.000000
L	0.2500000	0.000000
K	1350.000	0.000000
SDL	0.5770000E-01	0.000000
MLD	172.3625	0.000000
SLD	68.23593	0.000000
ECOST	12195.56	0.000000
ORDERINGCOST	3625.539	0.000000
HOLDINGCOST	8316.928	0.000000
SHORTAGECOST	253.0971	0.000000
Q	256.7225	0.000000
R	267.0948	0.000000
SHORTAGES	2.567225	0.000000
SAFETYSTOCK	97.29955	0.000000
SLM	0.9900000	0.000000
Z	1.388306	0.000000
EOQCALC	223.4577	0.000000

Appendix D

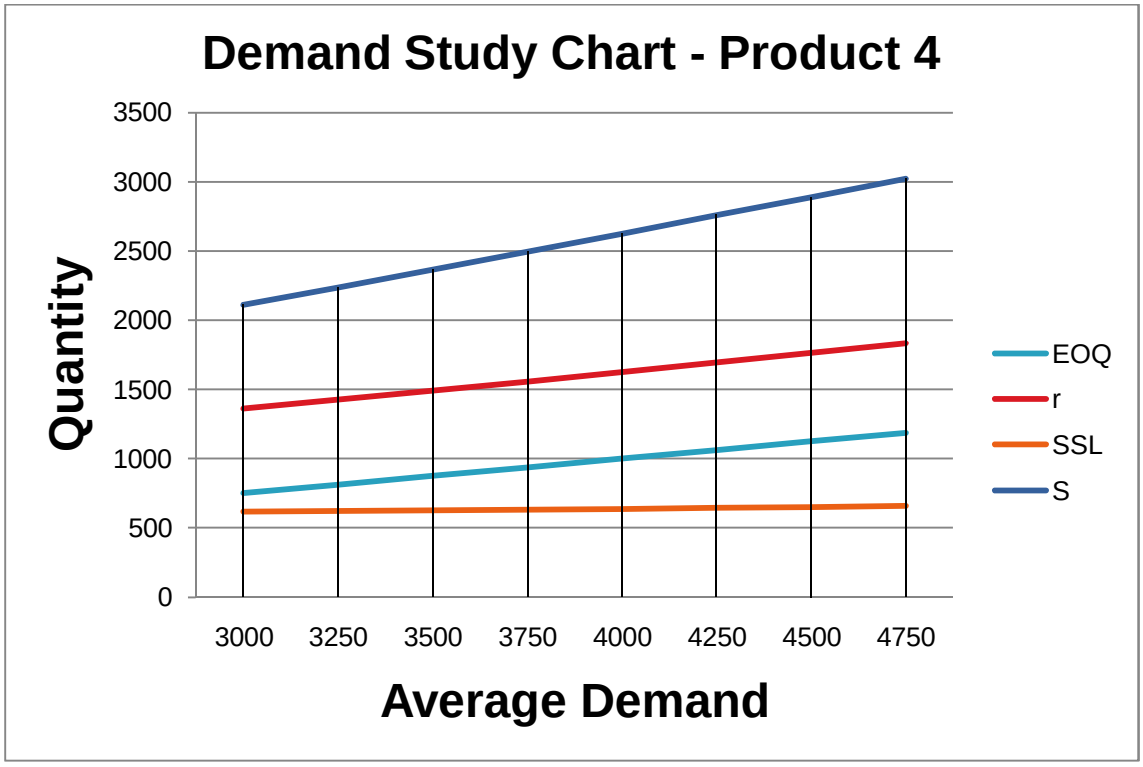
Product 2: Oxford Satin Stitch duvet Queen



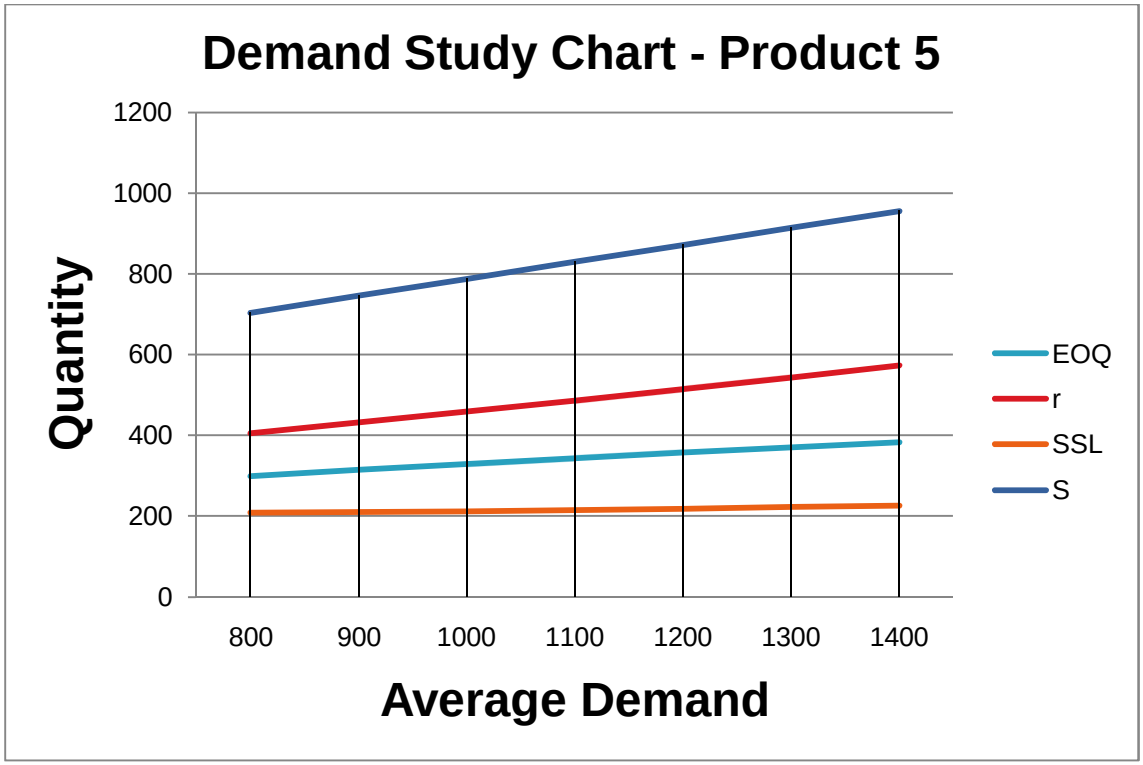
Product 3: Flat sheet Queen



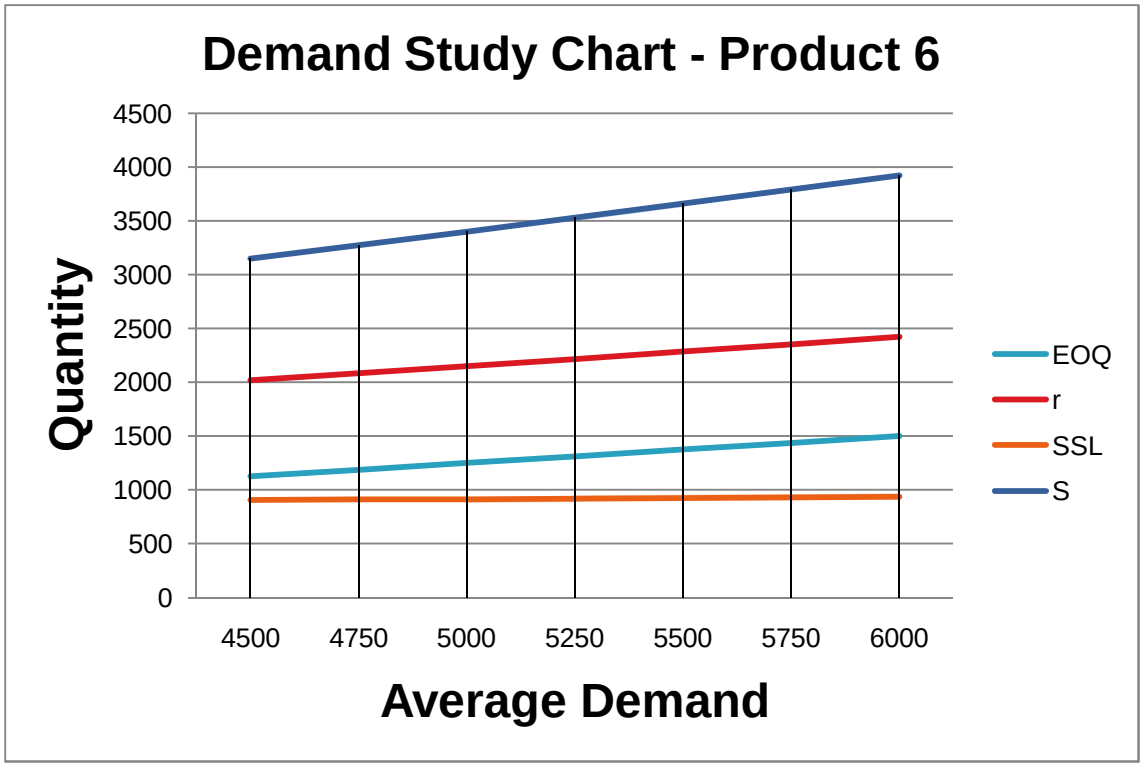
Product 4: Pillowcase Oxford Satin Stitch



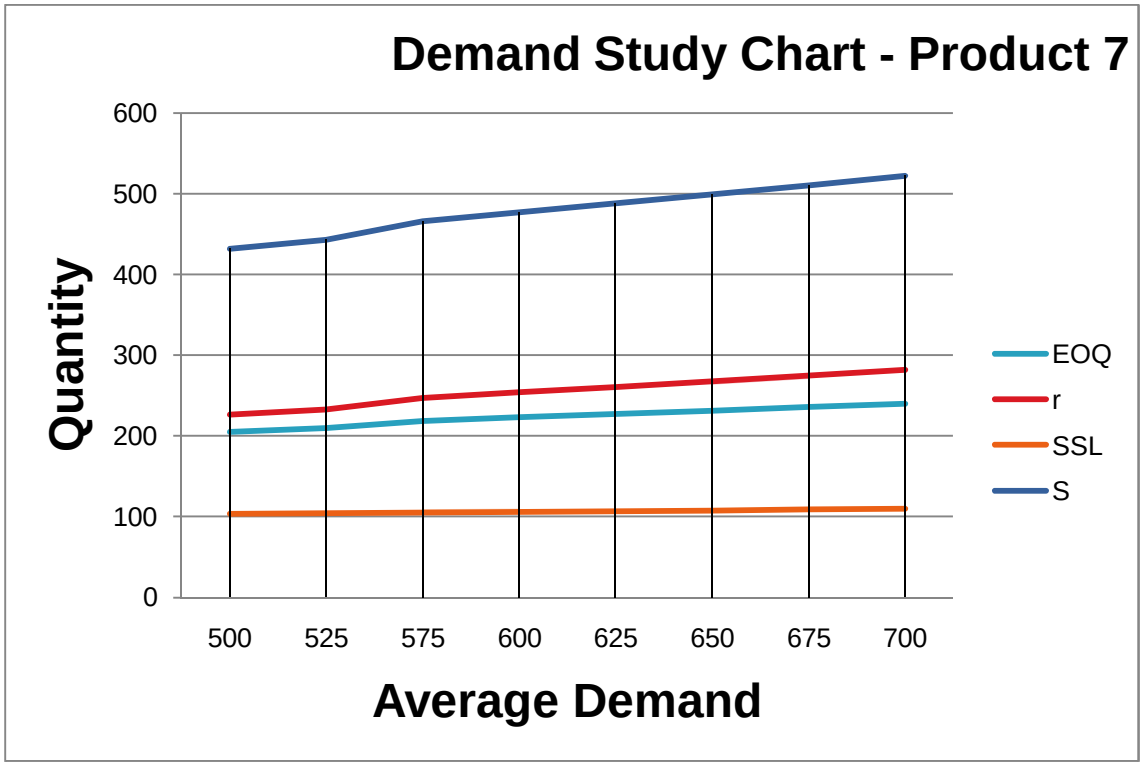
Product 5: Flat sheet King



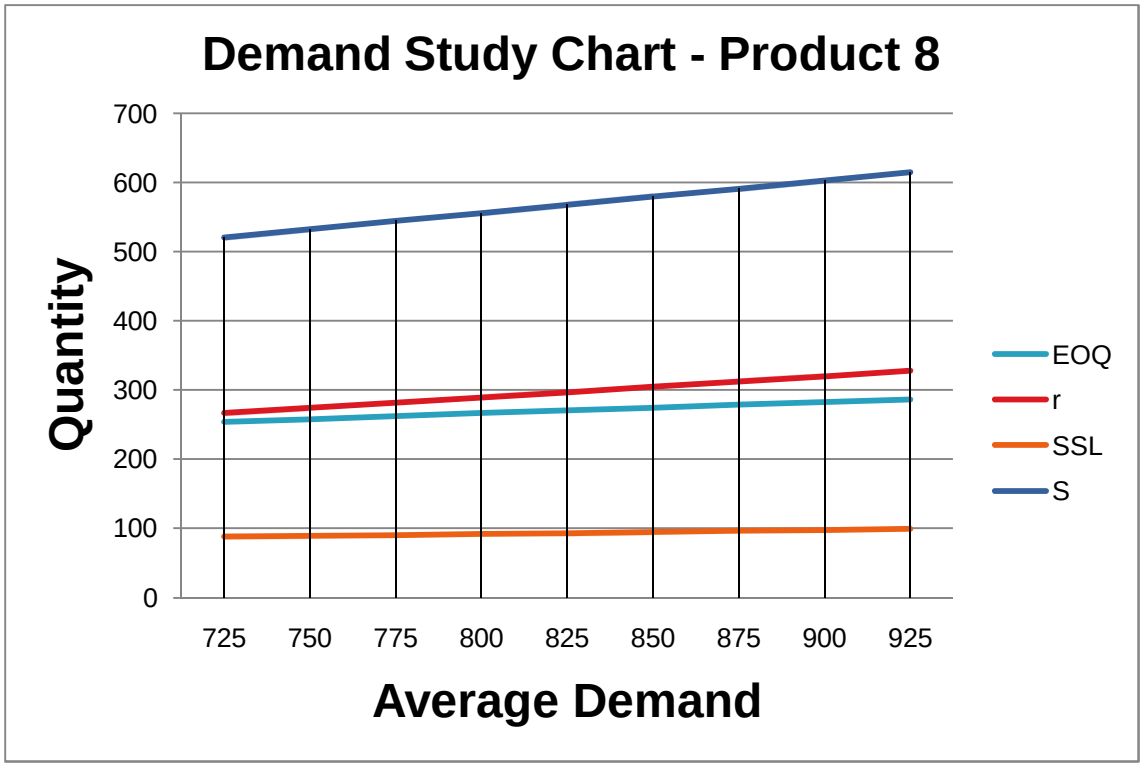
Product 6: Pillowcase Standard



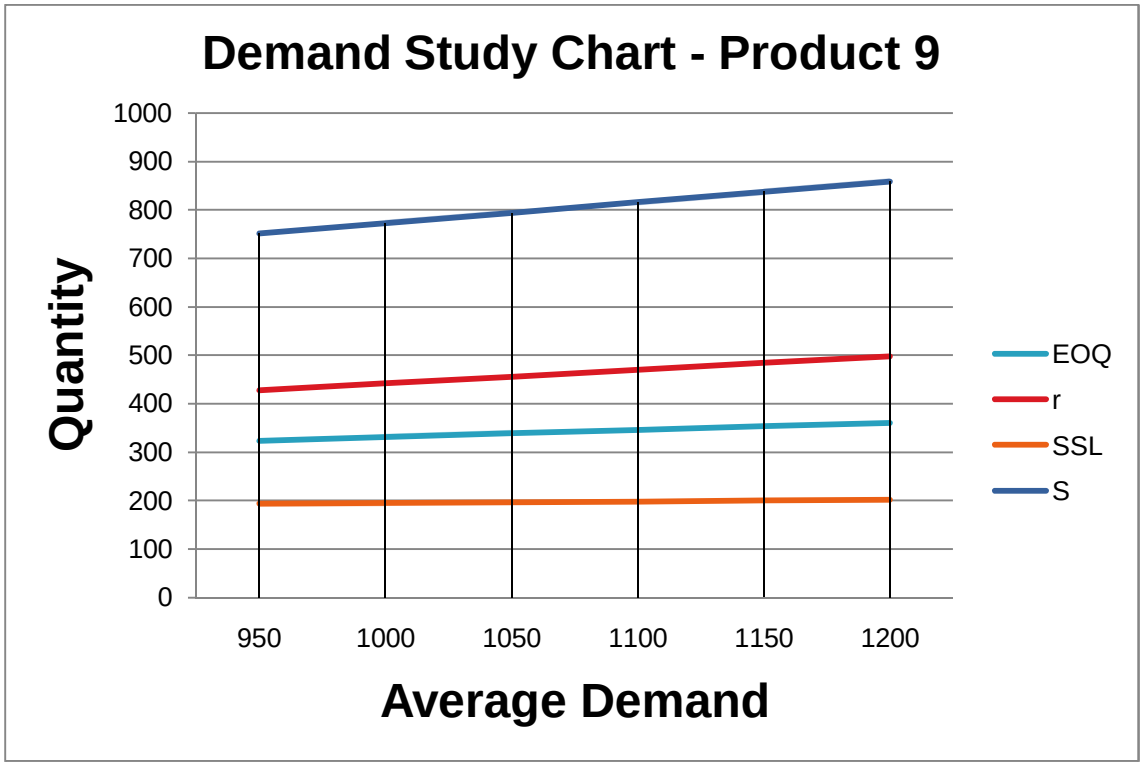
Product 7: Oxford Satin Stitch duvet 3 Quarter



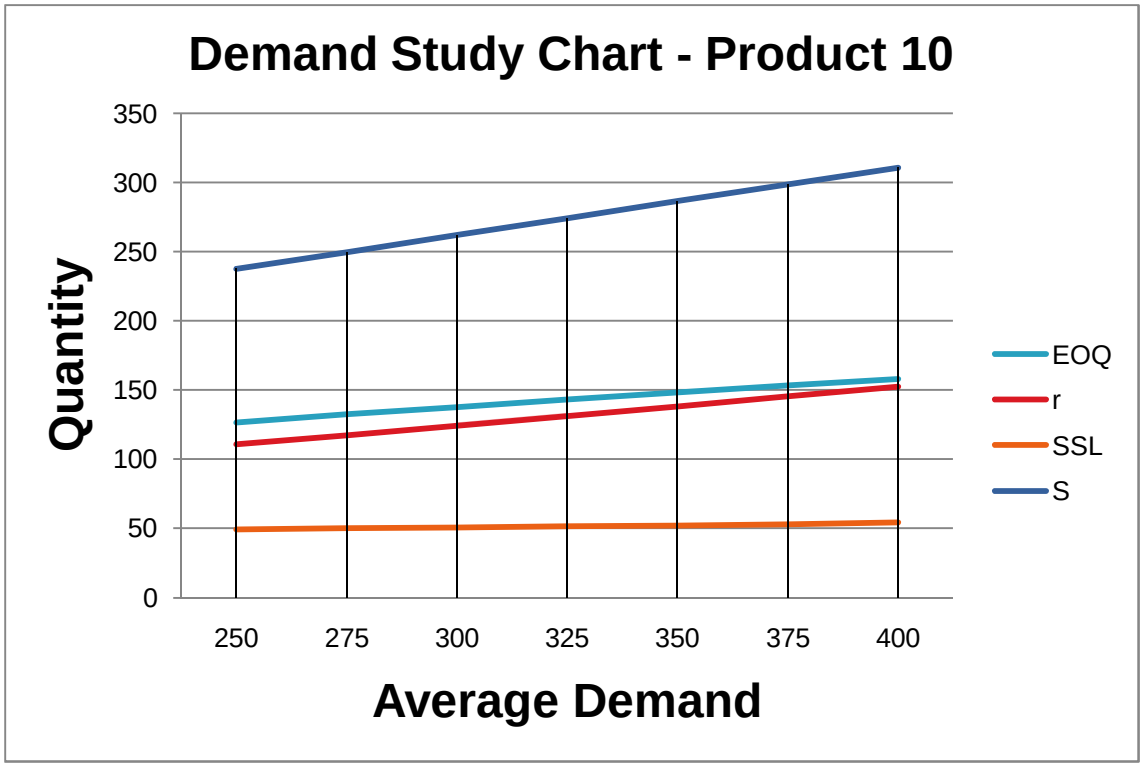
Product 8: Fitted sheet: XL XD King



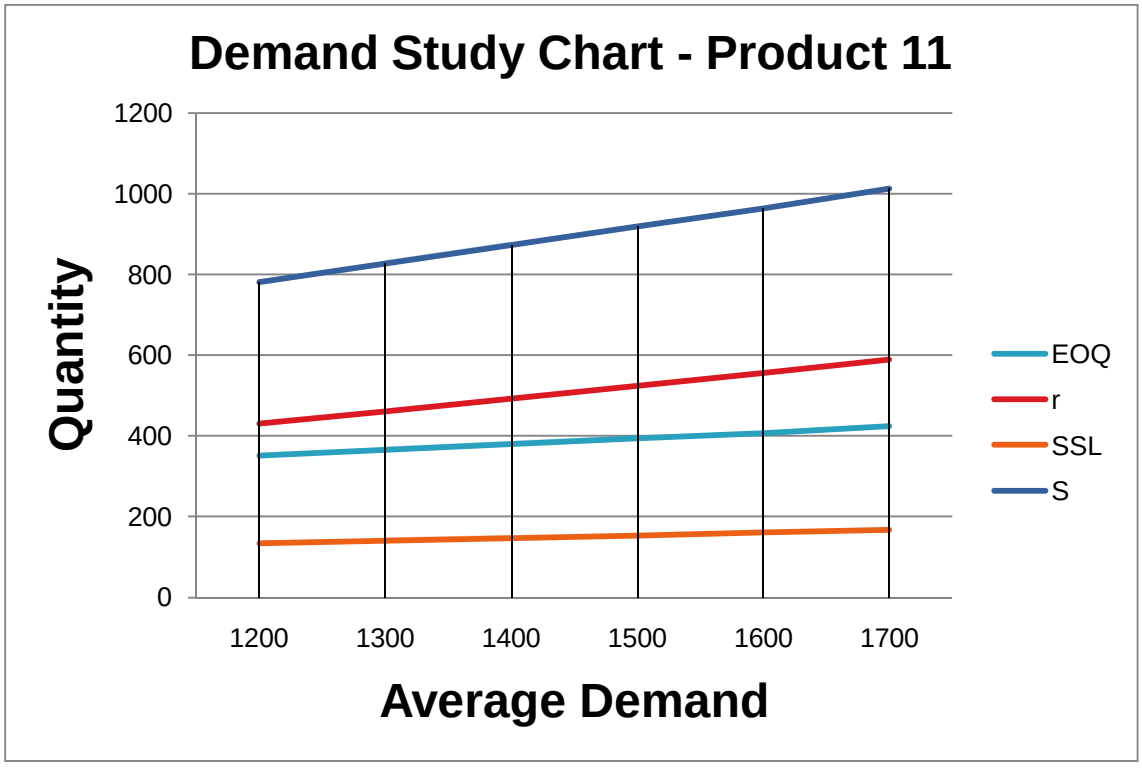
Product 9: Fitted sheets: Standard Queen



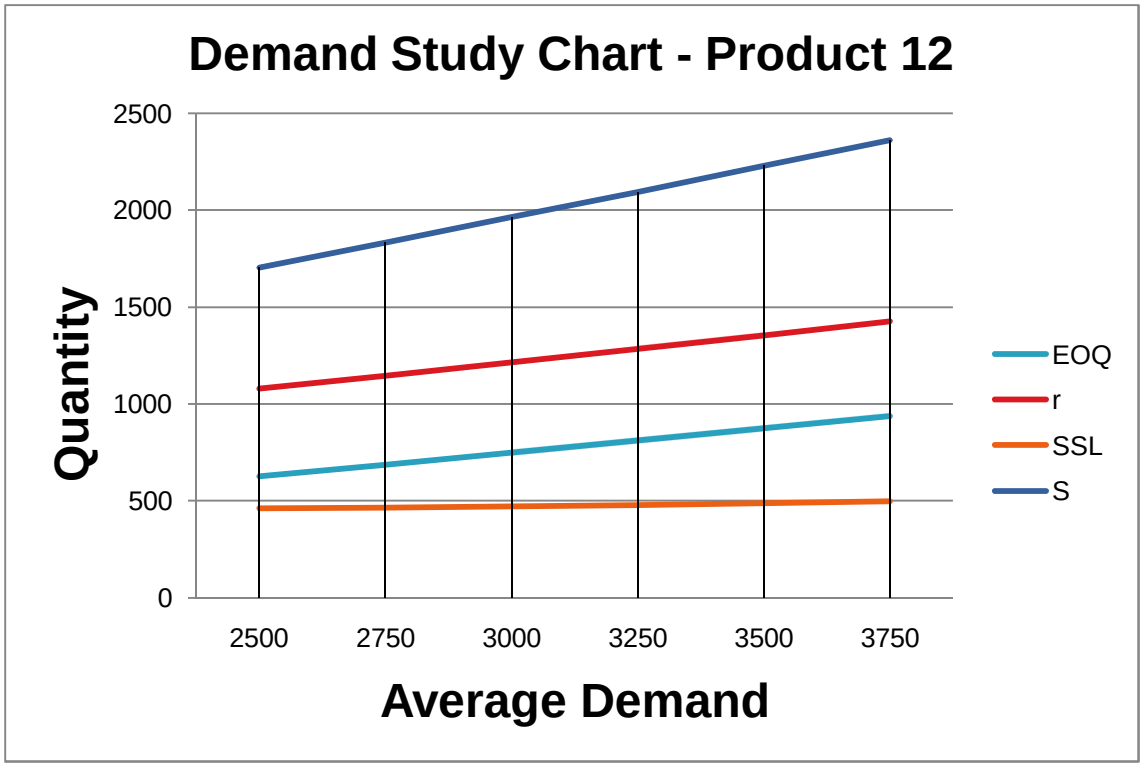
Product 10: Oxford Satin Stitch duvet S/King



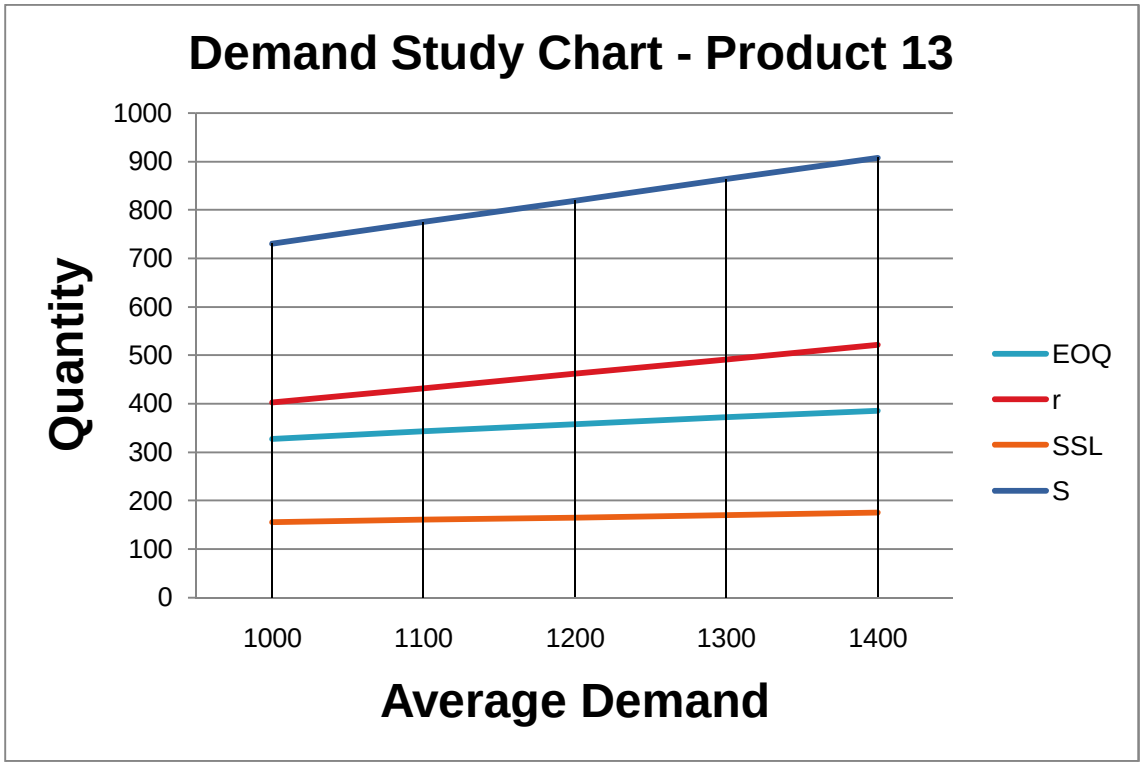
Product 11: Fitted sheets: Standard



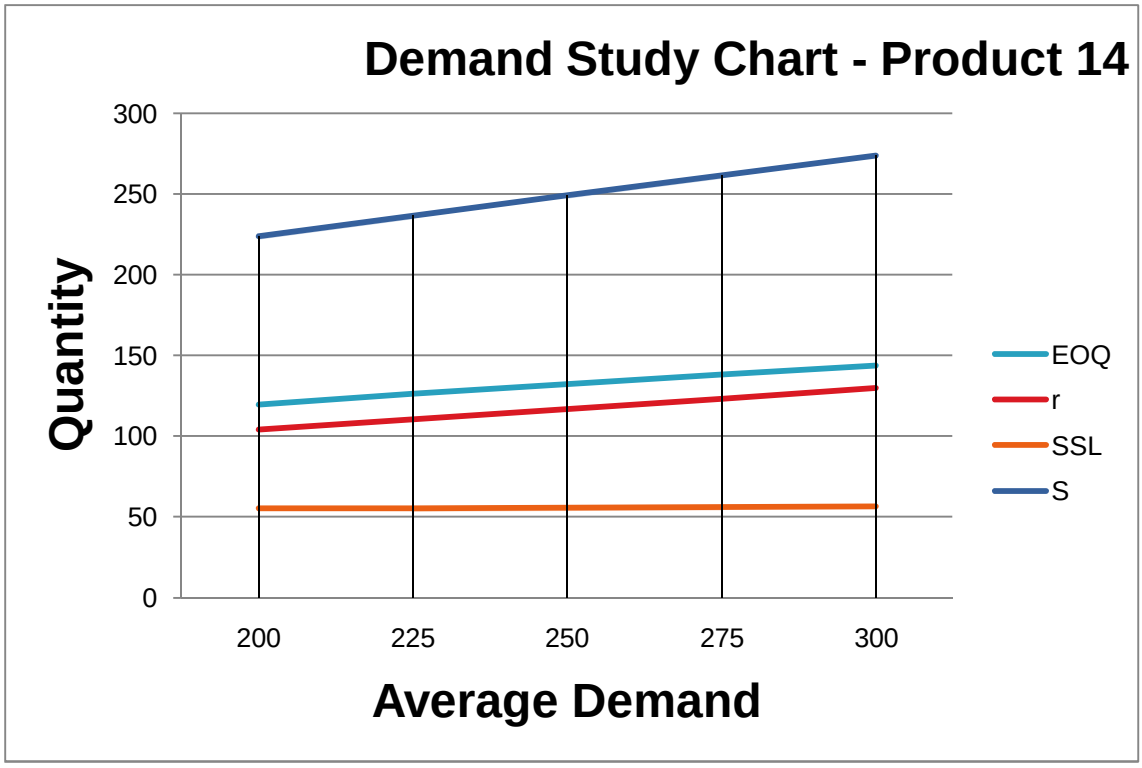
Product 12: Fitted sheets: Standard Single



Product 13: Pillowcase Oxford



Product 14: Flat sheet Single



Product 15: Oxford Satin Stitch duvet Double