Improvement of Inventory Management Policies

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IMPROVEMENT OF INVENTORY MANAGEMENT POLICIES

by

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PROJECT REPORT SUMMARY

IMPROVEMENT OF INVENTORY MANAGEMENT POLICIES

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A company's inventory is a current asset and consist of raw materials, work-in-process, items committed to maintenance, repair and operating and finished goods. Inventory is often the largest asset on a company's balance sheet and hence it is very important to manage the inventory effectively and efficiently.

This report consists of an inventory problem identified and solved at the company MineEquip. This was done by investigating literature relevant to the field of the inventory problem together with the use of industrial engineering principles, methods, tools and techniques. The focus of the inventory project is on item classification, sales analysis and inventory policies.

MineEquip is one of the many companies whose largest asset on its balance sheet is inventory. The Company also has large expenses related to financing and maintaining inventories. Furthermore MineEquip experiences problems from their supply and demand sides of their supply chain. The Company are subjected to a variety of lead times and a variation in the delivery times of their suppliers. On the demand side MineEquip experiences a variation in their demand and their customers, primarily mines, demand short delivery times. Therefore proficient inventory management policies that will enable the Company to manage their inventory at an optimal level have to be in place.

A study of the Company's sales data was conducted in order to determine the products that contribute the most to MineEquip's profit. These products were the project's focus and is branded as the Company's class A products. The results obtained from the sales analysis was used to estimate the demand of the class A products. MineEquip's financial system was studied in order to understand all the costs related to the Company's inventory.

The proposed inventory model is the basic economic order quantity model with lead times. The model was used to determine optimal order policies and safety stock levels and reorder points for all of the raw materials of which the class A products consist of.

The proposed order policy was validated by comparing the total cost per month of the proposed order policy to the current order policy. The results obtained predict that the proposed order policy will be more economical than the current order policy. It is also predicted that the proposed order policy will maintain the Company's current order fulfilment rate of 97.5%.

DECLARATION

I, the undersigned hereby declare that:

I understand what plagiarism is and I am aware of the University's policy in this regard;

The work contained in this report is my own original work;

I did not refer to work of current or previous students, lecture notes, handbooks or any other study material without proper referencing;

Where other people's work has been used this has been properly acknowledged and referenced;

I have not allowed anyone to copy any part of my report;

I have not previously in its entirety or in part submitted this report at any university for a degree.

SIGNATURE OF STUDENT:_______________

NAME OF STUDENT: Ziné van Reenen

STUDENT NUMBER: 28050208

DATE: 11 October 2011

Happy are those who dream dreams and

are ready to pay the price to make them come true.

–Leon J. Suenes

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I am thankful for all the employees at MineEquip, everyone was enthusiastic to contribute towards the success of my project. I am also very grateful for Me Lipawsky, the English teacher at Hoërskool Wagpos, who proof read all the documents for this final year project.

Table of Contents

List of Tables

List of Figures

List of Equations

1. Chapter 1 Introduction to the Inventory Project

1.1 Background and Overview

This project consists of finding a solution to the inventory problem identified at the company MineEquip.

MineEquip was established in 1928. The company produces mining products, fluid transfer equipment, hose connections, valves and snatch blocks. They also manufacture all kinds of light equipment, allied to the use of air and water in the mining and civil engineering fields. (Collins, 2010)

Today the Company's catalogue consists of 600 products of which the majority are available off-the-shelf products. Eighty five percent of the Company's imports of raw material are from China, the remaining fifteen percent of raw material are sourced locally. The Company's products are bought by mines throughout South Africa and they export their products to mines in Australia, Canada, Zimbabwe, Zambia, Mexico and the UK.

1.2 The Inventory Problem

Think about inventory as stacks of money sitting on ships, planes, in trucks while in transit and on forklift and shelves in warehouses. Inventory is exactly this - money. It is found that in most companies inventory is the largest, or among the largest, asset on the balance sheet of the financial statements. In most cases this inventory is not very liquid and thus it is preferred to keep inventory levels down as far as possible. (Jacobs, Chase and Aquilano, 2009)

MineEquip is one of the many companies whose largest asset on its balance sheet is inventory. This company has 49% of its capital tied up in stock. There are also expenses related to financing and maintaining inventories. The monthly expenses of raw materials, components and finished products add up to 80% of the company's total monthly expenses. Thus inventory costs the company a substantial amount of money.

These figures illustrate the importance of inventory and inventory management at MineEquip and raised the following questions among the top management of the Company. Is the inventory managed with the aim to obtain the optimal inventory level? Are effective and efficient inventory policies in place?

MineEquip experience problems from their supply and demand sides of their supply chain. The problems they are experiencing from their demand side are that mines do not inform MineEquip of their future need of mining equipment, orders are placed on demand and as the need arises. Nineteen nine percent of MineEquip's customers are mines, the remaining percent are individuals. This variation in the demand results in an uncertainty in the Company's products forecasts.

It is a modern trend among mines to not keep stock of additional mining equipment. Therefore mines demand their suppliers to deliver quickly when a need arises. MineEquip signs a contract with every mine that they supply equipment to. The average delivery time specified on the contracts is one week.

On the other side of the supply chain, MineEquip experiences a variation in the delivery times of their suppliers and therefore find it difficult to rely on their suppliers for punctual deliveries. The raw materials, which are mainly ordered from factories in China, have a lead time of three months. Therefore MineEquip has long lead times acquiring their raw materials while their customers demand short delivery times.

MineEquip has to manage their inventory extraordinarily well due to the external factors that influence the Company. It is very difficult for any company that has long lead times to keep their inventory levels low. The fact that MineEquip's customers demand short delivery times makes it even more difficult to keep low inventory levels. Consequently effective and efficient inventory management policies have to be in place in order to manage the Company's inventory at an optimal level.

1.3 The Aim of the Project

The objective of this project is to improve the inventory management policies, in line with management objectives, at MineEquip. This will be done by improving the ordering policy of the raw materials, which is responsible for the balance achieved between the investment made and the customer service. The aim right through this report is to reduce costs. The project's aim will be achieved by making use of industrial engineering principles, methods, tools and techniques.

1.4 The Project Scope

This project is about inventory control and the aim is to minimize inventory costs. The project's focus is on item classification, sales analysis, ordering policies and safety stock levels for the raw materials. The project concentrated on the products that contribute the most to MineEquip's revenue. The model was validated at the end of the project. The validation was done by comparing the proposed order policies to the current order policies.

The project deliverables is for MineEquip's unique circumstances, but the methods developed to determine these outputs are general.

1.5 The Project Deliverables

a) Literature review.

b) The class A items by making use of an item classification system.

c) Statistical analysis of the class A products' sales data in order to determine the nature of the demand.

d) Proposed ordering policies which will state the order quantity, re-order point and safety stock level for each raw material of the class A products.

1.6 Organization of the Report

The aim of the research report is to find a solution to MineEquip's inventory problem. The report starts by reviewing relevant literature which is followed by methods used and analysis conducted with the aim of converting the Company's data into useful information that contribute to achieve the aim of the project. Next the results obtained from the analysis conducted are presented. The proposed results are validated and conclusions are drawn and recommendations made.

The research report consists of the following chapters:

- Chapter 1 presents an introduction of the project, states the inventory problem, the aim in order to obtain the solution and the scope which within the project will be conducted.

- Chapter 2 investigates literature relevant to the field of the inventory problem identified.

- Chapter 3 describes the methods, tools and techniques used to obtain the data that is used in this project and presents the theoretical and data analysis conducted.

- Chapter 4 presents the results obtained through the theoretical and data analysis.

- Chapter 5 describes the validation of the proposed results.

- Chapter 6 presents the conclusions drawn from the project and states the recommendations made based on the findings.

2 Chapter 2 Literature Review

In this Chapter the terms inventory, inventory system, inventory control, inventory policies and the four types of inventory are clarified. Followed by a number of reasons for why companies keep inventory.

Forecasting plays a very important role in inventory control for it is the initiation of an order, thus a brief overview of forecasting are presented. This will be followed by an investigation of the problems companies experience with the control of their inventory. At the end of this chapter appropriate methods, tools and techniques for inventory control are presented.

2.1 Inventory Terms Classified

Jacobs *et al*. (2009;547) states that "Inventory is the stock of any item or resource used in an organization." These authors define an inventory system, in the same book, as a system that comprises of the set of controls and policies that monitor inventory levels and determine the optimal levels that should be maintained.

Inventory Control is defined by the online business dictionary as management of the delivery, availability, and utilization of a company's inventory in order to ensure sufficient supplies while at the same time minimizing inventory costs.

Inventory policies set basic principles and associated guidelines on the movement of inventory under the company's control. The two most important features established by an inventory policy are, when an order should be made, also known as the re-order point, and the quantity that has to be ordered.

Heizer and Render (2001) classifies inventory of a firm into four types:

- Raw material inventory. This type of inventory is at the command of the firm. The objective of maintaining these items is to eliminate supplier variability in quality, quantity or delivery time.

- Work-in-process inventory. This inventory is processed inside the firm. Although these items are not in their final state, changes were made to them.
- Inventories which are committed to maintenance, repair and operating. The motive of keeping these inventories is to assure continuous running of plants, devices etc.
- Finished goods inventory. These are the completed products that are ready to be sold. They are kept because future demand is unknown.

2.2 Reasons for Keeping Inventory

Jacobs *et al*. (2009) any company keeps a supply of inventory for the following reasons:

- To maintain independence of operations.
- To meet variation in product demand.
- To allow flexibility in production scheduling.
- To provide a safeguard for variation in raw material delivery time.
- To take advantage of economic purchase order size.

2.3 Forecasting

Arsham (2011) states that it is important to understand the interaction between forecasting and inventory control, because this interface influences the performance of the inventory system.

One must keep in mind that a perfect forecast is generally impossible. There are too many factors in the business environment that cannot be predicted with certainty. Thus it is important to establish the practice of continual review of forecasts and to live with inaccurate forecasts.

Everyone makes forecasting mistakes, even those especially known for their intelligence and great success. Bill Gates, CEO of Microsoft made a forecast mistake in 1991. Bill Gates said: "640K (of memory) ought to be enough for anybody." Today an average computer consists of at least 320 gigabytes.

Forecasting future events to make good decisions is a common problem among companies. Forecasting is the basis of corporate long-run planning. In finance and accounting departments forecast is the basis of budgetary planning and cost control. Sales forecasts are used in marketing to plan for new products, compensate and make other important decisions. Forecasts are also used by production and operations personnel to make periodic decisions regarding process selection, capacity planning and facility layout and continual decisions about production planning, scheduling and inventory. (Jacobs *et al*. 2009)

There are a wide range of forecasting techniques available. The time period for which the forecast are made and the availability of information both have an influence on the forecast being made. The four major categories of forecasting are qualitative and judgemental techniques, statistical time-series analysis, explanatory or casual methods and simulation models. (Jacobs *et al*. 2009)

2.4 The Problem of Inventory Control

2.4.1 Inventory Control Models

The following, according to Dear (1990), are the major problems of inventory control:

Characteristics of good stock control are that the system is logical, objective and not subject to erratic input under the disguise of market knowledge. In practice stock control is often found to be just the opposite. The stock control system is more often than not; illogical, subjective and subject to erratic input under the disguise of market knowledge.

Sensible ordering on an item-by-item basis may result in an undesirable bigger picture.

Inventory problems are more likely to be derived from slight bias over a long period of time than from obvious large mistakes in ordering.

Three types of common inventory control problems according to Dear (1990):

1. Formal rules are poorly defined or non-existent.
2. The system incorporates a formal set of rules, for example:
   - Exponential smoothing.
   - Desired level approach to setting safety stocks.
   - Economic order quantity calculation.

   In practice these rules are not closely followed and the suggestions are changed by more than 15%. Thus problems exist concerning the rules or the person doing the ordering.
3. The system consists of an over simplistic set of clearly defined rules, for example:
   - Simple moving averages.
   - Safety stock in 'weeks' or units.
   - Order quantity in 'weeks' or units.

   All three of the above problems are created due to an inability to determine the control of an inventory in a systematic and detailed manner.

2.4.2 Balancing Cost and Customer Service Requirements

One of the concerns regarding inventory decisions is the relationship between cost and customer service level. Figure 1 illustrates the common relationship between inventory cost and customer service levels. From this figure it is obvious that as investments made in inventory increases, it may result in higher customer service levels. While this relationship is valid a great need exist to identify solutions that will yield high levels of customer service together with reduced inventory investments.

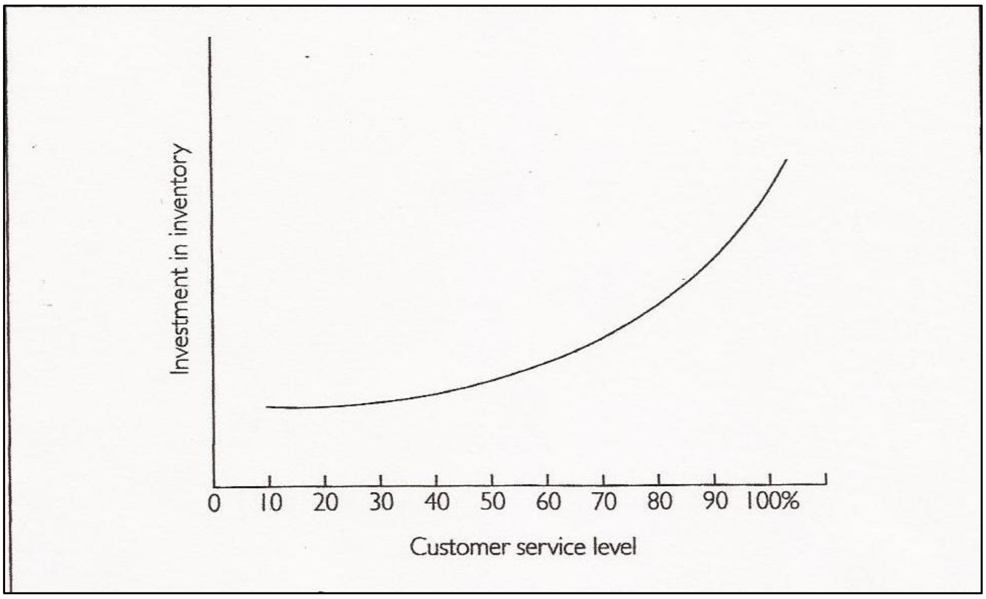

Figure 1: Relationship between Inventory and Customer Service Level.
Langley et al. (2008, p.349)

2.5 Appropriate Methods, Tools and Techniques for Inventory Control

According to Dear (1990), effective inventory control is applied common sense, although it has to be based on some knowledge of the available literature.

A wide variety of methods, tools, techniques and theories exist regarding inventory control. The 1950`s was the golden age of inventory control research, as described by Jaber (2009), when conceptual and mathematical inventory models were formulated for the first time. The following were all great contributors to the field of inventory control; Whitin (1957) had a classic conceptualization of inventory management. Operations research also contributed to theoretical clarification of inventory management for example the classic article of Ackoff (1956). Important contributors from Stanford University on conceptualization and mathematical formulation of inventory control was Arrow, Karlin and Scarf in 1958 and Scarf, Gilford and Shelley in 1963.

Through the use of literature relevant to inventory control a number of different methods, tools, techniques and theories were studied and will be discussed next.

2.5.1 Inventory Classification System

An inventory classification system is used to facilitate managing a large number of items effectively. Many different inventory classification systems exist. ABC analysis is a classification system that is well known and widely used. The classical ABC classification is based on a single criterion. There are a great variety of techniques available that are derived from the ABC analysis. These techniques make use of multi-criteria inventory classification. In practice there are a number of factors that can play a role in inventory management and therefore multi-criteria classification should be considered.

The Classical ABC Classification System

The ABC analysis created by Dickie (1951) is based upon the Pareto principle. This approach, as described by Chen (2011), classifies items into three groups, class A, B and C, based on a single criterion. The objective of this system is to identify the small number of items that accounts for most of the profit. This will typically be the class A items. The class A items are the most important ones to manage for effective inventory management. Items that represent a small contribution to the profit, but are large in numbers are the typical class C items. Class B items are those items that behave between classes A and C.

Figure 2 illustrates an example of how ABC analysis is applied at a company. In this example 20% of the product line's items are class A items and they account for 80% of the total sales. Class B items take up 50% of the total items and contribute to 15% of the total sales. From the total amount of items, 30% are Class C items and they account only for 5% of the total sales.

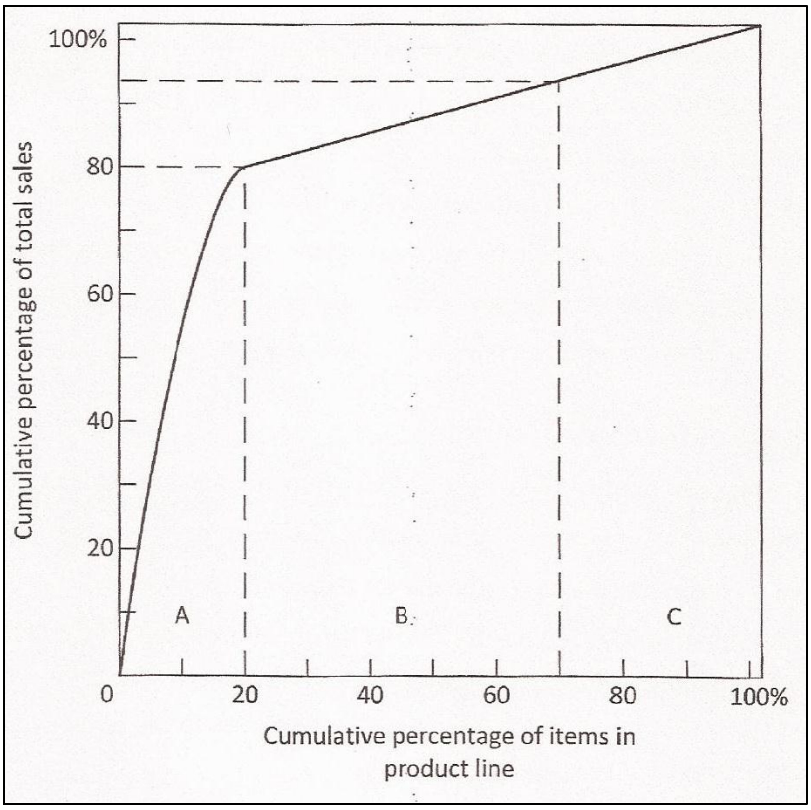

Figure 2: ABC Inventory Analysis. Coyle *et al*. (2003, p.209)

Multi-criteria Inventory Classification

Chen (2011) lists the following factors that can be important for inventory classification; Annual use value, average unit cost, lead time, part criticality, substitutability, durability, demand distribution, etc. In an environment where more than one of these factors should be taken into account, a multi-criteria classification system should be used.

(Chen, 2011) Among the methodologies that contributed to multi-criteria inventory classification are genetic algorithm (Erel & Guvenir, 1998), the artificial neural network (ANN) (Anandarajan & Partovi, 2002), the joint criteria matrix (Flores & Whybark, 1987), the clustering procedure (Cohen & Ernst, 1988; 1990), the analytic hierarchy process (Burton & Partovi, 1993; Flores et al., 1992; Hopton & Partovi, 1994), the fuzzy set theory (Puente et al, 2002), the principal component analysis (PCA) (Lei, 2005), the distance-based multi-criteria consensus framework with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model (Bhattacharya, 2007), the fuzzy AHP (Cakir & Canbolat, 2008), the case-based distance model (Chen, 2008), the particle swarm optimization method (Tsai & Yeh, 2008), the ABC-fuzzy classification method (Chu, 2008), the rule-based inference system (Dowlatshahi & Rezaei, 2010), the weighted linear optimization (Fan & Zhou, 2007; Hadi-Vencheh, 2010; Ng, 2007; Ramanathan, 2006) , etc.

2.5.2 Overview of Inventory Control Models

Numerous inventory control models are available in literature. In a broad sense inventory models can be categorized into three categories; analytic, simulation and conceptual models. In a more detailed sense there are many types of models found within these three categories. There are also a great variety of models derived from the classical models.

The three categories with examples of the respective models found within them.

1. Analytic Models

For example: DEL, EOQ, News Vendor Problem, etc.

2. Simulation Models

For example: Monte Carlo Simulation, etc.

3. Conceptual Models

For example: Lean Manufacturing, Theory of Constraints, Just-in-Time, etc.

Models such as Dynamic Programming, Linear Optimization and Game Theory can be solved analytically or with the aid of simulation, depending on the nature of the problem. Simulation models are very useful when an inventory problem cannot be solved analytically.

Figure 3 provides a brief overview of the type of models used for inventory analysis and how these models are applied in accordance with the nature of demand. In this figure the models are categorised according to their respective nature of demand over time and certainty of demand.

Demand over Time	Certainty of Demand: Known Deterministic	Certainty of Demand: Not Known Random
Varies	Analytic Models DEL	Simulation Models Monte Carlo Simulation
Constant	Analytic Models EOQ	Analytic Models News Vendor Problem Markov Chains

Figure 3: Inventory Models Categorised According to the Dynamics of Demand.

Inventory models are classified into Single-period or Multiple-period inventory models. Jacobs *et al*. (2009) explains the two inventory models as follows. A Single-period system is the decision of a one-time purchasing decision and the purchase is intended to cover a fixed period of time. The item will also not be re-ordered in this type of system. A Multiple-period system is a decision that involves an item that will be purchased periodically. In this situation inventory should be kept in stock in order to be used on demand.

The classical Newsvendor Problem is an example of a Single-period inventory model.

According to Winston (2004) a news vendor problem is identified when an inventory problem follows the following sequence of events:

1. The organization decides how many units to order. We let q be the number of units ordered.

2. With probability p(d), a demand of d units occurs. In this section, we assume that d must be a non negative integer. We let D be the random variable representing demand.

3. Depending on d and q, a cost (d,q) is incurred.

The logic of the News Vendor Problem can be explained through the following scenario. A vendor has to decide on the amount of newspapers that he should order, on a daily basis, from the newspaper plant. If the vendor orders too many newspapers he would have a surplus of valueless newspapers at the end of the day. Alternatively if the vendor orders too few newspapers he will lose profit that could have been earned if he ordered enough newspapers to meet demand. Thus the news vendor has to order the number of news papers that would balance these costs accurately.

Multiple-period inventory models can be divided into two general types: Fixed-order quantity models and Fixed-time period models. See Figure 4 and Figure 5 respectively. The main difference between these two types is that Fixed-order quantity models are "event triggered" where Fixed-time period models are "time triggered".

The following models are examples of Multiple-period Probabilistic Inventory Models:

- EOQ with Uncertain Demand: (r, q) and (s, S) Models
- EOQ with Uncertain Demand: The Service Level Approach to Determining Safety Stock Level.
- (R, S) Periodic Review Policy.

Fixed-order quantity models are also known as Continuous Review models or Two-level systems, and Fixed-time period models are also recognised as Periodic Review models or a One-level inventory systems.

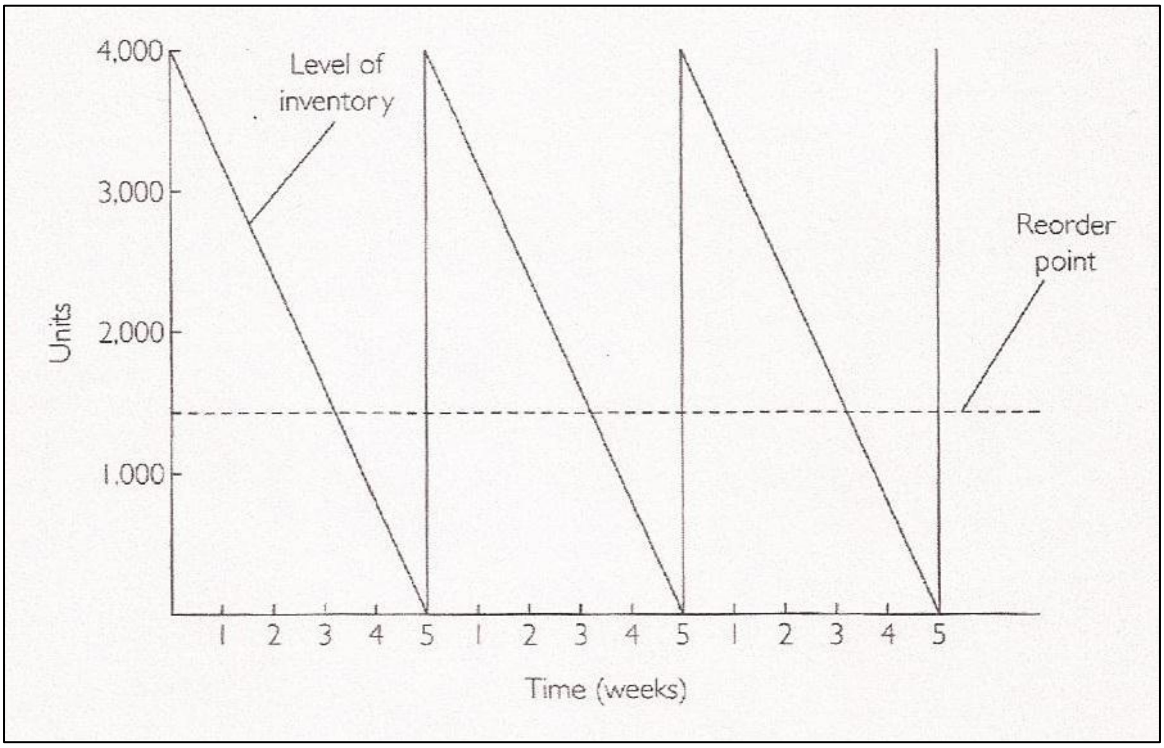

Figure 4: Fixed-order Quantity Model under the Condition of Certainty.
Langley et al. (2008, p.354)

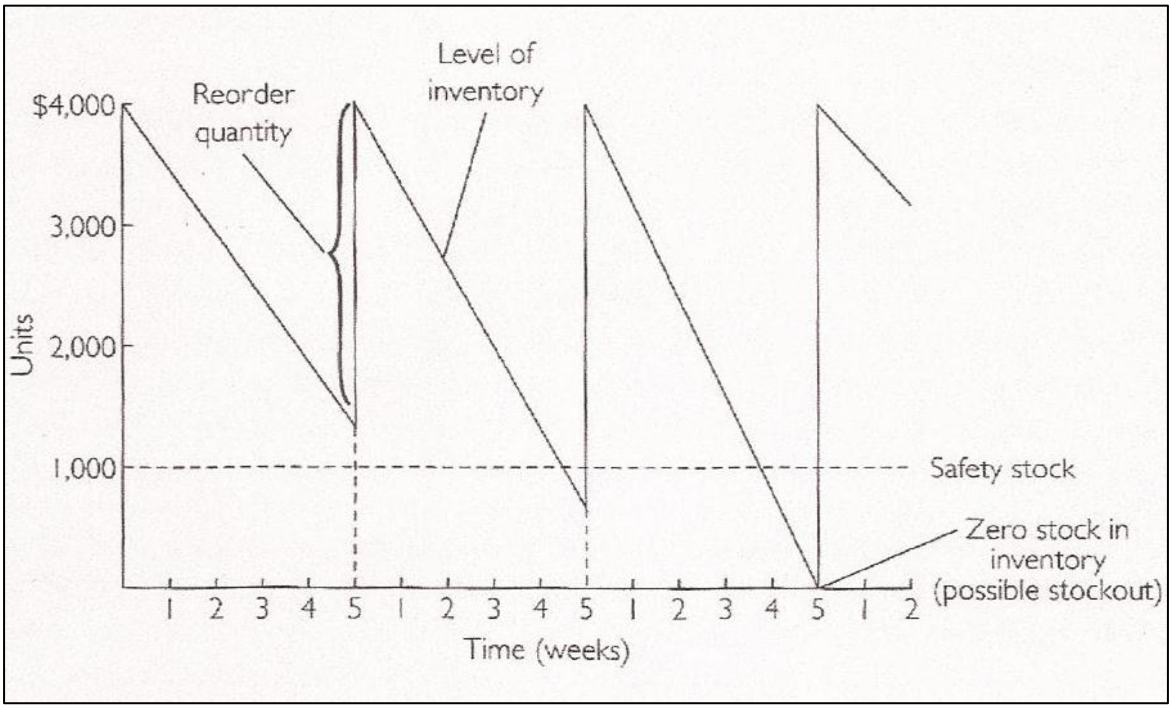

Figure 5: Fixed-time Period Model with Safety Stock. Langley et al. (2008, p.371)

Some of the inventory control models mentioned above will now be discussed in more detail.

2.5.3 Discussion of Inventory Control Models

Monte Carlo Simulation

This decision model consists of generating random values for uncertain inputs in order to compute the output variables of interest. This process is repeated for many trials in order to understand the distribution of the output results. (Evans, 2010)

The paper of Zabawa and Mielczarek (2007) explains how a simulation model of supply chain can be built and describes the implementation by making use of general purpose tool and the simulation package. This was done by taking the output of Monte Carlo experiments from spreadsheet formulas in Microsoft Excel as well as from the software graphical environment. These sources were revised and then the model was used to discover the minimal inventory cost.

Cooperative Game Theory and Inventory Management

According to Fiestras-Janeiro et al (2010) in today's era, globalization of markets dominate business decisions. Therefore business decisions have to take the increasing competition between firms into consideration. Only at the end of a long supply chain, that is composed of many independent firms, do products reach the end customer. Thus research in supply chain has reallocated its focus from single-firm to multi-firm analysis. These chains consist of firms that are independent actors with the goal of optimizing their individual objectives. The decision made by a firm in a supply chain has an effect on the performance of the other parties in this supply chain. The interactions between the firms' decisions which requires alignment and coordination of actions are the reason why game theory is well suited for this problem.

For example; a number of companies face EOQ problems and choose to coordinate by placing joint orders and storing the products in the most economical storehouse of the group.

Game theory could be applied to non-cooperation or cooperation in a deterministic or stochastic inventory state.

In a cooperation deterministic inventory state, when a number of firms face the same inventory problems, it is possible that savings could be made if they cooperate. After a saving is made the question arises of how should this savings be distributed among these firms?

In a cooperation stochastic inventory state, where optimization is conducted, the savings are distributed in non-deterministic centralized inventory systems. Most of the studies performed in this field are based on news-vendor type problems.

Periodic Review Inventory Control Policies

Drake & Marley (2010) illustrates the concept of the review interval for the periodic review system.

The Continuous Review system is when an organisation continuously examines its inventory levels. As soon as the inventory level falls below a predetermined reorder point an order for a fixed quantity is placed. Thus orders are reliant on the actual demand and can be placed at any time.

In a Periodic Review system an organisation examines their inventory levels on a cyclic basis or establishes a constant order and delivery rate with their suppliers. Thus this policy entails a person to monitor the current inventory level at a consistent point and to place an order to return the current inventory level to a predetermined order-up-to level. This predetermined order-up-to level is also known as the Target Inventory Level.

Advantages of the Periodic Review system are that it can be easily managed and coordinated. This policy also benefits from its low ordering and transportation costs. The disadvantages of this policy is the long time period and thus increased inventory necessary to protect the company against stock outs.

The desired order-up-to level is specially formulated to cover the demand for the product over the protection interval. The protection interval is the time period of the sum of the order lead time (L) plus the length of the review period (P). This protection interval, computed as (P+L) is the time period that a company has to rely on its safety stock to protect the company against stock outs.

The importance of using the review period as (P+L) could be demonstrated with Simulation in Crystal Ball.

Dynamic Economic Lot-size Models

According to Winston (2004) Wagner and Whitin developed a method in 1958 that simplifies the calculation of optimal production schedules for dynamic lot-size models.

This dynamic lot-size model is described as:

1. Demand d_t during period *t*(t = 1,2....,T) is known at the beginning of period 1.

2. Demand for period *t* must be met on time from inventory or from period *t* production.

   The cost c(x) of producing x units during any period is given by

   c(0) = 0, and for x > 0, c(x) = K + cx, where K is a fixed cost for setting up production during a period, and c is the variable per-unit cost of production.

3. At the end of period *t*, the inventory level i_t is observed, and a holding cost hi_t is incurred. We let i_0 denote the inventory level before period 1 production occurs.

4. The goal is to determine a production level x_i for each period *t* that minimizes the total cost of meeting (on time) the demands for periods 1,2,....,T.

5. There is a limit c_t placed on period *t*'s ending inventory.

6. There is a limit r_t placed on period *t*'s production.

The Silver-Meal (S-M) heuristic can be used to find a near-optimal production schedule and is even less effort than the Wagner-Whitin algorithm. The objective of the S-M heuristic is to minimize average cost per period. For the reason stated, variable production costs may be ignored.

Economic Ordering Quantity Models

The Economic Order Quantity (EOQ) is the order quantity that minimizes holding and ordering costs, also known as total variable costs of inventory. EOQ provides the optimal quantity that a firm can order every time, when replenishing their stock.

F. W. Harris presented the famous economic ordering quantity (EOQ) formula in 1913, ever since a great interest aroused in the study of economic lot size models.

According to Harris the following assumptions had to be made in order to make successful use of the basic EOQ model:

1. The inventory system is based on a single item which operates over an infinite planning horizon.
2. The rate of demand is a known constant, demand is D ($D > 0$).
3. The inventory is continuously revised.
4. The ordering cost is fixed regardless of the lot size, ordering cost is K ($K > 0$).
5. The holding cost is a linear function of the average inventory, holding cost is h. ($h > 0$).
6. The lot size per cycle is an unknown constant and it is the decision variable, lot size per cycle or ordering quantity is q ($q > 0$).
7. Shortages are not allowed.

The objective of the basic EOQ model is to minimize the sum of the ordering and the inventory holding cost where C(q) is the cost obtained at an order quantity of q, $q > 0$.

The ordering cost and inventory holding cost equation is:

$$\text{Minimize } C(q) = \frac{KD}{q} + \frac{hq}{2} \qquad \text{[Equation 2.1]}$$

The optimal solution known as the optimal order quantity is given by the expression:

$$q = \sqrt{\frac{2KD}{h}} \quad \text{[Equation 2.2]}$$

Figure 6 illustrates the trade-off between holding cost and ordering cost. This figure confirms that the order quantity is at the optimum where total cost is at a minimum and this is at the point where annual carrying cost is equal to annual ordering cost.

The total annual cost (TC) is the annual purchase cost plus the annual ordering/setup cost plus the annual holding cost:

$$TC = pD + \frac{KD}{q} + \frac{hq}{2} \quad \text{[Equation 2.3]}$$

The time dimension used in Equation 2.3 could be days, months or years as long as it is used consistently throughout the equation.

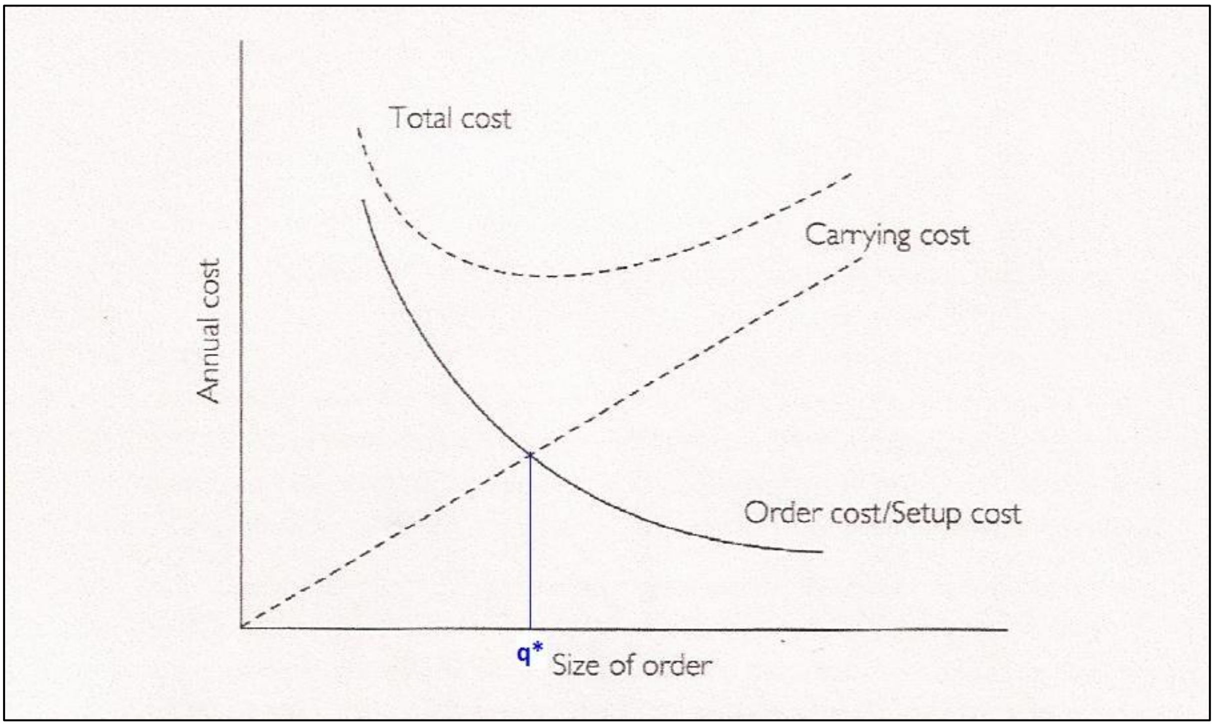

Figure 6: Illustration of the Optimum Q in Total Cost Terms. Langley et al. (2008, p.360)

Numerous models are derived from the basic EOQ model, for example the continuous rate EOQ model, EOQ model with back orders allowed, multiple-product EOQ models, quantity discount EOQ models and EOQ with periodic setup costs etc.

A more in depth look at the basic EOQ with lead time and how EOQ models are applied to integer lot sizes, uncertain demand with a service level approach, and a demand shift will follow.

The Basic EOQ Model with Lead Time

The basic EOQ model assumes that demand is known and is a constant. In practice it is more often than not found that demand is not constant but rather varies over time. Under these circumstances a preventative measure, known as safety stock, is taken in order to reduce the risk of a stock out. According to Jacobs et al (2009) safety stock is the full amount of inventory carried additionally to the normal demand.

The amount of safety stock kept is not the amount of units ordered extra each time an order is placed. The company will still order according to the economic order quantity, but the delivery of stock would be particularly scheduled so that it is expected to have only the amount of safety stock in inventory when the new order arrives.

There are a variety of different methods available to establish safety stock levels. One of the common approaches to setting safety stock levels is the Probability Approach. This approach assumes that the demand is normally distributed over a certain period of time with a mean and a standard deviation (Jacobs et al, 2009). The level of safety stock maintained depends on the service level required.

The basic EOQ model with lead time as defined by Jacobs et al. (2009).

The following variables are defined for this model:

t = Cycle time in days.

$\bar{d}$ = Average daily demand.

L = Lead time in days.

L_{eff} = Lead effective time.

R = Reorder point in units.

z = Number of standard deviations for the service level required.

σ_L = Standard deviation of usage during lead time.

The safety stock level is given by the expression:

$$SS = z\sigma L$$ [Equation 2.4]

The order cycle time is calculated by the following equation:

$$t = \frac{q}{D}$$ [Equation 2.5]

The lead time effective is determined by the equation:

$$L_{eff} = L \bmod t$$ [Equation 2.6]

The reorder point is give by the expression:

$$R = \bar{d}Leff + z\sigma L$$ [Equation 2.7]

The time dimension used in Equation 2.4 to Equation 2.7 could be days, months or years as long as it is used consistently throughout the equation.

σ_M Refers to the standard deviation over one month, when lead time extends over several months, the statistical premise is preferred by Jacobs et al. (2009).

The equation used to calculate the sum of standard deviations:

$$\sigma m = \sqrt{\sigma 1^2 + \sigma 2^2 + \sigma 3^2 + \cdots + \sigma m^2}$$ [Equation 2.8]

The Basic EOQ Model with Integer Lot Size

In the paper by Cardenas-Barron *et al.* (2010) a method to obtain the solution of the classic economic ordering quantity model, when the lot size is an integer quantity, is presented.

The mathematical formulation of the EOQ model is given by Equation 2.1.

Lot size q is restricted to be an integer and therefore we cannot make use of differential calculus to find the optimal lot size q. The initiative and classical method to solve this model consists of comparing the values $C([q_l])$ and $C([q_u])$,
where [x] = max {y integer : y <= x} and [x] = min {y integer : y ≤ x}.

If $C([q_l]) = C([q_u])$ we have two optimal solutions; if not, there exists a unique solution.

After this model is solved with marginal analysis the following results were obtained:

$$ql = -0.5 + \sqrt{0.25 + \frac{2KD}{h}} \qquad \text{[Equation 2.9]}$$

$$qu = 0.5 + \sqrt{0.25 + \frac{2KD}{h}} \qquad \text{[Equation 2.10]}$$

Take into consideration that [x] = [x + 1] only if x is not an integer number, a unique optimal solution is obtained. ($q_l = q_u$). Otherwise two optimal solutions exist.

In order to obtain the integer lot size one only need to apply one of the two previous equations, that is q_l or q_u.

The EOQ with Uncertain Demand: The Service Level Approach to Determining Safety Stock Level

According to Winston (2004) it is often difficult to determine the precise cost of a shortage or lost sale, therefore it could be desirable to choose a re-order point that meets a desired service level.

Two general measures of service level are:

- Service Level Measure 1 (SLM_1)
  The expected fraction (usually expressed as a percentage) of all demand that is met on time.

- Service Level Measure 2 (SLM_2)
  The expected number of cycles per year during which a shortage occurs.

If the assumption could be made that lead time is normally distributed, for a desired value SLM_1, the re-order point r is found from

$$NL\left(\frac{r-E(X)}{\sigma X}\right) = \frac{q(1-SLM1)}{\sigma X}$$ [Equation 2.11]

Where *NL(y)* is the normal loss function and q is the EOQ.

R = Inventory level at which order is placed. (reorder point)

X= Continuous random variable representing demand during lead time.

E(X) = Mean.

σ_X = Variance.

If lead time demand is a continuous random variable and we desire SLM_2 = S*o* shortages per year. The reorder point will be the smallest value of r satisfying

$$P(X \geq r) = \frac{soq}{E(D)}$$ [Equation 2.12]

E(D) = Mean of demand.

If lead time demand is a discrete random variable and we desire SLM_2 = S*o* shortages per year. The re-order point will be the smallest value of r satisfying

$$P(X \geq r) \leq \frac{soq}{E(D)} \quad \text{[Equation 2.13]}$$

Shift in Demand

Palano (2009) proposed two inventory control frameworks after studying a product line and customers` expectations. The frameworks are a fixed service level policy for raw materials and an optimized policy for finished goods. In this analysis a shift in demand is detected. Palano suggests that when it happens that a shift in the average volumes occurs, for example from one year to another, this factor should be taken into consideration. This can be done by updating the control parameters for the shift in demand.

2.6 Literature Review Concluding Remark

All of the methods, tools and techniques discussed in this chapter will be taken into consideration to choose and develop the appropriate inventory control policies for the Company.

3. Chapter 3 Methods and Analysis

The methods used to obtain the necessary data from MineEquip is discussed. A company works with loads of data. Each company has its own method of documenting the data with the aim of converting the data into useful information. According to the online Business Dictionary this conversion will take place if the data is accurate and timely, specific and organized for a purpose and presented within a meaningful and relevant context.

The aim of this chapter is to convert the data obtained into useful information to present a better understanding of the inventory problem in order to be able to propose improved inventory policies.

3.1 Product, Process and Layout Analysis

3.1.1 Types of Inventory

MineEquip is a company in the manufacturing industry. In the manufacturing environment inventory is typically classified into raw material, work-in-progress, component parts, finished products and supplies.

The project focus is on the raw materials. If an improvement can be made in the management of the raw materials it will have an improved affect on the whole company's inventory. This is due to the fact that the finished products are a function of the components of which it is composed of, and the components are again a function of the raw materials from which it is machined out of. See Appendix A for the diagram that illustrates the flow of inventory through the company. This diagram also illustrates the important role of the order policy.

3.1.2 Product Type

The company manufactures and sells mining equipment. This is best described as market pull products. Market pull products are when a market opportunity is identified and the appropriate technologies are selected to meet the needs of the customers. According to Jacobs *et al*. (2009) the process of manufacturing market pull products typically includes distinct planning and concept development, system-level design, detail design, testing and refinement and production ramp-up phases.

3.1.3 Process Type

MineEquip follows a Make-to-stock process. According to MineEquip's Managing Director the company chose this process as the lead time of their raw materials are very long and their customers demand short delivery times. A make-to-stock process is activated to meet forecasted demand. Customer orders are filled with available off-the-shelf products. A steady production is required to maintain inventory levels.

3.1.4 Factory Layout

MineEquip's factory consists of 7 workshops and a mixture of different layouts are found within and among these shops. These layouts includes a Process, Product and Cellular Layout. The Fixed Posistion layout type is not used at MineEquip.

3.2 Ordering Process Analysis

According to Dear (1990), the main objective of inventory control is to keep the inventory levels low and the customer service high. The ordering process generates the actual balance achieved between the investment made and the customer service and therefore it is a very important process.

MineEquip orders eighty five percent of their stock from Good Metals and Shanxi which are situated in China. The remaining percentage they order from local companies. An order is initiated by a forecast which is made to enable the Company to satisfy demand.

3.2.1 Current Forecasting Method

The Company's forecasts are based on sales data and management's experience. MineEquip makes use of the Moving Averages forecasting technique. A six months Moving Average analysis and a twelve month Moving Average analysis are conducted. The Company takes the larger forecast among these two analyses as the Forecast per month. The calculation of the Basic Forecast is explained next. If MineEquip wants to order for the next X amount of months the Forecast per month is multiplied with X to obtain the Basic Forecast for the X months.

3.2.2 MineEquip's Current Ordering Policy

The managers at MineEquip meet at the beginning of each month, to examine their inventory levels. MineEquip may order at any time, thus the suppliers do not make use of fixed ordering windows.

MineEquip orders according to the Basic Order Amount. The Basic Order Amount is equal to the current stock subtracted from the Basic Forecast. This figure is usually adjusted by management. For example when the part is ordered from China and the sales manager came to know of some event, like for example a change in the economy, which is going to influence the orders.

The Current Stock consists of the stock on hand plus the stock in order. Stock in Months is calculated by dividing the Current Stock amount by the Forecast per month. Stock in Months shows how many months MineEquip would still have stock of that specific item. Stock in Months is the figure they use to decide which items are necessary to order. If the number of Stock in Months is beneath 4.5 (minimum number of Stock in Months) the item needs to be ordered according to the item's Basic Order Amount. The minimum Stock in Months number varies according to the time of year, due to the higher demand from July to November.

The order policy specifies that the order must be made three to four months in advance if the supplier is in China. Local orders are made as the need arises.

Stock Policy

MineEquip keeps at least four and a half months of stock for each raw material. A stock level of three to four weeks is kept of the Company's finished products.

MineEquip stock up in May to August, because there is a higher demand for the Company's products from July to November. Thus from May to August some item's minimum number of Stock in Months is greater than 4.5

Prevent Stockouts

The Company strives to keep their customer service level as high as possible and avoid shortages at all times. The production manager compiles a low stock item graph on a weekly basis. This graph is used when orders are made, in order to prevent out of stock possibilities.

Price Breaks

The suppliers do not provide any price breaks to MineEquip. The supplier will inform MineEquip if the order is too small and it is not profitable for them to make the order.

Shipping Policy

Orders from China are shipped in 20 ton containers to South Africa. Company policy is to fill up the container before it is shipped. This is because the company has to pay for a full container, regardless of the level to which the container is filled. Thus a variety of MineEquip's products are shipped together in a container. When an order is placed to a company in China the Basic Order Amount is adjusted to ensure that the sum of all the orders will fill up the minimum number of containers.

It may happen that the container cannot be fully filled with MineEquip's products, for example when MineEquip need some materials urgently and the container must be shipped immediately. In a situation like this the company makes use of a shared container and share space in the container with products of other companies. Each company that used the container pays his contribution according to the weight of the products. MineEquip's products are picked out from the container when it reaches SA harbour.

MineEquip orders batches near to the Basic Order Amount at local companies.

3.2.3 Suppliers and Supplier Lead Times

The Company's suppliers from China are mainly Good Metals and Shanxi. Some of MineEquip's local suppliers are Max Steel, Malliable Casting, Scor Metals, Chain Products, Sovereign Steel, Bearing Man, etc.

Orders from China take 3 months to arrive at MineEquip. It takes companies in China 2 months to manufacture the orders and the remaining month is the time it takes for the order to be shipped from China to South Africa and then couriered to MineEquips's premises.

The lead time for an order from a local foundry, for castings, is 2 months. The lead time from other local companies that supply steel products, plates, nuts and bolts is around 3 days. For the local suppliers there are no constraints on how much can be ordered or at what time it can be ordered.

3.2.4 Supplier Agreement

The agreement with the suppliers in China is that they take responsibility for the freight in China until the freight is loaded onto the ship. From the moment the freight leaves China's borders it becomes MineEquip's responsibility.

The agreement with the local suppliers is that the suppliers are responsible for the goods until the goods are delivered at MineEquip's premises.

3.2.5 Supplier Reliability of on Time Delivery and Quality

According to the Managing Director of MineEquip supplier reliability for Good Metals and Shanxi can be rated at about 80%. Local suppliers have a reliability of 90% except for local foundries which are rated at 60%. The reliability of local foundries is the lowest, because they have many problems especially with patterns. Patterns are not made anymore, because most of the craftsmen were not trained to make patterns like they were in the past. Many of the local foundries have also closed down recently due to this problem.

3.2.6 Delivery Time

MineEquip is rated by South Africa's mines as the company with the best order fullfillment time. The company believes that this is their special ability that keeps them ahead in the market.

3.3 Concluding Remark on the Current Forecast and Ordering Methods

MineEquip make use of the method of moving averages to calculate their forecast. The company's order quantity is determined based on the 'weeks' or units of stock and the company's safety stock are according to weeks of supply. Thus MineEquip falls into category three according to the common inventory problems described by Dear (1990) in the Literature Review chapter.

3.4 Inventory Classification Analysis

MineEquip sells 600 products and manufactures the majority of these products itself. This is a large product range and therefore an inventory classification system will be used to prioritise the inventory according to the Company's requirements. This will enable the Company to focus on their most important products. These products are known as class A products which are a small number of products, that account for most of the profit. In agreement with MineEquip's managing director the products must be ranked according to their respective Gross Profit values. A Gross Profit value (GP value) of a product is the product's cost subtracted from its sales value. The traditional ABC analysis was conducted and the criterion used was the sum of the product's GP value over the previous 12 months. The class A products with their respective GP values can be seen in Appendix B.

The ABC classification analysis is conducted by making use of the Cost of Sales Report. This report calculates the GP Value of each product and ranked all 600 products according to their GP Values.

From this report the top 33 products which are only 5.5% of the total product, contributes 51% towards MineEquip's profit. This very small amount of products, contributes to more than half of the Company's products, and therefore they are selected as class A products.

3.5 Estimation of Demand

Demand is what the customer wants. This is a difficult parameter to determine, because it is based on external factors that MineEquip has no control over. Sales records and the managements experience are the only available sources that will be used to estimate MineEquip's demand.

Demand properties are the most important component in an inventory system. Inventory problems exist, as a consequence of demands. Thus a product's demand plays a very important role in choosing the appropriate inventory model. An analysis of the demand is conducted in order to investigate how the demand behaves over time and the certainty of the demand.

3.6 Statistical Analysis of the Sales Data

The record of MineEquip's sale data together with the influence of management are used as an estimation of the company's demand.

MineEquip implemented a new information system in the beginning of 2007. The oldest data that the Company has record of is from the 1st of February 2007. The Company does not keep record of their sales data and the number of returned products separately. Thus backorders are included in the sales data and therefore in 1 613 sale data points there are 3 negative data points. These negative data points are included in the analysis, because it is possible that other positive sales data could have a negative component as well. The Managing Director stated that the rejection rate of the Company's products is very low and thus there are a small number of sale data points that include back orders. The reason for the low rejection rate is because the products the company is selling are economic consumables to the mines which are fit for purpose products that are easy to manufacture.

For all of MineEquip's class A products the following statistical analysis was conducted in Microsoft Excel:
The Sales Quantity Reports were used to obtain the products sales figures of the past four years.

The sales data was used to plot the sales quantities over 51 months. This graph displays the pattern of the product's sales and was used to determine if the product's sales have a trend or not. If the sales data displays a trend it can be concluded that demand varies over time, otherwise it can be concluded that demand is constant over time.

In Figure 7 the sales pattern over 51 months of the product ranked 1st in the Company's class A products is illustrated. From this figure the sales appear not to have a trend.

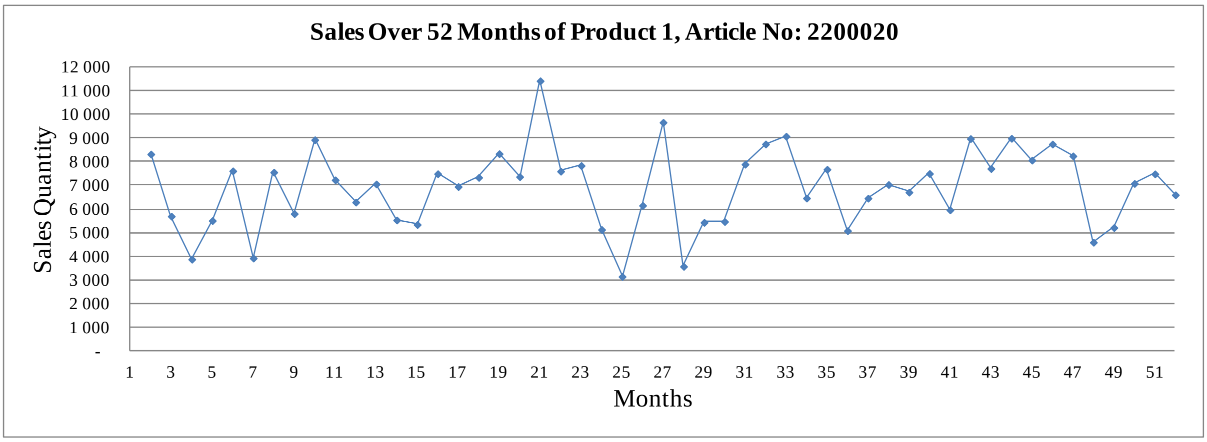

Figure 7: Sales Data of the product ranked 1st in Class A.

The sales patterns of the other class A products can be seen in Appendix C. Thirty two of the thirty three products appear not to have a trend in their sales data. One product, the product ranked twenty sixth in class A, shows a trend. This is a new product that was introduced to the market in November 2009. The Managing Director predicts that this product's sales will continue to grow in the near future and that it will then eventually stabilize. Based on the reasons that this is only one product out of the thirty three products and that this product's sales will adapt the nature of the other products' sales in the future the product is treated as if it does not have a trend in the sales data. Thus it is concluded that all of the Company's products do not have a trend in their sales data.

After it is established that there is not a trend in the sales data the next step was to test for seasonality in the data.

The Managing Director at MineEquip stated that there was a shift in the yearly demand of their products. The mines tend to order more equipment from July to November than the rest of the year.

The following procedure was followed in order to prove statistically if there was an indication of seasonality in the sales data:

It was decided to model the sales data as a step function. For the months from December to June the mean demand tend to be exceptionally lower than the mean demand for July to November.

The sales data was used to construct a histogram, with the aim to test if the distribution of the data was fairly normal. If the shape of the histogram is roundabout the same shape as a normal distribution, the probability that the data is fairly normal is high. This test alone is not sufficient and the Summary Statistics in Microsoft Excel was run in order to test the Kurtosis and the Skewness of the data. The histograms constructed and the summary statistics can be seen in Appendix D.

The Kurtosis and Skewness are defined by Montgomery and Runger (2007) as follows;

Kurtosis is a measure of the degree to which a unimodal distribution is peaked. Skewness is a term for asymmetry usually employed with respect to a histogram of data or a probability distribution. A normal distribution will have a Skewness and Kurtosis value of zero.

Thus if the Skewness and Kurtosis are more or less zero it is likely that the data is fairly normally distributed. Testing the normality of data with a histogram, Skewness and Kurtosis is not the best techniques available. SAS is a program that provides very good techniques to test for normality of the data. Unfortunately due to a time constraint this program was not used to test this project's data. Thus the normality test consisted of the results from the histogram, Skewness and Kurtosis.

All of the thirty three products' histograms, Skewness and Kurtosis results can be seen in Appendix D. Based on the normality test results it was concluded that all of the thirty three products' sales data was fairly normal.

After it was proven that the sales data of the products were fairly normally distributed, the t-Test for two-sample assuming equal variances was conducted. The t-Test for two-sample assuming equal variances tests if the statistical mean between two periods is the same. If the statistical mean between two periods is the same it is likely that there is not a shift in the demand pattern and thus not an indication of seasonality. If the statistical mean between two periods is not the same it is likely that there is a shift in the demand pattern and thus there is an indication of seasonality. A t-Test for two-sample assuming equal variances was conducted for a variety of stages, each stage consists of two periods.

The following hypotheses were stated for every stage:

- H_0 = Hypothesis that there is not a shift in the demand pattern.
- H_1 = Hypothesis that there is a shift in the demand pattern.

The following stages with their respective periods were chosen for all of the products except for product 6, product 19 and product 26:

Stage 1 consists of the months February to November 2007:
- Period 1: The sales data from February to June.
- Period 2: The sales data from July to November.

Stage 2 consists of the months December 2007 to November 2008:|
- Period 1: The sales data from December to June.
- Period 2: The sales data from July to November.

Stage 3 consists of the months December 2008 to November 2009:
- Period 1: The sales data from December to June.
- Period 2: The sales data from July to November.

Stage 4 consists of the months December 2009 to November 2010:
- Period 1: The sales data from December to June.
- Period 2: The sales data from July to November.

The sales data of December 2010 and for January to April 2011 were excluded from the study of these products, because after these four stages were tested these remaining periods were too short to conduct a t-test on.

The following stages with their respective periods were chosen for product 6:

Stage 5 consists of the months July 2009 to June 2010:|
- Period 1: The sales data from July to November.

- Period 2: The sales data from December to June.

Stage 6 consists of the months July 2010 to April 2011:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to April.

The following stages with their respective periods were chosen for product 19:

Stage 7 consists of the months July 2007 to June 2008:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to June.

Stage 8 consists of the months July 2008 to June 2009:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to June.

Stage 9 consists of the months July 2009 to June 2010:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to June.

Stage 10 consists of the months July 2010 to April 2011:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to April.

The following stages with their respective periods were chosen for product 26:

Stage 11 consists of the months July 2010 to April 2011:

- Period 1: The sales data from July to November.
- Period 2: The sales data from December to April.

This test was conducted with a 5% level of significance. This means that if the test is performed a 100 times, the chances are good that 5 times out of this 100 the outcome may be wrong.

One of the outcomes of the t-Test for two-sample, assuming equal variances are t-stat. If t-stat falls between the t-critical intervals it proves that the null is likely true. If the null is likely to be true it means that there is not a shift in the demand pattern, thus no indication of seasonality in the data and it can be concluded that the sales data are due to pure randomness.

Otherwise if t-stat falls outside of the t-critical intervals the null is rejected. If the null is rejected it means that there is a shift in the demand pattern, thus an indication of seasonality is present in the data and it can be concluded that the sales data displays a level of significance.

The t-critical intervals consist of two intervals namely the t-critical one-tail and the t-critical two-tail interval. The t-critical one-tail interval consists of the t-critical one-tail number as a negative and positive and the period found in between. The interval for the t-critical two-tail can be found by applying the same method to obtain the t-critical one-tail number to the t-critical two-tail number.

Table 1 to Table 3 display the statistical results from the t-Test for two-sample assuming equal variances. On Table 1 the top 18 products in class A are displayed. On Table 2 product 19 of class A is displayed. On Table 3 products 20 to 33 of class A are displayed.

In Table 1 to Table 3 for every t-stat, with their respective t-critical one tail and t-critical two tail, one of the following three scenarios is identified:

- Scenario 1 is a t-stat that is indicated in dark brown, with a t-critical one tail indicated in light brown. This signifies that the t-stat falls within the t-critical one tail interval. If t-stat falls within the t-critical one tail interval it will also fall within the t-critical two tail interval which will be indicated in dark brown. This signifies that the null is likely true and that the proposed shift in demand is not justified. Thus it can be concluded that the demand is due to randomness.

- Scenario 2 is a t-stat that is indicated in purple and a t-critical two tail that is also indicated in purple. This signifies that the t-stat does not fall within the t-critical two tail interval. If t-stat does not fall within the t-critical two tail interval it will also not fall within the t-critical one tail interval which will also be indicated in purple. This signifies that the null is rejected and that the proposed shift in demand is justified. Thus it can be concluded that a strong level of significance is present.

- Scenario 3 is a t-stat that is illustrated in pink which will have a t-critical one tail that is also indicated in pink. This signifies that the t-stat is very close to the t-critical one tail interval which indicates that there is a possibility that the proposed shift in demand is justified. Thus it can be concluded that there is a level of significance in the demand.

The conclusion of each class A products' demands can be seen in the Results chapter under the nature of the products' demands.

Table 1: T-test Statistical Results for Class A's Top 18 Products

The Statistical Results of the Sales Data of the Class A Products							
Product Ranking	**Statistical Parameters**	02/2007 - 11/2007 **Stage 1**	12/2007 - 11/2008 **Stage 2**	12/2008 - 11/2009 **Stage 3**	12/2009 -11/2010 **Stage 4**	07/2009 -06/2010 **Stage 5**	07/2010 -04/2011 **Stage 6**
1	t Stat	**-0.416849629**	**-2.656640588**	**-2.373840187**	**-2.603542677**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
2	t Stat	**-1.511501667**	**-1.738341628**	**-1.723230972**	**-4.106767998**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
3	t Stat	**-2.550610005**	**-2.178878836**	**-1.838185546**	**-0.330203392**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
4	t Stat	**-2.202369077**	**-0.36370272**	**-1.048817476**	**-0.547593469**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
5	t Stat	**-2.035959769**	**-0.52947959**	**-2.634446847**	**-2.035277757**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
6	t Stat					**0.767713721**	**2.659321054**
	t Critical one-tail					1.812461102	1.859548033
	t Critical two-tail					2.228138842	2.306004133
7	t Stat	**0.550854114**	**-0.463501335**	**-1.651035479**	**-3.02768376**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
8	t Stat	**0.13233755**	**-0.521209827**	**-0.5223449**	**-0.801661165**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
9	t Stat	**0.192733144**	**0.393906512**	**-1.802231561**	**-0.375714463**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
10	t Stat	**0.744944879**	**-0.722124818**	**-1.566968816**	**-1.826879867**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
11	t Stat	**0.583027318**	**0.343821849**	**-3.310146849**	**-0.021864965**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
12	t Stat	**-1.0309414**	**-0.549107715**	**-1.775200557**	**-1.811976502**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
13	t Stat	**3.00173098**	**1.226404961**	**-1.283028853**	**-2.687628555**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
14	t Stat	**-0.486679859**	**-0.351271779**	**-0.858282998**	**-0.800066232**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
15	t Stat	**0.720932591**	**-0.759475161**	**-1.894062458**	**-2.857891169**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
16	t Stat	**0.519132389**	**-0.225408543**	**-2.747470345**	**-0.557418387**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
17	t Stat	**0.320701555**	**-0.517329958**	**-2.905377382**	**-2.902431066**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		
18	t Stat	**0.449078967**	**-0.52544489**	**-0.490047639**	**0.15500386**		
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102		
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842		

Table 2: T-test Statistical Results for Product 19 in Class A

Product Ranking	Statistical Parameters	07/2007-06/2008	07/2008-06/2009	07/2009-06/2010	07/2010-04/2011
		Stage 7	Stage 8	Stage 9	Stage 10
19	t Stat	**-2.928212278**	**-1.360098372**	**0.831160053**	**0.712681496**
	t Critical one-tail	1.812461102	1.812461102	1.812461102	1.859548033
	t Critical two-tail	2.228138842	2.228138842	2.228138842	2.306004133

Table 3: T-test Statistical Results for Class A's Products 20 to 33

Product Ranking	Statistical Parameters	02/2007 - 11/2007	12/2007 - 11/2008	12/2008 - 11/2009	12/2009 -11/2010	07/2010-04/2011
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 10
20	t Stat	**-0.727101906**	**-1.571372634**	**-0.660692302**	**0.40553572**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
21	t Stat	**-1.090491534**	**1.107256047**	**-0.685941415**	**0.298526373**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
22	t Stat	**-0.818361902**	**1.233989889**	**-5.439894829**	**-1.271463183**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
23	t Stat	**0.546135039**	**-1.227843581**	**-2.879611353**	**-4.04097921**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
24	t Stat	**-0.551749459**	**-4.201425966**	**-5.813958638**	**-2.838436987**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
25	t Stat	**-0.227489375**	**-1.600951587**	**-0.011760396**	**0.849687664**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	2.306004133	2.228138842	2.228138842	2.228138842	
26	t Stat					**-0.82723017**
	t Critical one-tail					1.859548033
	t Critical two-tail					2.306004133
27	t Stat	**-1.716644137**	**-1.835689643**	**-0.54329215**	**0.039028252**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
28	t Stat	**1.137466952**	**-0.935246314**	**-0.96649661**	**0.236832733**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
29	t Stat	**-0.637058154**	**-2.077407419**	**-2.193125502**	**-0.476863257**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
30	t Stat	**-0.683517223**	**-0.009012778**	**-1.877227332**	**-0.640689213**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
31	t Stat	**-0.611979409**	**-1.992958296**	**-1.117994995**	**-0.787170742**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
32	t Stat	**-1.832221586**	**-0.60115495**	**-1.106760392**	**-3.783046924**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	
33	t Stat	**-0.354830864**	**-0.940999219**	**-2.817767701**	**-0.435811486**	
	t Critical one-tail	1.859548033	1.812461102	1.812461102	1.812461102	
	t Critical two-tail	**2.306004133**	**2.228138842**	**2.228138842**	**2.228138842**	

3.6.1 Conclusion of The Nature of Demand

Throughout the report the nature of demand is divided into two classes.

- The nature of demand can be due to randomness (as referred to as scenario 1). In the proposed inventory model a product with this type of demand has one mean demand.

- Or the nature of demand can display either a strong level of significance (as referred to as scenario 2), or display a level of significance (as referred to as scenario 3). In the proposed inventory model a product with this type of demand has a step function in the demand. The products' demand for the period July to November is known as the mean demand for the high period and the product's demand for the rest of the year is known as the mean demand for the low period.

3.7 The Financial System

A study of MineEquip's financial system was performed in order to understand how the system works.

Stock is sold on a First In First Out basis. MineEquip make use of a backlog system for the customer orders. In this way the old orders that still have to be packed are revealed.

Each product consists of the following costs:

- Material cost
- Labour cost
- Overheads

An overview will follow next of the method MineEquip uses to account for each of these three costs that a product consists of.

3.7.1 Standard Costing System

The company uses a Standard Costing system to assign costs to items. The Standard Costing system initially records the cost of an item (purchased or manufactured) at standard. Later when actual costs become known, the entry is adjusted. For example component A used to cost R 100.00 and now the supplier's price for this component went up to R 110.00. The component is booked at standard price of R 100.00. The R 10.00 difference is booked as Purchase Price Variance. At the end of the month the standard price will be updated to R 110.00.

The Standard Costing System is used for booking the purchase cost of raw materials. All the standard prices are updated on a monthly basis.

3.7.2 Traditional Based Costing

MineEquip makes use of traditional based costing. Traditional based costing is used to assign overheads to products by means of a predetermined overhead rate. At the Company a machine rate per hour is used as the predetermined overhead rate.

The sum of overheads and labour costs is known as production cost. Production cost is assigned to products by means of a machine rate per hour.

Overheads includes: maintenance, quality control, tool room, canteen, waste removal services, factory services, electricity, water, depreciation etc.

Labour cost consists of direct and indirect labour costs.

MineEquip operates on an average of R 200.00 per machine hour. The Company's utilisation is estimated to be 83%. The remaining 17% is for downtime and the setting of machines. A working shift at MineEquip is 8.2 hours. This results in 6.806 productive machine hours per shift.

3.8 Unit Cost

Two types of unit costs will be used in this project. One is the unit cost of raw material and the other is the unit cost of a finished product.

Both these unit costs of the class A products were obtained from each product's Detailed Calculation Statement. This statement presents the unit cost of a finished product as well as the breakdown of this cost. The production cost (labour and overheads) and raw material cost of each raw material used in the finished product are presented in this statement.

3.8.1 Unit Cost of Raw Material

The unit cost of raw material is the cost a unit of raw material is purchased at.

3.8.2 Unit Cost of a Finished Product

The unit cost of a finished product is the sum of the material cost, labour cost and overheads of that product.

3.9 Inventory Costs Analysis

Inventory cost is all the costs involved with getting the inventory in the right state and at the right place as aimed by management. (Koornhof *et al*. 2009).

3.9.1 Holding Cost

Holding cost is the amount it costs MineEquip to store an item. The word item is used when what is referred to could be a raw material or a finished product. The following costs were the costs considered in determining the holding cost.

- Rent for the necessary space needed to store the inventory.
- The cost of insurance in order to insure the inventory.
- Depreciation and or deterioration of inventories.
- Cost of capital to finance inventory.
- Storage cost of inventory.
- Cost of handling inventory.
- Taxes on inventory.
- Fees on inventory.
- Maintenance due to inventory.
- Security costs due to inventory.
- Other expenses directly related to the storing of inventory.

These costs contribute to holding cost if they are affected by the order quantity and/or the stock level of the Company.

The unit used for holding cost is per item per month.

3.9.2 Setup Cost

The cost incurred to setup for production. It takes a lot of time to set the machines to produce a new product. It also takes time to test the 1st offs, this is the first 2 to 3 products which are produced, in order to ensure that the machine's settings are correct according to the specifications of the new product. When production time is lost fewer products are finished at the end of the day, thus fewer products are sold and this results in a loss of income.

The unit of setup cost is per order.

3.9.3 Ordering Cost

Ordering cost is all the costs involved in placing an order. This could include the cost of delivering an order, the ordering personnel, telephone costs, stationary costs, etc.

Other relevant ordering costs that have to be considered for imported orders.

- Shipping and transport cost of inventory.
- Customs charges of the products that are imported.
- Customs duty of imported products.
- The cost of the clearing agent.
- The cost of the transport agent.
- Administration costs incurred in placing an order.
- Inspection cost of orders received.

The unit of ordering cost is per order.

3.9.4 Shortage Cost

Shortage cost is an estimation of what is lost if the stock is inadequate to meet demand. This cost is difficult to measure and one way of handling this cost is by establishing a service level policy. (Arsham, 2011)

Shortages are not allowed at MineEquip and therefore this cost is excluded from the analysis.

3.10 Estimation of Inventory Cost Parameters

Holding cost, set up cost, and ordering cost were obtained from Financial Statements and the Total Overheads Report.

3.10.1 Holding Cost

A study was conducted on all of the costs that have to be considered when holding cost was determined. Each one of these costs were analysed to determine if they were affected by the order quantity and/or the stock level of MineEquip.

a) Rent for the necessary space needed to store the inventory.

MineEquip owns the premises of the Company and therefore there is no rent that has to be paid.

b) The cost of insurance to insure the inventory.

MineEquip pays the following insurance costs;

- Insurance on buildings and trucks.
  This insurance depends on the worth of the buildings and trucks.
- Marine Insurance
  The insurance cost depends on the worth of the products shipped. An increase in the amount of products shipped will result in an increase in the worth of the products shipped.
- National Policy Insurance
  This insurance cost depends on the worth of the products transported. An increase in the amount of products transported will result in an increase in the worth of the products transported.

At the end of a year MineEquip has a forecasted demand figure of what the demand will be for the following year. This figure is used by the Marine and National policy insurances to determine the cost they will charge MineEquip for the insurance. Therefore the Marine and National policy insurances depend on the demand and not on the order quantity. Thus these insurances are part of overheads irrespective of the order quantity. The conclusion made is that none of these three insurance costs contribute to holding cost.

c) Obsolete or deteriorated inventories.

The majority of MineEquip's items are made from hard steel and they are very well packed for the shipment from China to South Africa. Items have never before rusted, thus it can be said that these items do not deteriorate.

There are certain products that have a very low and/ or infrequent demand. The Company makes stock provision for slow moving and/ obsolete items.

The conclusions made are that the deterioration cost is zero. The provision made for slow moving and/ obsolete items are based on the amount of slow moving items kept per year. The aim of the ordering policy is to keep these types of products to a minimum and therefore this cost is affected by the ordering policy. Thus this provision made for slow moving and/ obsolete items is relevant, and contributes to holding costs.

d) Cost of capital to finance inventory.

MineEquip has a loan of 9% per year to finance their inventory. This is a cost directly related to the amount of inventory and therefore it contributes to holding cost.

e) Interest lost on invested capital.

The Company's inventory generates a larger income than the 9% interest rate the Company could gain for investing money at a bank. The investment's risk is higher for investing in inventory than it would be for depositing the money in a bank. The Company choose to rather invest their capital in their inventory, for not only is the profit that can be made worth the risk they are taking, it is also necessary for the Company's existence.

It is clear that it is the better choice to invest in MineEquip's inventory, and consequently the cost of interest lost on invested capital is zero.

f) Storage cost of inventory.

The storage personnel and packers are permanent workers of MineEquip and the amount of these workers is not directly linked to the levels of inventory kept.

Thus these personnel do not contribute to the holding cost.

g) Cost of handling inventory.

MineEquip will use the same amount of labour irrespective of the order quantity amount.

Thus the conclusion is drawn that labour does not contribute to holding cost.

h) Inventory Thief

The Company store some of their items outside of the buildings during peak season, but the items are stored in crates that weigh a few tons. The weight of these crates makes it impossible for a person or a group of persons to steal it. At the gates of MineEquip metal detector sensors are installed, thus a worker cannot steal a few items at a time either.

Thus there are no costs involved in holding cost due to stealing.

i) Taxes on inventories.

All the taxes paid on inventory are claimed back at the end of the financial year.

Thus taxes on inventories do not contribute to holding cost.

j) The following costs incurred cannot be directly linked to the amount of inventory kept at MineEquip.

- Maintenance
- Security costs

Conclusion of Holding Cost

Thus it is concluded that the cost of stock provision made for slow moving/ obsolete items and the cost of capital to finance inventory is the relevant holding costs.

The stock provision made for slow moving/ obsolete items is a fixed amount paid per year and depend on the amount of items stored by the Company. This cost is evenly distributed among all of MineEquip's raw materials. This cost is added as a fixed cost per month to each raw material's holding cost.

The cost of capital to finance inventory consists of a bank loan at 9% simple interest per year and is given by the expression:

$$\text{Cost of Capital} = \frac{0.09 * \text{Raw Material's Unit Cost}}{12}$$ [Equation 2.14]

3.10.2 Setup Cost

The setting of the machines is not related to the order quantities or the level of inventory kept. The Company will also make use of the same amount of personnel responsible for the setting of the machines, irrespective of the order quantities.

Conclusion of Setup Cost

The conclusion drawn is that setup cost is zero.

3.10.3 Ordering Cost

The administration costs incurred when placing an order includes the salaries of the stores clerk and stores manager. They have the responsibility of placing, confirming and receiving the orders and thus they are paid to deal with orders. Other administration costs are the telephone and stationary costs incurred in the ordering process.

The ordering cost taken into account when a local order is placed is only administration costs. The local suppliers incorporate their delivery costs into their item purchase cost and therefore this cost does not depend on the amount of orders made. Eighty percent of the orders placed for the raw materials of the class A products is at local suppliers.

Ordering cost for orders placed at the suppliers in China consists of the administration costs incurred as well as the ordering cost to transport a twenty ton container from China to MineEquip's premises. Twenty percent of the orders placed for the raw materials of the class A products are at suppliers in China. Thus twenty percent of the administration costs incurred are for imported orders.

In Table 4 the ordering costs incurred to ship a twenty ton container from the suppliers in China to MineEquip's premises are illustrated.

Table 4: Order Costs Incurred per 20ton Container.

Description	**Amount**
Cargo dues	R 2 119.14
Cartage	R 11 501.53
Shipping Line Fee	R 3 267.14
CTO-Merchant Haulage	R 150.00
Documentation	R 655.00
Agency	R 4 491.33
B/L Release Fee	R 90.00
Communication	R 60.00
Total	R 22 334.14

Conclusion of Ordering Cost

Ordering cost for the raw materials ordered from local suppliers is:

$$\frac{\text{Salaries of the Stores Personnel /Month} + \text{Average Telephone and Stationary Costs /Month}}{\text{Average Amount of Orders Placed per Month}}$$

$\times\ 0.8$ [Equation 2.15]

Ordering cost for the raw materials ordered from suppliers in China is:

$$\frac{\text{Salaries of the Stores Personnel /Month} + \text{Average Telephone and Stationary Costs /Month}}{\text{Average Amount of Orders Placed per Month}}$$

$\times\ 0.2 +$ R22 334.14 [Equation 2.16]

3.11 Inventory Control Model

In order to manage the class A inventory effectively the appropriate inventory control model has to be in place. The inventory control model which best suites the company's particular needs was chosen based on the knowledge gained through the available literature together with the results obtained from the sales and company analysis.

The proposed inventory control model prescribes for each raw material of the class A products an ordering policy and a safety stock level. The ordering policy consists of an optimal order quantity and a reorder point. The optimal order quantity refers to the most economical order quantity without decreasing the current level of customer service. The reorder point identifies when the stock level has reached the certain amount of units when the next order has to be placed.

3.11.1 Proposed Inventory Control Model

The proposed inventory control model is the basic economic order quantity model with lead times. This model is chosen for the Company's unique circumstances. The demand of the class A products do not have a trend. Twenty one of MineEquip's class A products' demand are due to randomness. A mean demand is calculated and used for each of these products' raw materials. The remaining twelve class A products' demand displays a level of significance. The demand is treated as a step function. This implies that the demand over a year is divided into two periods a high demand period and a low demand period. A mean demand for the high period and a mean demand for the low period are calculated for every raw material that is used in the class A products. For each raw material an ordering policy is proposed for the high demand period and the low demand period. In addition there is a safety stock level also prescribed for each raw material in both time periods of the year.

The following were calculated for each raw material of the class A products:

The economic order quantity and total cost by applying the equations of the basic economic order quantity model:

- Optimal order quantity calculated by Equation 2.2.
- Total cost per month calculated by Equation 2.3.

The cycle time, reorder point and safety stock level were calculated by applying the equations of the basic economic order quantity model with lead times:

- Safety stock level calculated by Equation 2.4.
- Cycle time in days calculated by Equation 2.5.
- Lead effective time calculated by Equation 2.6.
- Reorder point in units calculated by Equation 2.7.
- Sum of standard deviations in demand calculated by Equation 2.8.

3.11.2 The Basic Economic Order Quantity Model with Lead Times

The inventory costs, demands and proposed economic order quantities, reorder points and safety stock levels are divided into two categories. The first category is the part of the model that consists of the raw materials ordered from local suppliers and the second category is the other part of the model that consists of the raw materials ordered from the suppliers in China.

The reason for dividing the model into two categories is because of the many differences between these two situations. The ordering cost is different for the orders placed at local suppliers than for orders placed at the suppliers in China. There are no constraints on the quantity ordered at local suppliers. For the orders placed at suppliers in China it is necessary to take into account that it is the cheapest to ship a full twenty ton container, and therefore the proposed model makes use of joint orders, in order to fill up containers. The basic economic order quantity model with lead time makes use of joint orders when it is applied to the raw materials that are ordered from China. The raw materials are joined together in a container based on the location of the foundries from which they are ordered in China. Information from MineEquip’s ordering forms where used to determine the types of raw materials in each joint order. The two suppliers MineEquip orders from in China are Good Metals and Shaxi. These suppliers order their raw materials from a variety of foundries all over China. If raw materials from foundries located near each other are joined and shipped together it reduces the lead time of that order.

4 Chapter 4 Results

4.1 Inventory Classification System

In Table 5 the top 33 products of MineEquip are ranked according to the sum of their respective Gross Profit values over the previous 12 months. After the classification analysis were executed it was clear that the top 33 products, which are only 5.5% of the total amount of products, contributes 51% to MineEquip's profit. Thus as stated by the classical ABC inventory classification system the top 33 can be classified as the typical class A products.

The product ranking together with the article number, which is indicated in light blue, are used as the index for the class A products. The real names of the products are not used in this report. Product coding is used upon a request of confidentiality from the Company.

Table 5: The Class A Products

Class A Product Index			
Product	**Article No**	**Drawing No**	**Description**
1	2200020	435003	PRODUCT BH2043
2	2500002	89201	PRODUCT MS2089
3	23303	26303810	PRODUCT BS2326
4	24301	27301910	PRODUCT BS2327
5	1000	90302	PRODUCT HC1090
6	7341010	M9LEEJ33W	PRODUCT SB7493
7	1800010	12529	PRODUCT HT1012
8	1650010	GS/17010M	PRODUCT SB1517
9	1300020	32749	PRODUCT MS1032
10	281312	23512820	PRODUCT BF2323
11	1800030	39411XE/5731	PRODUCT HF1039
12	9110020	644203	PRODUCT BV9164
13	1700010	37516	PRODUCT HT1037
14	4900010	11497	PRODUCT HT4011
15	2600010	151	PRODUCT HT2015
16	1400020	13502	PRODUCT MS1013
17	2300030	29901	PRODUCT HM2029
18	4540010	C01600M	PRODUCT SB4401
19	7421010	L79000M	PRODUCT SB7279
20	5800010	67712	PRODUCT HC5067
21	8911010	LA18500M	PRODUCT SB8118
22	4100010	33401	PRODUCT HT4033
23	3000010	241	PRODUCT HT3024
24	1600010	47801	PRODUCT HC1047
25	250010	3008832	PRODUCT SV2030
26	6251010	MEEpin-M/SC36M	PRODUCT SB3662
27	2790010	17424	PRODUCT FL1727
28	2030	2036492	PRODUCT SB2020
29	2431	2231782	PRODUCT SB2224
30	1390010	103424	PRODUCT FL1013
31	6200010	85791	PRODUCT HT8562
32	8600030	52501	PRODUCT TS5268
33	2335	2835782	PRODUCT BF2823

4.2 The Sales Analysis

4.2.1 Nature of the Products' Demand

In Table 6 the nature of demand of each product in Class A is tabulated. The nature of the products' demand is determined by making use of tables one, two and three in Chapter 3.6. If the majority of the product's sales data is due to randomness the final conclusion is that the product's demand is probably due to randomness. The same with when the majority of the product's sales data displays a level of significance then the final conclusion is that the product's demand probably displays a level of significance. When it happens that the sales data displays an equal amount of randomness and level of significance then the final conclusion is made based on the more recent data.

Only the product ranked 1st shows a strong level of significance, 11 products display a significant level of significance and 21 products' demands are due to pure randomness.

Table 6: Nature of the Demand of the Class A Products

Nature of the Class A Products Demands			
Product Ranking	**Article No**	**Nature of the Demand**	**Demand Concluded**
1	2200020	Strong Level of Significance	Step Function in the Demand
2	2500002	Display a Level of Significance	Step Function in the Demand
3	23303	Display a Level of Significance	Step Function in the Demand
4	24301	**Randomness**	**Demand with One Mean**
5	1000	Display a Level of Significance	Step Function in the Demand
6	7341010	Display a Level of Significance	Step Function in the Demand
7	1800010	Display a Level of Significance	Step Function in the Demand
8	1650010	**Randomness**	**Demand with One Mean**
9	1300020	**Randomness**	**Demand with One Mean**
10	281312	Display a Level of Significance	Step Function in the Demand
11	1800030	**Randomness**	**Demand with One Mean**
12	9110020	Display a Level of Significance	Step Function in the Demand
13	1700010	**Randomness**	**Demand with One Mean**
14	4900010	**Randomness**	**Demand with One Mean**
15	2600010	Display a Level of Significance	Step Function in the Demand
16	1400020	**Randomness**	**Demand with One Mean**
17	2300030	Display a Level of Significance	Step Function in the Demand
18	4540010	**Randomness**	**Demand with One Mean**
19	7421010	**Randomness**	**Demand with One Mean**
20	5800010	**Randomness**	**Demand with One Mean**
21	8911010	**Randomness**	**Demand with One Mean**
22	4100010	**Randomness**	**Demand with One Mean**
23	3000010	Display a Level of Significance	Step Function in the Demand
24	1600010	Display a Level of Significance	Step Function in the Demand
25	250010	**Randomness**	**Demand with One Mean**
26	6251010	**Randomness**	**Demand with One Mean**
27	2790010	**Randomness**	**Demand with One Mean**
28	2030	**Randomness**	**Demand with One Mean**
29	2431	**Randomness**	**Demand with One Mean**
30	1390010	**Randomness**	**Demand with One Mean**
31	6200010	**Randomness**	**Demand with One Mean**
32	8600030	**Randomness**	**Demand with One Mean**
33	2335	**Randomness**	**Demand with One Mean**

4.3 The Basic Economic Order Quantity Model with Lead Times

The basic economic order quantity model with lead time is applied to 119 raw materials that are ordered from local suppliers and 34 raw materials that are ordered from suppliers in China.

For Table 7 to Table 20 all of the raw materials that are used in more than one of the thirty three products are displayed in different colours and the raw materials that are only used in one of the thirty three products are transparent.

For the raw materials ordered from local suppliers the drawing number together with the description of the raw material are used as their index. The joint order number plus the drawing number, which is indicated in light green, are used as the index for the raw materials ordered from the suppliers in China.

The real names of the raw materials are not used in this report. Product coding is used upon a request of confidentiality from the Company.

All the tables referred to in this section are listed at the end of this section.

4.3.1 Inventory Costs and Demands

The cost of capital component of the holding cost for orders placed at local and Chinese suppliers is calculated by Equation 2.14. The ordering cost for raw materials ordered from local suppliers is calculated with Equation 2.15. The ordering cost for raw materials ordered from suppliers in China is calculated with Equation 2.16.

The unit and inventory costs results for the raw materials ordered from local suppliers are displayed in Table 7.

The unit costs and weighted unit costs for the raw materials ordered from the suppliers in China are listed in Table 10. In Table 10 the demand ratios for each raw material were calculated by dividing each raw material's monthly demand by the Demand of the Joint Orders. Then the weighted unit cost was calculated. This is the unit cost that represents the raw materials in the joint order. The weighted unit cost is obtained by calculating the sum of all the raw materials' unit cost multiplied with their respective demand ratio. Table 11 lists the inventory costs for the orders from China. The holding cost is determined for each joint order by making use of the weighted unit cost. The ordering cost is also calculated per joint order.

A diversity of raw materials are used in a variety of products. See Table 8 for the raw materials that are ordered locally and used in different class A products. Table 12 illustrates the raw materials that are ordered from China and used in different class A products. In this case the raw material's order quantity, reorder point and safety stock level are calculated for the summation of all of the class A products that this particular raw material is used in.

Table 8 and Table 12 displays the demand in months for all the raw materials ordered locally and from China respectively. It may happen that a raw material is used in a product with a demand due to randomness and that the same raw material is used in a different product with a demand that displays a level of significance. This results in a raw material with a mean demand for the first product and for the second product a mean demand for the high period and a mean demand for the low period. For this reason each raw material's demand is divided into a mean demand, high period demand and low period demand, indicated in grey in Table 8 and Table 12. The sum of all the demands of the raw materials used in different products are calculated by adding the mean demands to the high period demands and the low period demands respectively. The final demands are one high period demand and one low period demand for each raw material. In Table 12 a joint demand for every joint order is calculated. This is the sum of all the raw materials' demands in the joint order.

The standard deviations in demand for each raw material are listed in Table 9 for the local orders and in Table 13 for the orders from China. The standard deviation in demand for each product is determined from the data obtained from the Sales Quantity Reports. The amount of the raw material used in the product is the quantity with which the standard deviation is multiplied in order to obtain the raw material's standard deviation for that product. The sum of the products' standard deviations in demands for the local orders and the Chinese orders are calculated with Equation 2.8 and displayed in Table 9 and Table 13 respectively.

4.3.2 Economic Order Quantity, Reorder Point and Safety Stock Level

The economic order quantity, reorder point and safety stock level is calculated based on the final demands of each raw material. During the months from July to November, which is known as the high period demand, a specific set of economic order quantities, reorder points and safety stock levels are prescribed. For the rest of the year, which is known as the low period demand, another set of economic order quantities, reorder points and safety stock levels are prescribed.

In Table 14 are the raw materials that are ordered from local suppliers' proposed order quantities and MineEquip's current order quantities displayed. In this project it is assumed that a month has twenty work days, thus there are twenty days in a month in which an order can be placed.

The Company's current order quantities are the monthly average of the forecasted order amounts taken over the period of August to October 2011. The forecasted amounts of the products in which the raw material is used are taken. The reason for taking the forecasted amounts instead of the order quantities on the ordering forms, are because the order amounts on the ordering forms are the raw material quantities ordered for all 600 products of the Company. This project focuses only on the Company's class A products.

In Table 16 all the raw materials that are ordered from suppliers in China's proposed order quantities are listed. An optimal order quantity for every joint order as well as for each raw material of which the order consists of is calculated. The joint order represents the order content of a container. The Demand of the Joint Orders is the sum of the demand of all the raw materials in the joint order. The optimal order quantity of each raw material can be obtained by making use of the demand ratios in Table 10.

The orders from China are shipped in twenty ton containers and therefore it is important to calculate the weight of these joint orders. The raw material weights were obtained from ordering forms. By making use of the raw material weights the total weight of a joint order was calculated.

Table 17 shows MineEquip's current order quantities for each raw material and each joint order that are ordered at suppliers in China. The current order quantities are obtained by multiplying the Forecasted order amount per month with the Order cycle time in months. The joint order quantity is the sum of the order quantities of the raw materials in the joint order.

Table 15 lists the lead time, cycle time, safety stock level and reorder point in units for each raw material ordered locally. In Table 18 the lead time, cycle time, safety stock level and reorder point in units for each raw material ordered from the suppliers in China are displayed. The required level of service specified by MineEquip is to have a 97.5% order fulfillment rate. The t-distribution is used to obtain the *z*-value for this required level of service. For an alpha of 0.025 and for 52 data points the *z*-value is two (Montgomery et al, 2007).

The total cost per month of the proposed order policy is compared with the company's current order policy for the raw materials ordered locally and from China in Table 19 and Table 20 respectively.

4.3.3 Comparing the Proposed Order Policy to the Current Order Policy

Raw Materials Ordered from Local Suppliers

There are nine out of the 119 raw materials whose proposed order policy expects a cost saving of less than R10.00 per month when compared to the current order policy. If the proposed order policy is implemented it predicts that it could have cost savings of over a R 1000.00 per month for 46 of the raw materials. The remaining raw materials' proposed order policy has a cost saving between R10.00 and a R 1000.00 per month when compared to the current order policy. The total saving predicted by the proposed order policy for 119 raw materials is R 192 712.01 per month.

The big savings made by the proposed order policy for the 46 raw materials where investigated. It was found that for all of these raw materials, the Company's cycle time between orders, are very long. According to MineEquip's stores manager the reason for this is that the majority of these orders are placed at foundries. Foundries have a lead time of two months. MineEquip orders at the Foundries according to a schedule of every two months. The remaining raw material orders are custom made orders at other local suppliers. The lead time for these orders is long, because the raw materials required for these orders have long manufacturing cycles in order to produce the custom made orders. MineEquip's order cycle time at these suppliers is also according to a schedule of the suppliers long lead times.

Raw Materials Ordered from Suppliers in China

The smallest anticipated cost saving, when the proposed order policy replaces the current order policy, is R 1 306.94 per month, and the largest is R 47 472.38 per month. The predicted total saving for the 34 raw materials if the proposed order policy substitutes the current order policy is R 120 072.11 per month.

For joint order number two and four the proposed order policies proposes to ship more of the class A products' raw materials than the current order policy. For the remaining joint orders the proposed order policy suggests to ship less of class A products' raw materials than what MineEquip does currently.

The cost savings made with the proposed order policy are greatly larger for the suppliers in China than for the orders placed locally. This matter was investigated and the reason for this is that MineEquip orders more than the forecasting figures from the suppliers in China. According to the stores manager this is done to fill up the twenty ton containers.

The total anticipated saving of the proposed order policy for all 153 raw materials of the class A products is R 312 784.12 per month.

Unit Costs, Inventory Costs and the Demands of Raw Materials

Table 7: Unit and Inventory Costs for Orders Placed at Local Suppliers

Raw Materials		Unit Cost	Inventory Costs			
Drawing No	Raw Material Type		Holding Cost (Slow Moving Stock Provision)	Holding Cost (Cost of Capital)	Total Holding Cost	Order Cost
5803631	BOLT 10 x 50	R 0.47	R 3.47	R 0.0035	R 3.47	R 466.00
453631	NUT M10	R 0.17	R 3.47	R 0.0013	R 3.47	R 466.00
46411XE	ECC CASTING 4411	R 15.41	R 3.47	R 0.1156	R 3.59	R 466.00
21602XE	ECC CASTING 2602	R 5.41	R 3.47	R 0.0406	R 3.51	R 466.00
32602XE	ECC CASTING 3602	R 5.94	R 3.47	R 0.0446	R 3.51	R 466.00
3831	GASKET ENB 25	R 1.36	R 3.47	R 0.0102	R 3.48	R 466.00
190131	RIVET 830	R 0.29	R 3.47	R 0.0022	R 3.47	R 466.00
1529121	SEAL DR94112	R 2.37	R 3.47	R 0.0178	R 3.49	R 466.00
C4XX052HB	HANDLE G9259	R 1.45	R 3.47	R 0.0109	R 3.48	R 466.00
1623711	ST BALL 25	R 7.71	R 3.47	R 0.0578	R 3.53	R 466.00
33212009	NUTS TH M10	R 0.19	R 3.47	R 0.0014	R 3.47	R 466.00
37216009	SXT WASHER MTH 10	R 0.14	R 3.47	R 0.0011	R 3.47	R 466.00
1022111	SPINDLE MK25	R 6.89	R 3.47	R 0.0517	R 3.52	R 466.00
31240009	ORING R4052	R 0.07	R 3.47	R 0.0005	R 3.47	R 466.00
1725111	SPINDLE MK50	R 17.97	R 3.47	R 0.1348	R 3.60	R 466.00
1829511	STD HANDLE 50	R 7.63	R 3.47	R 0.0572	R 3.53	R 466.00
163311	ST BALL 50	R 20.21	R 3.47	R 0.1516	R 3.62	R 466.00
045/3LD	SEAT V/B 50	R 8.37	R 3.47	R 0.0628	R 3.53	R 466.00
32270009	ORING R8081	R 0.12	R 3.47	R 0.0009	R 3.47	R 466.00
31222009	NUT TH M12	R 0.29	R 3.47	R 0.0022	R 3.47	R 466.00
39226009	SXT WASHER MTH 12	R 0.18	R 3.47	R 0.0014	R 3.47	R 466.00
34291009	ORING 4.5x95	R 0.69	R 3.47	R 0.0052	R 3.48	R 466.00
1039701	CAP LP 50	R 45.71	R 3.47	R 0.3428	R 3.81	R 466.00
13188009	45 SPINDLE MNBUSH	R 1.12	R 3.47	R 0.0084	R 3.48	R 466.00
39303XE	ECC CASING 5466	R 10.55	R 3.47	R 0.0791	R 3.55	R 466.00
513631	M12 x 75 BOLT	R 1.25	R 3.47	R 0.0094	R 3.48	R 466.00
483631	NUT MPC12	R 0.29	R 3.47	R 0.0022	R 3.47	R 466.00
MWL4601LP	PULLEY 200	R 63.00	R 3.47	R 0.4725	R 3.94	R 466.00
WL520/04LB	SPINDLE 200	R 28.50	R 3.47	R 0.2138	R 3.68	R 466.00
2970CC	INT CIRCLIP 55	R 1.44	R 3.47	R 0.0108	R 3.48	R 466.00
SR72702600B	BEARING GSR72500	R 7.95	R 3.47	R 0.0596	R 3.53	R 466.00
661MN	NUT M16	R 0.50	R 3.47	R 0.0038	R 3.47	R 466.00
MWL0052PPS	PSWL HANDLE 250	R 21.76	R 3.47	R 0.1632	R 3.63	R 466.00
910/20BL	HINGE PIN x 44	R 2.85	R 3.47	R 0.0214	R 3.49	R 466.00
442MN	NUT M24	R 1.86	R 3.47	R 0.0140	R 3.48	R 466.00
15249	DISC FF01	R 0.96	R 3.47	R 0.0072	R 3.48	R 466.00
L1001PD	DOWEL PIN 25	R 0.08	R 3.47	R 0.0006	R 3.47	R 466.00
GR5 L12061CN	GRD5 L120LLE61CN	R 11.32	R 3.47	R 0.0849	R 3.55	R 466.00
510/04LB	SPINDLE 200 CCB	R 21.11	R 3.47	R 0.1583	R 3.63	R 466.00
GR TST 081/82	PIN/H DIA 20x60 PCR	R 10.75	R 3.47	R 0.0806	R 3.55	R 466.00

Raw Materials		Unit Cost	Inventory Costs			
Drawing No	**Raw Material Type**		**Holding Cost (Slow Moving Stock Provision)**	**Holding Cost (Cost of Capital)**	**Total Holding Cost**	**Order Cost**
3900/LF FB	BLANK PLATE 05077	R 0.49	R 3.47	R 0.0037	R 3.47	R 466.00
240/22LB	SOLID TAIL/P 100	R 5.68	R 3.47	R 0.0426	R 3.51	R 466.00
M5052-061APS	SPC HANDLE 60-50	R 26.51	R 3.47	R 0.1988	R 3.67	R 466.00
0152-061PD	DOW PIN C 40-20	R 0.11	R 3.47	R 0.0008	R 3.47	R 466.00
37403XE	ECC CASTING 6342	R 19.34	R 3.47	R 0.1451	R 3.62	R 466.00
916	GASKET KNB 25	R 2.03	R 3.47	R 0.0152	R 3.49	R 466.00
34250009	ORING R120	R 0.08	R 3.47	R 0.0006	R 3.47	R 466.00
1629602	DISC MACH P/P 200	R 48.99	R 3.47	R 0.3674	R 3.84	R 466.00
1725142	WAF B/F SPINDLE 50	R 11.77	R 3.47	R 0.0883	R 3.56	R 466.00
45236009	P/W CIRCLIPS 12018	R 0.33	R 3.47	R 0.0025	R 3.47	R 466.00
39275009	M6 x15 CAP SCREW	R 0.14	R 3.47	R 0.0011	R 3.47	R 466.00
1022912	HANDLE BFSTF 50	R 6.94	R 3.47	R 0.0521	R 3.52	R 466.00
1222422	RETAINING WASHER 200	R 2.76	R 3.47	R 0.0207	R 3.49	R 466.00
1623142	TNFB SPINDLE 501	R 35.45	R 3.47	R 0.2659	R 3.74	R 466.00
39211009	SELLOCK PIN 5 x25	R 0.59	R 3.47	R 0.0044	R 3.47	R 466.00
28206009	WASHER PN M10	R 0.08	R 3.47	R 0.0006	R 3.47	R 466.00
524211	BODY BV 4215	R 21.56	R 3.47	R 0.1617	R 3.63	R 466.00
614211	BV HANDLE 2589	R 10.67	R 3.47	R 0.0800	R 3.55	R 466.00
744211	BV BONNET 6935	R 5.53	R 3.47	R 0.0415	R 3.51	R 466.00
894211	SPINDLE BV 7012	R 6.41	R 3.47	R 0.0481	R 3.52	R 466.00
964211	SEAL 50BV	R 2.58	R 3.47	R 0.0194	R 3.49	R 466.00
105211	ST BALL 30	R 2.11	R 3.47	R 0.0158	R 3.49	R 466.00
312/11131	TENSION PIN 5142	R 0.52	R 3.47	R 0.0039	R 3.47	R 466.00
2652	GASKET SNB50	R 1.00	R 3.47	R 0.0075	R 3.48	R 466.00
80802XE	ECC CASTING 6563	R 44.12	R 3.47	R 0.3309	R 3.80	R 466.00
67203XE	ECC CASTING 7420	R 21.88	R 3.47	R 0.1641	R 3.63	R 466.00
77203XE	ECC CASTING 780	R 21.88	R 3.47	R 0.1641	R 3.63	R 466.00
6002	GASKET NBE 320	R 4.30	R 3.47	R 0.0323	R 3.50	R 466.00
M10131	PROT CAP DER 6151	R 0.66	R 3.47	R 0.0050	R 3.47	R 466.00
0880CC	INT CIRCLIP 550	R 2.80	R 3.47	R 0.0210	R 3.49	R 466.00
SR02703600B	BEARING SR580	R 20.67	R 3.47	R 0.1550	R 3.63	R 466.00
300/04LB	SPINDLE 605	R 24.60	R 3.47	R 0.1845	R 3.65	R 466.00
370/02LB	TAIL PIECE SS 200	R 4.41	R 3.47	R 0.0331	R 3.50	R 466.00
WL41320W	WL PL ND 150	R 29.25	R 3.47	R 0.2194	R 3.69	R 466.00
WL220/04LB	SPINDLE 100 SWL	R 21.11	R 3.47	R 0.1583	R 3.63	R 466.00
HS9052PPS	HANDLE NSLB 150	R 21.32	R 3.47	R 0.1599	R 3.63	R 466.00
240/02LB	TAIL PIECE BB	R 3.43	R 3.47	R 0.0257	R 3.50	R 466.00
0190X02NB	10 x 80 BOLT & NUT	R 5.19	R 3.47	R 0.0389	R 3.51	R 466.00
553631	M10 x 30 BOLT	R 0.35	R 3.47	R 0.0026	R 3.47	R 466.00
396211	VN BODY 15	R 38.63	R 3.47	R 0.2897	R 3.76	R 466.00

Raw Materials		Unit Cost	Inventory Costs			
Drawing No	Raw Material Type		Holding Cost (Slow Moving Stock Provision)	Holding Cost (Cost of Capital)	Total Holding Cost	Order Cost
877311	VST SPINDLE 15	R 13.98	R 3.47	R 0.1049	R 3.57	R 466.00
85311	ST VALVE HOLDER 15	R 4.88	R 3.47	R 0.0366	R 3.51	R 466.00
51/12131	LONG SPLIT PIN 4001	R 0.10	R 3.47	R 0.0008	R 3.47	R 466.00
30/11141	GLAND RUBBER 10	R 1.62	R 3.47	R 0.0122	R 3.48	R 466.00
33/11141	ORING R959	R 0.44	R 3.47	R 0.0033	R 3.47	R 466.00
GR5 L12061 CN	CHAIN 61120	R 11.32	R 3.47	R 0.0849	R 3.55	R 466.00
1901424	60 BODY 1465	R 24.76	R 3.47	R 0.1857	R 3.66	R 466.00
315411	EXT PIPE 784	R 4.62	R 3.47	R 0.0347	R 3.50	R 466.00
280161	TABLE C FLANGE 417	R 16.89	R 3.47	R 0.1267	R 3.60	R 466.00
4505-1324	STAND FT 2541	R 27.80	R 3.47	R 0.2085	R 3.68	R 466.00
197203	KFTCB VALVE 50x50	R 72.42	R 3.47	R 0.5432	R 4.01	R 466.00
471/10751	RED SOCKET IBC 25x50	R 7.61	R 3.47	R 0.0571	R 3.53	R 466.00
360/30751	BARREL NIPPEL HW 140	R 3.03	R 3.47	R 0.0227	R 3.49	R 466.00
419203	LKT COMBI VALVE 15	R 63.75	R 3.47	R 0.4781	R 3.95	R 466.00
500361	STICKER 7848	R 0.58	R 3.47	R 0.0044	R 3.47	R 466.00
1524702	DISC MACH SS 100	R 45.46	R 3.47	R 0.3410	R 3.81	R 466.00
1323422	RETAINING WASHER 100	R 2.64	R 3.47	R 0.0198	R 3.49	R 466.00
1425242	SPINDLE ACTUA FC 100	R 21.04	R 3.47	R 0.1578	R 3.63	R 466.00
1826242	WFB BOT SPINDLE 200	R 7.97	R 3.47	R 0.0598	R 3.53	R 466.00
20380009	ORING R3210	R 0.10	R 3.47	R 0.0008	R 3.47	R 466.00
36221009	SELLOCK PIN 2x50	R 0.64	R 3.47	R 0.0048	R 3.47	R 466.00
39295009	CAP SCREW M8 4512	R 0.35	R 3.47	R 0.0026	R 3.47	R 466.00
42746009	P/W CIRCLIPS 252	R 0.62	R 3.47	R 0.0047	R 3.47	R 466.00
12218609	ACTUATOR 451S5	R 142.56	R 3.47	R 1.0692	R 4.54	R 466.00
3125512	LOCKING DEVICE BFWH	R 1.34	R 3.47	R 0.0101	R 3.48	R 466.00
300131	SPRING WASHER M10 21	R 0.07	R 3.47	R 0.0005	R 3.47	R 466.00
791/11131	TENSION PIN 8745	R 0.84	R 3.47	R 0.0063	R 3.48	R 466.00
1523712	BF SPRING 150	R 1.47	R 3.47	R 0.0110	R 3.48	R 466.00
66206009	WASHER 854	R 0.50	R 3.47	R 0.0038	R 3.47	R 466.00
37264009	CAP SCREW M6 989	R 0.14	R 3.47	R 0.0011	R 3.47	R 466.00
3822512	MSTOP PLATE FB 23	R 5.68	R 3.47	R 0.0426	R 3.51	R 466.00
1924142	SPINDLE MS 640	R 34.49	R 3.47	R 0.2587	R 3.73	R 466.00
50236009	EXT CIRCLIP 15	R 0.21	R 3.47	R 0.0016	R 3.47	R 466.00
1700424	B0DY 5021	R 24.76	R 3.47	R 0.1857	R 3.66	R 466.00
359411	EXT PIPE 038	R 9.89	R 3.47	R 0.0742	R 3.54	R 466.00
311/10751	RED SOCKET IBC 65x20	R 7.61	R 3.47	R 0.0571	R 3.53	R 466.00
470/30751	BARREL NIPPEL HW 701	R 4.21	R 3.47	R 0.0316	R 3.50	R 466.00
96421XE	CASTING LM 595	R 45.11	R 3.47	R 0.3383	R 3.81	R 466.00
2407121	DISC MACH 084	R 113.15	R 3.47	R 0.8486	R 4.32	R 466.00

Table 8: Demands for Raw Materials Ordered from Local Suppliers

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
5803631	BOLT 10 x 50	1	2200020	2	15806.10	12599.46		17731.67	14525.03
		20	5800010	2			1925.57		
453631	NUT M10	1	2200020	2	15806.10	12599.46		23137.47	17995.57
		20	5800010	2			1925.57		
		24	1600010	2	5405.80	3470.54			
46411XE	ECC CASTING 4411	2	2500002	1	3916.80	2700.15		4494.15	3277.51
		32	8600030	1			577.35		
21602XE	ECC CASTING 2602	2	2500002	1	3916.80	2700.15		4494.15	3277.51
		32	8600030	1			577.35		
32602XE	ECC CASTING 3602	2	2500002	1	3916.80	2700.15		4494.15	3277.51
		32	8600030	1			577.35		
3831	GASKET ENB 25	2	2500002	1	3916.80	2700.15		4494.15	3277.51
		32	8600030	1			577.35		
190131	RIVET 830	2	2500002	2	7833.60	5400.31		11200.85	8767.56
		16	1400020	2			2212.55		
		32	8600030	2			1154.71		
1529121	SEAL DR94112	3	23303	2	9236.90	5807.08		9236.90	5807.08
C4XX052HB	HANDLE G9259	3	23303	1	4618.45	2903.54		4618.45	2903.54
1623711	ST BALL 25	3	23303	1	4618.45	2903.54		4618.45	2903.54
33212009	NUTS TH M10	3	23303	1	4618.45	2903.54		5275.88	3513.37
		10	281312	1	331.80	284.20			
		29	2431	1			224.94		
		33	2335	1			100.69		
37216009	SXT WASHER MTH 10	3	23303	1	4618.45	2903.54		5275.88	3513.37
		10	281312	1	331.80	284.20			
		29	2431	1			224.94		
		33	2335	1			100.69		

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
1022111	SPINDLE MK25	3	23303	1	4618.45	2903.54			
31240009	ORING R4052	3	23303	2	9236.90	5807.08		10551.75	7026.73
		10	281312	2	663.60	568.40			
		29	2431	2			449.88		
		33	2335	2			201.37		
1725111	SPINDLE MK50	4	24301	1			950.13	950.13	950.13
1829511	STD HANDLE 50	4	24301	1			950.13	950.13	950.13
163311	ST BALL 50	4	24301	1			950.13	950.13	950.13
045/3LD	SEAT V/B 50	4	24301	2			1900.26	1900.26	1900.26
32270009	ORING R8081	4	24301	2			1900.26	1900.26	1900.26
31222009	NUT TH M12	4	24301	1			950.13	950.13	950.13
39226009	SXT WASHER MTH 12	4	24301	1			950.13	950.13	950.13
34291009	ORING 4.5x95	4	24301	1			950.13	950.13	950.13
1039701	CAP LP 50	4	24301	1			950.13	950.13	950.13
13188009	45 SPINDLE MNBUSH	4	24301	1			950.13	950.13	950.13
39303XE	ECC CASING 5466	5	1000	2	14102.90	11556.85		14102.90	11556.85
513631	M12 x 75 BOLT	5	1000	2	14102.90	11556.85		14102.90	11556.85
483631	NUT MPC12	5	1000	2	14102.90	11556.85		14102.90	11556.85
MWL4601LP	PULLEY 200	6	7341010	1	1101.22	727.25		2467.36	2093.39
		19	7421010	1			378.02		
		21	8911010	1			452.12		
		26	6251010	1			536.00		
WL520/04LB	SPINDLE 200	6	7341010	1	1101.22	727.25		1101.22	727.25
2970CC	INT CIRCLIP 55	6	7341010	1	1101.22	727.25		2963.03	2589.06
		8	1650010	1			495.67		
		19	7421010	1			378.02		
		21	8911010	1			452.12		
		26	6251010	1			536.00		

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
SR72702600B	BEARING GSR72500	6	7341010	2	2202.44	1454.50		5926.06	5178.11
		8	1650010	2			991.33		
		19	7421010	2			756.04		
		21	8911010	2			904.24		
		26	6251010	2			1072.00		
661MN	NUT M16	6	7341010	2	2202.44	1454.50		6114.10	5366.15
		8	1650010	2			991.33		
		18	4540010	2			188.04		
		19	7421010	2			756.04		
		21	8911010	2			904.24		
		26	6251010	2			1072.00		
MWL0052PPS	PSWL HANDLE 250	6	7341010	1	1101.22	727.25		2089.34	1715.37
		26	6251010	1			536.00		
		21	8911010	1			452.12		
910/20BL	HINGE PIN x 44	6	7341010	1	1101.22	727.25		2561.38	2187.41
		18	4540010	1			94.02		
		19	7421010	1			378.02		
		21	8911010	1			452.12		
		26	6251010	1			536.00		
442MN	NUT M24	6	7341010	2	2202.44	1454.50		6114.10	5366.15
		8	1650010	2			991.33		
		18	4540010	2			188.04		
		19	7421010	2			756.04		
		21	8911010	2			904.24		
		26	6251010	2			1072.00		

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
15249	DISC FF01	6	7341010	1	1101.22	727.25		2089.34	1715.37
		21	8911010	1			452.12		
		26	6251010	1			536.00		
L1001PD	DOWEL PIN 25	6	7341010	1	1101.22	727.25		2467.36	2093.39
		19	7421010	1			378.02		
		21	8911010	1			452.12		
		26	6251010	1			536.00		
GR5 L12061CN	GRD5 L120LLE61CN	6	7341010	1	1101.22	727.25		1690.91	1316.94
		8	1650010	1			495.67		
		18	4540010	1			94.02		
510/04LB	SPINDLE 200 CCB	8	1650010	1			495.67	495.67	495.67
GR TST 081/82	PIN/H DIA 20x60 PCR	8	1650010	1			495.67	495.67	495.67
3900/LF FB	BLANK PLATE 05077	8	1650010	1			495.67	495.67	495.67
240/22LB	SOLID TAIL/P 100	8	1650010	1			495.67	495.67	495.67
M5052-061APS	SPC HANDLE 60-50	8	1650010	1			495.67	495.67	495.67
0152-061PD	DOW PIN C 40-20	8	1650010	1			495.67	495.67	495.67
37403XE	ECC CASTING 6342	9	1300020	1			3613.43	3613.43	3613.43
916	GASKET KNB 25	9	1300020	1			3613.43	3613.43	3613.43
34250009	ORING R120	10	281312	2	663.60	568.40		1314.85	1219.65
		29	2431	2			449.88		
		33	2335	2			201.37		
1629602	DISC MACH P/P 200	10	281312	1	331.80	284.20		556.74	509.14
		29	2431	1			224.94		
1725142	WAF B/F SPINDLE 50	10	281312	1	331.80	284.20		657.43	609.83
		29	2431	1			224.94		
		33	2335	1			100.69		

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
1725142	WAF B/F SPINDLE 50	10	281312	1	331.80	284.20		657.43	609.83
		29	2431	1			224.94		
		33	2335	1			100.69		
45236009	P/W CIRCLIPS 12018	10	281312	1	331.80	284.20		657.43	609.83
		29	2431	1			224.94		
		33	2335	1			100.69		
39275009	M6 x15 CAP SCREW	10	281312	2	663.60	568.40		1384.62	1289.42
		28	2030	2			69.76		
		29	2431	2			449.88		
		33	2335	2			201.37		
1022912	HANDLE BFSTF 50	10	281312	1	331.80	284.20		331.80	284.20
1222422	RETAINING WASHER 200	10	281312	1	331.80	284.20		657.43	609.83
		29	2431	1			224.94		
		33	2335	1			100.69		
1623142	TNFB SPINDLE 501	10	281312	1	331.80	284.20		331.80	284.20
39211009	SELLOCK PIN 5 x25	10	281312	1	331.80	284.20		657.43	609.83
		29	2431	1			224.94		
		33	2335	1			100.69		
28206009	WASHER PN M10	10	281312	1	331.80	284.20		331.80	284.20
524211	BODY BV 4215	12	9110020	1	2289.80	1765.08		2289.80	1765.08
614211	BV HANDLE 2589	12	9110020	1	2289.80	1765.08		2289.80	1765.08
744211	BV BONNET 6935	12	9110020	1	2289.80	1765.08		2289.80	1765.08
894211	SPINDLE BV 7012	12	9110020	1	2289.80	1765.08		2289.80	1765.08
964211	SEAL 50BV	12	9110020	2	4579.60	3530.15		4579.60	3530.15

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
105211	ST BALL 30	12	9110020	1	2289.80	1765.08		2289.80	1765.08
312/11131	TENSION PIN 5142	12	9110020	1	2289.80	1765.08		3420.98	2896.25
		25	250010	1			1131.18		
2652	GASKET SNB50	13	1700010	1			4877.96	4877.96	4877.96
80802XE	ECC CASTING 6563	16	1400020	1			1106.27	1106.27	1106.27
67203XE	ECC CASTING 7420	16	1400020	1			1106.27	1106.27	1106.27
77203XE	ECC CASTING 780	16	1400020	1			1106.27	1106.27	1106.27
6002	GASKET NBE 320	16	1400020	1			1106.27	1106.27	1106.27
M10131	PROT CAP DER 6151	16	1400020	1			1106.27	1106.27	1106.27
0880CC	INT CIRCLIP 550	18	4540010	1			94.02	94.02	94.02
SR02703600B	BEARING SR580	18	4540010	2			188.04	188.04	188.04
300/04LB	SPINDLE 605	18	4540010	1			94.02	94.02	94.02
370/02LB	TAIL PIECE SS 200	18	4540010	1			94.02	94.02	94.02
WL41320W	WL PL ND 150	18	4540010	1			94.02	94.02	94.02
WL220/04LB	SPINDLE 100 SWL	19	7421010	1			378.02	1366.14	1366.14
		21	8911010	1			452.12		
		26	6251010	1			536.00		
HS9052PPS	HANDLE NSLB 150	19	7421010	1			378.02	378.02	378.02
240/02LB	TAIL PIECE BB	19	7421010	1			378.02	2467.36	2093.39
		21	8911010	1			452.12		
		26	6251010	1			536.00		
		6	7341010	1	1101.22	727.25			
0190X02NB	10 x 80 BOLT & NUT	21	8911010	2			904.24	904.24	904.24
553631	M10 x 30 BOLT	24	1600010	2	5405.80	3470.54		5405.80	3470.54
396211	VN BODY 15	25	250010	1			1131.18	1131.18	1131.18

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
877311	VST SPINDLE 15	25	250010	1			1131.18	1131.18	1131.18
85311	ST VALVE HOLDER 15	25	250010	1			1131.18	1131.18	1131.18
51/12131	LONG SPLIT PIN 4001	25	250010	1			1131.18	1131.18	1131.18
30/11141	GLAND RUBBER 10	25	250010	1			1131.18	1131.18	1131.18
33/11141	ORING R959	25	250010	1			1131.18	1131.18	1131.18
GR5 L12061 CN	CHAIN 61120	26	6251010	1			536.00	536.00	536.00
1901424	60 BODY 1465	27	2790010	1			97.06	97.06	97.06
315411	EXT PIPE 784	27	2790010	4			388.24	558.00	558.00
		30	1390010	2			169.76		
280161	TABLE C FLANGE 417	27	2790010	1			97.06	181.94	181.94
		30	1390010	1			84.88		
4505-1324	STAND FT 2541	27	2790010	2			194.12	363.88	363.88
		30	1390010	2			169.76		
197203	KFTCB VALVE 50x50	27	2790010	1			97.06	97.06	97.06
471/10751	RED SOCKET IBC 25x50	27	2790010	1			97.06	97.06	97.06
360/30751	BARREL NIPPEL HW 140	27	2790010	1			97.06	97.06	97.06
419203	LKT COMBI VALVE 15	27	2790010	4			388.24	558.00	558.00
		30	1390010	2			169.76		
500361	STICKER 7848	27	2790010	1			97.06	181.94	181.94
		30	1390010	1			84.88		
1524702	DISC MACH SS 100	28	2030	1			34.88	34.88	34.88
1323422	RETAINING WASHER 100	28	2030	1			34.88	34.88	34.88
1425242	SPINDLE ACTUA FC 100	28	2030	1			34.88	34.88	34.88
1826242	WFB BOT SPINDLE 200	28	2030	1			34.88	34.88	34.88
20380009	ORING R3210	28	2030	5			174.41	174.41	174.41

Raw Materials		Used in Products		Quantity per Product	Demand in Months				
					Step Function		Random	Sum of all Products	
Drawing No	Raw Material Type	Product Ranking	Article No		High Period	Low Period	Mean	High Period	Low Period
36221009	SELLOCK PIN 2x50	28	2030	1			34.88	34.88	34.88
39295009	CAP SCREW M8 4512	28	2030	4			139.53	139.53	139.53
42746009	P/W CIRCLIPS 252	28	2030	1			34.88	34.88	34.88
12218609	ACTUATOR 451S5	28	2030	1			34.88	34.88	34.88
3125512	LOCKING DEVICE BFWH	28	2030	1			34.88	34.88	34.88
300131	SPRING WASHER M10 21	28	2030	4			139.53	139.53	139.53
791/11131	TENSION PIN 8745	28	2030	1			34.88	34.88	34.88
1523712	BF SPRING 150	29	2431	1			224.94	325.63	325.63
		33	2335	1			100.69		
66206009	WASHER 854	29	2431	1			224.94	325.63	325.63
		33	2335	1			100.69		
37264009	CAP SCREW M6 989	29	2431	2			449.88	651.25	651.25
		33	2335	2			201.37		
3822512	MSTOP PLATE FB 23	29	2431	1			224.94	325.63	325.63
		33	2335	1			100.69		
1924142	SPINDLE MS 640	29	2431	1			224.94	325.63	325.63
		33	2335	1			100.69		
50236009	EXT CIRCLIP 15	29	2431	1			224.94	325.63	325.63
		33	2335	1			100.69		
1700424	B0DY 5021	30	1390010	1			84.88	84.88	84.88
359411	EXT PIPE 038	30	1390010	2			169.76	169.76	169.76
311/10751	RED SOCKET IBC 65x20	30	1390010	1			84.88	84.88	84.88
470/30751	BARREL NIPPEL HW 701	30	1390010	1			84.88	84.88	84.88
96421XE	CASTING LM 595	31	6200010	1			641.25	641.25	641.25
2407121	DISC MACH 084	33	2335	1			100.69	100.69	100.69

Table 9: Standard Deviations in Demands of the Raw Materials Ordered from Local Suppliers

Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
Drawing No	Raw Material Type	Product Ranking	Article No		
5803631	BOLT 10 x 50	1	2200020	3342.42	3526.924595
		20	5800010	1125.8	
453631	NUT M10	1	2200020	3342.42	3901.26
		20	5800010	1125.8	
		24	1600010	1667.52	
46411XE	ECC CASTING 4411	2	2500002	1270.4	1359.563982
		32	8600030	484.25	
21602XE	ECC CASTING 2602	2	2500002	1270.4	1359.563982
		32	8600030	484.25	
32602XE	ECC CASTING 3602	2	2500002	1270.4	1359.563982
		32	8600030	484.25	
3831	GASKET ENB 25	2	2500002	1270.4	1359.563982
		32	8600030	484.25	
190131	RIVET 830	2	2500002	2540.8	2826.61
		16	1400020	772.06	
		32	8600030	968.50	
1529121	SEAL DR94112	3	23303	4165.16	4165.16
C4XX052HB	HANDLE G9259	3	23303	2082.58	2082.58
1623711	ST BALL 25	3	23303	2082.58	2082.58
33212009	NUTS TH M10	3	23303	2082.58	2105.99
		10	281312	212.69	
		29	2431	195.17	
		33	2335	121.33	
37216009	SXT WASHER MTH 10	3	23303	2082.58	2105.99
		10	281312	212.69	
		29	2431	195.17	
		33	2335	121.33	
1022111	SPINDLE MK25	3	23303	2082.58	2082.58
31240009	ORING R4052	3	23303	4165.16	4211.98
		10	281312	425.38	
		29	2431	390.34	
		33	2335	242.66	
1725111	SPINDLE MK50	4	24301	603.73	603.73
1829511	STD HANDLE 50	4	24301	603.73	603.73
163311	ST BALL 50	4	24301	603.73	603.73
045/3LD	SEAT V/B 50	4	24301	1207.46	1207.46
32270009	ORING R8081	4	24301	1207.46	1207.46
31222009	NUT TH M12	4	24301	603.73	603.73
39226009	SXT WASHER MTH 12	4	24301	603.73	603.73
34291009	ORING 4.5x95	4	24301	603.73	603.73

Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
Drawing No	**Raw Material Type**	**Product Ranking**	**Article No**		
1039701	CAP LP 50	4	24301	603.73	603.73
13188009	45 SPINDLE MNBUSH	4	24301	603.73	603.73
39303XE	ECC CASING 5466	5	1000	2745.78	2745.78
513631	M12 x 75 BOLT	5	1000	2745.78	2745.78
483631	NUT MPC12	5	1000	2745.78	2745.78
MWL4601LP	PULLEY 200	6	7341010	676.55	823.15
		19	7421010	227.83	
		21	8911010	269.83	
		26	6251010	308.46	
WL520/04LB	SPINDLE 200	6	7341010	676.55	676.55
2970CC	INT CIRCLIP 55	6	7341010	676.55	879.32
		8	1650010	309.23	
		19	7421010	227.83	
		21	8911010	269.83	
		26	6251010	308.46	
SR72702600B	BEARING GSR72500	6	7341010	1353.1	1758.64
		8	1650010	618.46	
		19	7421010	455.66	
		21	8911010	539.66	
		26	6251010	616.92	
661MN	NUT M16	6	7341010	1353.1	1764.54
		8	1650010	618.46	
		18	4540010	144.12	
		19	7421010	455.66	
		21	8911010	539.66	
		26	6251010	616.92	
MWL0052PPS	PSWL HANDLE 250	6	7341010	676.55	791.00
		26	6251010	308.46	
		21	8911010	269.83	
910/20BL	HINGE PIN x 44	6	7341010	676.55	826.30
		18	4540010	72.06	
		19	7421010	227.83	
		21	8911010	269.83	
		26	6251010	308.46	
442MN	NUT M24	6	7341010	1353.1	1764.54
		8	1650010	618.46	
		18	4540010	144.12	
		19	7421010	455.66	
		21	8911010	539.66	
		26	6251010	616.92	

Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
Drawing No	Raw Material Type	Product Ranking	Article No		
15249	DISC FF01	6	7341010	676.55	791.00
		21	8911010	269.83	
		26	6251010	308.46	
L1001PD	DOWEL PIN 25	6	7341010	676.55	823.15
		19	7421010	227.83	
		21	8911010	269.83	
		26	6251010	308.46	
GR5 L12061CN	GRD5 L120LLE61CN	6	7341010	676.55	747.35
		8	1650010	309.23	
		18	4540010	72.06	
510/04LB	SPINDLE 200 CCB	8	1650010	309.23	309.23
GR TST 081/82	PIN/H DIA 20x60 PCR	8	1650010	309.23	309.23
3900/LF FB	BLANK PLATE 05077	8	1650010	309.23	309.23
240/22LB	SOLID TAIL/P 100	8	1650010	309.23	309.23
M5052-061APS	SPC HANDLE 60-50	8	1650010	309.23	309.23
0152-061PD	DOW PIN C 40-20	8	1650010	309.23	309.23
37403XE	ECC CASTING 6342	9	1300020	1332.76	1332.76
916	GASKET KNB 25	9	1300020	1332.76	1332.76
34250009	ORING R120	10	281312	425.38	626.26
		29	2431	390.34	
		33	2335	242.66	
1629602	DISC MACH P/P 200	10	281312	212.69	288.67
		29	2431	195.17	
1725142	WAF B/F SPINDLE 50	10	281312	212.69	313.13
		29	2431	195.17	
		33	2335	121.33	
45236009	P/W CIRCLIPS 12018	10	281312	212.69	313.13
		29	2431	195.17	
		33	2335	121.33	
39275009	M6 x15 CAP SCREW	10	281312	425.38	632.80
		28	2030	90.74	
		29	2431	390.34	
		33	2335	242.66	
1022912	HANDLE BFSTF 50	10	281312	212.69	212.69
1222422	RETAINING WASHER 200	10	281312	212.69	313.13
		29	2431	195.17	
		33	2335	121.33	
1623142	TNFB SPINDLE 501	10	281312	212.69	212.69
39211009	SELLOCK PIN 5 x25	10	281312	212.69	313.13
		29	2431	195.17	
		33	2335	121.33	

Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
Drawing No	Raw Material Type	Product Ranking	Article No		
28206009	WASHER PN M10	10	281312	212.69	212.69
524211	BODY BV 4215	12	9110020	792.62	792.62
614211	BV HANDLE 2589	12	9110020	792.62	792.62
744211	BV BONNET 6935	12	9110020	792.62	792.62
894211	SPINDLE BV 7012	12	9110020	792.62	792.62
964211	SEAL 50BV	12	9110020	1585.24	1585.24
105211	ST BALL 30	12	9110020	792.62	792.62
312/11131	TENSION PIN 5142	12	9110020	792.62	994.41
		25	250010	600.51	
2652	GASKET SNB50	13	1700010	1539.18	1539.18
80802XE	ECC CASTING 6563	16	1400020	386.03	386.03
67203XE	ECC CASTING 7420	16	1400020	386.03	386.03
77203XE	ECC CASTING 780	16	1400020	386.03	386.03
6002	GASKET NBE 320	16	1400020	386.03	386.03
M10131	PROT CAP DER 6151	16	1400020	386.03	386.03
0880CC	INT CIRCLIP 550	18	4540010	72.06	72.06
SR02703600B	BEARING SR580	18	4540010	144.12	144.12
300/04LB	SPINDLE 605	18	4540010	72.06	72.06
370/02LB	TAIL PIECE SS 200	18	4540010	72.06	72.06
WL41320W	WL PL ND 150	18	4540010	72.06	72.06
WL220/04LB	SPINDLE 100 SWL	19	7421010	227.83	468.89
		21	8911010	269.83	
		26	6251010	308.46	
HS9052PPS	HANDLE NSLB 150	19	7421010	227.83	227.83
240/02LB	TAIL PIECE BB	19	7421010	227.83	823.15
		21	8911010	269.83	
		26	6251010	308.46	
		6	7341010	676.55	
0190X02NB	10 x 80 BOLT & NUT	21	8911010	539.66	539.66
553631	M10 x 30 BOLT	24	1600010	1667.52	1667.52
396211	VN BODY 15	25	250010	600.51	600.51
877311	VST SPINDLE 15	25	250010	600.51	600.51
85311	ST VALVE HOLDER 15	25	250010	600.51	600.51
51/12131	LONG SPLIT PIN 4001	25	250010	600.51	600.51
30/11141	GLAND RUBBER 10	25	250010	600.51	600.51
33/11141	ORING R959	25	250010	600.51	600.51
GR5 L12061 CN	CHAIN 61120	26	6251010	308.46	308.46
1901424	60 BODY 1465	27	2790010	66.20	66.20
315411	EXT PIPE 784	27	2790010	264.80	283.22
		30	1390010	100.48	

Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
Drawing No	Raw Material Type	Product Ranking	Article No		
280161	TABLE C FLANGE 417	27	2790010	66.20	83.11
		30	1390010	50.24	
4505-1324	STAND FT 2541	27	2790010	132.40	166.21
		30	1390010	100.48	
197203	KFTCB VALVE 50x50	27	2790010	66.20	66.20
471/10751	RED SOCKET IBC 25x50	27	2790010	66.20	66.20
360/30751	BARREL NIPPEL HW 140	27	2790010	66.20	66.20
419203	LKT COMBI VALVE 15	27	2790010	264.80	283.22
		30	1390010	100.48	
500361	STICKER 7848	27	2790010	66.20	83.11
		30	1390010	50.24	
1524702	DISC MACH SS 100	28	2030	45.37	45.37
1323422	RETAINING WASHER 100	28	2030	45.37	45.37
1425242	SPINDLE ACTUA FC 100	28	2030	45.37	45.37
1826242	WFB BOT SPINDLE 200	28	2030	45.37	45.37
20380009	ORING R3210	28	2030	226.85	226.85
36221009	SELLOCK PIN 2x50	28	2030	45.37	45.37
39295009	CAP SCREW M8 4512	28	2030	181.48	181.48
42746009	P/W CIRCLIPS 252	28	2030	45.37	45.37
12218609	ACTUATOR 451S5	28	2030	45.37	45.37
3125512	LOCKING DEVICE BFWH	28	2030	45.37	45.37
300131	SPRING WASHER M10 21	28	2030	181.48	181.48
791/11131	TENSION PIN 8745	28	2030	45.37	45.37
1523712	BF SPRING 150	29	2431	195.17	229.81
		33	2335	121.33	
66206009	WASHER 854	29	2431	195.17	229.81
		33	2335	121.33	
37264009	CAP SCREW M6 989	29	2431	390.34	459.62
		33	2335	242.66	
3822512	MSTOP PLATE FB 23	29	2431	195.17	229.81
		33	2335	121.33	
1924142	SPINDLE MS 640	29	2431	195.17	229.81
		33	2335	121.33	
50236009	EXT CIRCLIP 15	29	2431	195.17	229.81
		33	2335	121.33	
1700424	B0DY 5021	30	1390010	50.24	50.24
359411	EXT PIPE 038	30	1390010	100.48	100.48
311/10751	RED SOCKET IBC 65x20	30	1390010	50.24	50.24
470/30751	BARREL NIPPEL HW 701	30	1390010	50.24	50.24
96421XE	CASTING LM 595	31	6200010	348.52	348.52
2407121	DISC MACH 084	33	2335	121.33	121.33

Table 10: Unit Costs and Weighted Unit Cost for Raw Materials Ordered from Suppliers in China

Drawing No	Raw Material	Unit Cost	Demand Ratios		Weighted Unit Cost	
			High Period	Low Period	High Period	Low Period
68403XE	ECC CASTING 598	R 5.72	0.06	0.08	R 5.82	R 5.87
45811XE	CASTING M1688	R 2.65	0.17	0.14		
14002XE	CASTING M3874	R 3.18	0.51	0.53		
100729	CRUTCH S1FD VALVE	R 4.31	0.04	0.05		
794901	BONET 50 HDV	R 12.82	0.21	0.19		
34603	VALVE CTFK 921	R 72.99	0.01	0.01		
GSM171A0P	PULLEY BDD 100	R 81.00	0.84	0.84	R 84.01	R 84.01
M24910P	PULLEY ABP 150	R 99.86	0.16	0.16		
1829301	BODY PSA 100	R 84.24	0.08	0.12	R 41.00	R 48.74
1423101	BODY PSA 50	R 21.91	0.41	0.38		
1633701	CAP/B ASS 5023	R 19.00	0.41	0.38		
1721232	BFSH BODY-RB 475	R 263.67	0.06	0.08		
12313320	ACT BODY FBR 100	R 303.70	0.0031	0.0045		
25262120	HANDLE AMS 50	R 19.71	0.03	0.04		
GR3 L132L61	GR3 L132L61	R 126.00	0.46	0.46	R 92.42	R 92.42
GR3 L563L10	GR3 L563L10	R 64.35	0.54	0.54		
LWLE47011C	CHEEK WLX 1058	R 73.95	0.09	0.10	R 62.48	R 63.06
WL94110C	CHEEK WL 352	R 93.98	0.02	0.02		
M122A0C	CHEEK PBE 798	R 93.15	0.05	0.06		
202A0C	CHEEK 100S	R 93.15	0.05	0.06		
452A0S	SHACKLE BIA875	R 42.08	0.05	0.06		
A71110FS	SHACKLE CF74/96	R 36.98	0.07	0.08		
3611CFS	SHACKLE CHAIN/R 387	R 42.16	0.21	0.19		
WLE87011C	CHEEK WLX 1048	R 65.60	0.18	0.16		
MWLE17011C	CHEEK 85S	R 73.95	0.05	0.06		
MWLE87011C	CHEEK 567S	R 67.08	0.22	0.20		
C33516	ST H/TAIL 509	R 9.81	0.21	0.24	R 12.14	R 12.47
151	H/TAIL BETN02	R 11.06	0.16	0.14		
281	H/TAIL BETM89	R 7.41	0.09	0.07		
34401	H/TAIL BETM69	R 30.46	0.06	0.07		
11497	H/TAIL KL30	R 6.15	0.10	0.11		
972521	H/TAIL K9780	R 11.58	0.19	0.19		
26901	HOSE MEMBER 5645	R 7.41	0.10	0.08		
10375EX11493	HOLDFAST HM20	R 24.41	0.09	0.10		

Table 11: Inventory Costs for Orders Placed at the Suppliers in China

Raw Materials		Inventory Costs						
Joint Order No	Drawing No	Holding Cost (Slow Moving Stock Provision)		Holding Cost (Cost of Capital)		Total Holding Cost		Order Cost
		High Period	Low Period	High Period	Low Period	High Period	Low Period	
1	68403XE 45811XE 14002XE 100729 794901 34603	R 3.47	R 3.47	R 0.04	R 0.04	R 3.51	R 3.51	R 22 450.64
2	GSM171A0P M24910P	R 3.47	R 3.47	R 0.63	R 0.63	R 4.10	R 4.10	R 22 450.64
3	1829301 1423101 1633701 1721232 12313320 25262120	R 3.47	R 3.47	R 0.31	R 0.37	R 3.78	R 3.84	R 22 450.64
4	GR3 L132L61 GR3 L563L10	R 3.47	R 3.47	R 0.69	R 0.69	R 4.16	R 4.16	R 22 450.64
5	LWLE47011C WL94110C M122A0C 202A0C 452A0S A71110FS 3611CFS WLE87011C MWLE17011C MWLE87011C	R 3.47	R 3.47	R 0.47	R 0.47	R 3.94	R 3.94	R 22 450.64
6	C33516 151 281 34401 11497 972521 26901 10375EX11493	R 3.47	R 3.47	R 0.09	R 0.09	R 3.56	R 3.56	R 22 450.64

Table 12: Demands for Raw Materials Ordered from the Suppliers in China

Joint Order No	Raw Materials		Used in Products		Quantity per Product	Demand per Month						
	Drawing No	Raw Material	Rank of Product	Article No		Step Function High Period	Step Function Low Period	Random Mean	Sum of Products High Period	Sum of Products Low Period	Joint Orders High Period	Joint Orders Low Period
1	68403XE	ECC CASTING 598	20	5800010	2	1925.57	1925.57		1925.57	1925.57	31031	23953
	45811XE	CASTING M1688	24	1600010	2	5405.80	3470.54		5405.80	3470.54		
	14002XE	CASTING M3874	1	2200020	2	15806.10	12599.46		15806.10	12599.46		
	100729	CRUTCH S1FD VALVE	25	250010	1			1131.18	1131.18	1131.18		
	794901	BONET 50 HDV	25	250010	1	6536.98	4601.71		6536.98	4601.71		
	34603	VALVE CTFK 921	30	1390010	3			224.94	224.94	224.94		
2	GSM171A0P	PULLEY BDD 100	8	1650010	1			495.67	495.67	495.67	589.69	589.69
	M24910P	PULLEY ABP 150	18	4540010	1			94.02	94.02	94.02		
3	1829301	BODY PSA 100	4	24301	1			950.13	950.13	950.13	11205	7727.6
	1423101	BODY PSA 50	3	23303	1	4618.45	2903.54		4618.45	2903.54		
	1633701	CAP/B ASS 5023	3	23303	1	4618.45	2903.54		4618.45	2903.54		
	1721232	BFSH BODY-RB 475	10	281312	1	331.80	284.20		657.43	609.83		
			29	2431	1			224.94				
			30	1390010	1			100.69				
	12313320	ACT BODY FBR 100	28	2030	1			34.88	34.88	34.88		
	25262120	HANDLE AMS 50	29	2431	1			224.94	325.63	325.63		
			30	1390010	1			100.69				
4	GR3 L132L61	GR3 L132L61	19	7421010	1			378.02	378.02	378.02	830.14	830.14
	GR3 L563L10	GR3 L563L10	21	8911010	1			452.12	452.12	452.12		

Joint Order No	Raw Materials		Used in Products		Quantity per Product	Demand per Month						
	Drawing No	Raw Material	Rank of Product	Article No		Step Function		Random	Sum of Products		Joint Orders	
						High Period	Low Period	Mean	High Period	Low Period	High Period	Low Period
5	LWLE47011C	CHEEK WLX 1058	19	7421010	1			378.02	830.14	830.14	9171.1	8049.2
			21	8911010	1			452.12				
	WL94110C	CHEEK WL 352	18	4540010	2				188.04	188.04		
	M122A0C	CHEEK PBE 798	8	1650010	1				495.67	495.67		
	202A0C	CHEEK 100S	8	1650010	1				495.67	495.67		
	452A0S	SHACKLE BIA875	8	1650010	1				495.67	495.67		
	A71110FS	SHACKLE CF74/96	18	4540010	1			94.02	630.02	630.02		
			26	6251010	1			536.00				
	3611CFS	SHACKLE CHAIN/R 387	6	7341010	1	1101.22	727.25		1931.36	1557.39		
			19	7421010	1			378.02				
			21	8911010	1			452.12				
	WLE87011C	CHEEK WLX 1048	6	7341010	1	1101.22	727.25		1637.22	1263.25		
			26	6251010	1			536.00				
	MWLE17011C	CHEEK 85S	21	7341010	1				452.12	452.12		
	MWLE87011C	CHEEK 567S	6	7341010	1	1101.22	727.25		2015.24	1641.27		
			19	7421010	1			378.02				
			26	6251010	1			536.00				
6	C33516	ST H/TAIL 509	13	1700010	1			4877.96	4877.96	4877.96	22832	20460
	151	H/TAIL BETN02	15	2600010	1	3565.00	2891.42		3565.00	2891.42		
	281	H/TAIL BETM89	23	3000010	1	2096.85	1430.23		2096.85	1430.23		
	34401	H/TAIL BETM69	22	4100010	1			1454.06	1454.06	1454.06		
	11497	H/TAIL KL30	14	4900010	1			2262.37	2262.37	2262.37		
	972521	H/TAIL K9780	7	1800010	1	4370.25	3853.54		4370.25	3853.54		
	26901	HOSE MEMBER 5645	17	2300030	1	2179.35	1663.54		2179.35	1663.54		
	10375EX11493	HOLDFAST HM20	11	1800030	1			2026.53	2026.53	2026.53		

Table 13: Standard Deviations in Demands of the Raw Materials Ordered from the Suppliers in China

Joint Order No	Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
	Drawing No	Raw Material	Rank of Product	Article No		
1	68403XE	ECC CASTING 598	20	5800010	1125.80	1125.80
	45811XE	CASTING M1688	24	1600010	1667.52	1667.52
	14002XE	CASTING M3874	1	2200020	3342.42	3342.42
	100729	CRUTCH S1FD VALVE	25	250010	600.51	600.51
	794901	BONET 50 HDV	25	250010	600.51	600.51
	34603	VALVE CTFK 921	30	1390010	195.17	195.17
2	GSM171A0P	PULLEY BDD 100	8	1650010	309.23	309.23
	M24910P	PULLEY ABP 150	18	4540010	72.06	72.06
3	1829301	BODY PSA 100	4	24301	603.73	603.73
	1423101	BODY PSA 50	3	23303	2082.58	2082.58
	1633701	CAP/B ASS 5023	3	23303	2082.58	2082.58
	1721232	BFSH BODY-RB 475	10	281312	212.69	313.13
			29	2431	195.17	
			30	1390010	121.33	
	12313320	ACT BODY FBR 100	28	2030	45.37	45.37
	25262120	HANDLE AMS 50	29	2431	195.17	229.81
			30	1390010	121.33	
4	GR3 L132L61	GR3 L132L61	19	7421010	227.83	227.83
	GR3 L563L10	GR3 L563L10	21	8911010	269.83	269.83

Joint Order No	Raw Materials		Used in Products		Standard Deviation in Demand	Sum of Products Standard Deviations in Demands
	Drawing No	Raw Material	Rank of Product	Article No		
5	LWLE47011C	CHEEK WLX 1058	19	7421010	227.83	353.15
			21	8911010	269.83	
	WL94110C	CHEEK WL 352	18	4540010	144.12	144.12
	M122A0C	CHEEK PBE 798	8	1650010	309.23	309.23
	202A0C	CHEEK 100S	8	1650010	309.23	309.23
	452A0S	SHACKLE BIA875	8	1650010	309.23	309.23
	A71110FS	SHACKLE CF74/96	18	4540010	72.06	316.77
			26	6251010	308.46	
	3611CFS	SHACKLE CHAIN/R 387	6	7341010	676.55	763.17
			19	7421010	227.83	
			21	8911010	269.83	
	WLE87011C	CHEEK WLX 1048	6	7341010	676.55	743.55
			26	6251010	308.46	
	MWLE17011C	CHEEK 85S	21	7341010	269.83	269.83
	MWLE87011C	CHEEK 567S	6	7341010	676.55	777.67
			19	7421010	227.83	
			26	6251010	308.46	
6	C33516	ST H/TAIL 509	13	1700010	1539.18	1539.18
	151	H/TAIL BETN02	15	2600010	1001.79	1001.79
	281	H/TAIL BETM89	23	3000010	700.19	700.19
	34401	H/TAIL BETM69	22	4100010	588.02	588.02
	11497	H/TAIL KL30	14	4900010	897.18	897.18
	972521	H/TAIL K9780	7	1800010	1258.35	1258.35
	26901	HOSE MEMBER 5645	17	2300030	690.96	690.96
	10375EX11493	HOLDFAST HM20	11	1800030	674.85	674.85

Economic Order Quantities, Reorder Points and Safety Stock Levels

Table 14: Proposed and Current Order Quantities for Orders Placed at Local Suppliers

Raw Materials		Proposed Order Quantity		Company's Current Order Policy		
Drawing No	Raw Material Type	High Period	Low Period	Forecasted Order Amount per Month	Order Cycle Time in Months	High Period
5803631	BOLT 10 x 50	2181	1974	19600	0.125	2450
453631	NUT M10	2492	2198	26200	0.125	3275
46411XE	ECC CASTING 4411	1081	923	5700	1.000	5700
21602XE	ECC CASTING 2602	1092	933	5700	1.000	5700
32602XE	ECC CASTING 3602	1092	932	5700	1.000	5700
3831	GASKET ENB 25	1097	937	5700	1.000	5700
190131	RIVET 830	1734	1534	14200	1.000	14200
1529121	SEAL DR94112	1571	1246	11000	1.000	11000
C4XX052HB	HANDLE G9259	1112	882	5500	0.125	688
1623711	ST BALL 25	1105	876	5500	0.125	688
33212009	NUTS TH M10	1190	971	6350	0.125	794
37216009	SXT WASHER MTH 10	1190	971	6350	0.125	794
1022111	SPINDLE MK25	1106	877	5500	0.125	688
31240009	ORING R4052	1683	1374	12700	0.125	1588
1725111	SPINDLE MK50	496	496	1550	0.125	194
1829511	STD HANDLE 50	501	501	1550	0.125	194
163311	ST BALL 50	494	494	1550	0.125	194
045/3LD	SEAT V/B 50	708	708	3100	1.000	3100
32270009	ORING R8081	714	714	3100	0.125	388
31222009	NUT TH M12	505	505	1550	0.125	194
39226009	SXT WASHER MTH 12	505	505	1550	0.125	194
34291009	ORING 4.5x95	505	505	1550	0.125	194
1039701	CAP LP 50	482	482	1550	1.000	1550
13188009	45 SPINDLE MNBUSH	505	505	1550	0.125	194
39303XE	ECC CASING 5466	1924	1742	14200	1.000	14200
513631	M12 x 75 BOLT	1944	1759	14200	0.125	1775
483631	NUT MPC12	1946	1761	14200	0.125	1775
MWL4601LP	PULLEY 200	764	703	2550	1.000	2550
WL520/04LB	SPINDLE 200	528	429	900	0.125	113
2970CC	INT CIRCLIP 55	891	833	3000	0.125	375
SR72702600B	BEARING GSR72500	1251	1169	6000	0.500	3000
661MN	NUT M16	1281	1200	6300	0.125	788
MWL0052PPS	PSWL HANDLE 250	732	663	2200	0.125	275
910/20BL	HINGE PIN x 44	827	764	2700	0.125	338
442MN	NUT M24	1279	1198	6300	0.125	788
15249	DISC FF01	748	678	2200	0.125	275
L1001PD	DOWEL PIN 25	814	750	2550	0.125	319
GR5 L12061CN	GRD5 L120LLE61CN	666	588	1500	2.000	3000
510/04LB	SPINDLE 200 CCB	357	357	450	1.000	450

Raw Materials		Proposed Order Quantity		Company's Current Order Policy		
Drawing No	Raw Material Type	High Period	Low Period	Forecasted Order Amount per Month	Order Cycle Time in Months	High Period
GR TST 081/82	PIN/H DIA 20x60 PCR	361	361	450	0.125	56
3900/LF FB	BLANK PLATE 05077	365	365	450	0.125	56
240/22LB	SOLID TAIL/P 100	363	363	450	0.125	56
M5052-061APS	SPC HANDLE 60-50	355	355	450	0.125	56
0152-061PD	DOW PIN C 40-20	365	365	450	0.125	56
37403XE	ECC CASTING 6342	965	965	4100	1.000	4100
916	GASKET KNB 25	983	983	4100	1.000	4100
34250009	ORING R120	594	572	1700	0.125	213
1629602	DISC MACH P/P 200	368	352	600	1.000	600
1725142	WAF B/F SPINDLE 50	415	400	850	0.125	106
45236009	P/W CIRCLIPS 12018	420	405	850	0.125	106
39275009	M6 x15 CAP SCREW	610	588	2200	0.125	275
1022912	HANDLE BFSTF 50	296	274	350	0.125	44
1222422	RETAINING WASHER 200	419	404	850	0.125	106
1623142	TNFB SPINDLE 501	288	266	350	0.125	44
39211009	SELLOCK PIN 5 x25	420	404	850	0.125	106
28206009	WASHER PN M10	298	276	350	0.125	44
524211	BODY BV 4215	767	673	3200	1.000	3200
614211	BV HANDLE 2589	775	681	3200	1.000	3200
744211	BV BONNET 6935	780	684	3200	1.000	3200
894211	SPINDLE BV 7012	779	684	3200	0.125	400
964211	SEAL 50BV	1106	971	6400	1.000	6400
105211	ST BALL 30	782	687	3200	0.125	400
312/11131	TENSION PIN 5142	958	881	3200	0.125	400
2652	GASKET SNB50	1143	1143	5100	1.000	5100
80802XE	ECC CASTING 6563	521	521	1400	1.000	1400
67203XE	ECC CASTING 7420	533	533	1400	1.000	1400
77203XE	ECC CASTING 780	533	533	1400	1.000	1400
6002	GASKET NBE 320	543	543	1400	1.000	1400
M10131	PROT CAP DER 6151	545	545	1400	0.125	175
0880CC	INT CIRCLIP 550	158	158	150	0.125	19
SR02703600B	BEARING SR580	220	220	300	0.500	150
300/04LB	SPINDLE 605	155	155	150	0.125	19
370/02LB	TAIL PIECE SS 200	158	158	150	0.125	19
WL41320W	WL PL ND 150	154	154	150	1.000	150
WL220/04LB	SPINDLE 100 SWL	592	592	1650	0.125	206
HS9052PPS	HANDLE NSLB 150	312	312	350	0.125	44
240/02LB	TAIL PIECE BB	811	747	2550	0.125	319
0190X02NB	10 x 80 BOLT & NUT	490	490	1200	0.125	150
553631	M10 x 30 BOLT	1205	965	6600	0.125	825

Raw Materials		Proposed Order Quantity		Company's Current Order Policy		
Drawing No	Raw Material Type	High Period	Low Period	Forecasted Order Amount per Month	Order Cycle Time in Months	High Period
396211	VN BODY 15	530	530	1100	1.000	1100
877311	VST SPINDLE 15	543	543	1100	0.125	138
85311	ST VALVE HOLDER 15	548	548	1100	0.125	138
51/12131	LONG SPLIT PIN 4001	551	551	1100	0.125	138
30/11141	GLAND RUBBER 10	550	550	1100	1.000	1100
33/11141	ORING R959	551	551	1100	0.125	138
GR5 L12061 CN	CHAIN 61120	375	375	700	2.000	1400
1901424	60 BODY 1465	157	157	160	0.125	20
315411	EXT PIPE 784	385	385	860	0.125	108
280161	TABLE C FLANGE 417	217	217	270	0.125	34
4505-1324	STAND FT 2541	304	304	540	0.125	68
197203	KFTCB VALVE 50x50	150	150	160	1.000	160
471/10751	RED SOCKET IBC 25x50	160	160	160	0.125	20
360/30751	BARREL NIPPEL HW 140	161	161	160	0.125	20
419203	LKT COMBI VALVE 15	363	363	860	1.000	860
500361	STICKER 7848	221	221	270	4.500	1215
1524702	DISC MACH SS 100	92	92	60	1.000	60
1323422	RETAINING WASHER 100	97	97	60	0.125	8
1425242	SPINDLE ACTUA FC 100	95	95	60	0.125	8
1826242	WFB BOT SPINDLE 200	96	96	60	0.125	8
20380009	ORING R3210	216	216	300	0.125	38
36221009	SELLOCK PIN 2x50	97	97	60	0.125	8
39295009	CAP SCREW M8 4512	194	194	240	0.125	30
42746009	P/W CIRCLIPS 252	97	97	60	0.125	8
12218609	ACTUATOR 451S5	85	85	60	1.000	60
3125512	LOCKING DEVICE BFWH	97	97	60	1.000	60
300131	SPRING WASHER M10 21	194	194	240	0.125	30
791/11131	TENSION PIN 8745	97	97	60	0.125	8
1523712	BF SPRING 150	295	295	500	0.125	63
66206009	WASHER 854	296	296	500	0.125	63
37264009	CAP SCREW M6 989	418	418	1000	0.125	125
3822512	MSTOP PLATE FB 23	294	294	500	1.000	500
1924142	SPINDLE MS 640	285	285	500	0.125	63
50236009	EXT CIRCLIP 15	296	296	500	0.125	63
1700424	B0DY 5021	147	147	110	0.125	14
359411	EXT PIPE 038	211	211	220	0.125	28
311/10751	RED SOCKET IBC 65x20	150	150	110	0.125	14
470/30751	BARREL NIPPEL HW 701	150	150	110	0.125	14
96421XE	CASTING LM 595	396	396	950	1.000	950
2407121	DISC MACH 084	147	147	250	1.000	250

Table 15: Safety Stock Levels and Reorder Points for Orders Placed at Local Suppliers

Raw Materials		Lead Time in Months	Cycle Time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock	Reorder Point (In Units)	
Drawing No	Raw Material Type		High Period	Low Period	High Period	Low Period			High Period	Low Period
5803631	BOLT 10 x 50	0.1	0.71	0.78	0.10	0.10	2.00	2231	4004	3683
453631	NUT M10	0.1	0.62	0.70	0.10	0.10	2.00	2467	4781	4267
46411XE	ECC CASTING 4411	2	1.39	1.63	0.61	0.37	2.00	3845	6596	5073
21602XE	ECC CASTING 2602	2	1.40	1.64	0.60	0.36	2.00	3845	6530	5017
32602XE	ECC CASTING 3602	2	1.40	1.64	0.60	0.36	2.00	3845	6533	5020
3831	GASKET ENB 25	0.1	1.41	1.65	0.10	0.10	2.00	860	1309	1188
190131	RIVET 830	0.1	0.89	1.01	0.10	0.10	2.00	1788	2908	2664
1529121	SEAL DR94112	0.1	0.98	1.24	0.10	0.10	2.00	2634	3558	3215
C4XX052HB	HANDLE G9259	0.1	1.39	1.75	0.10	0.10	2.00	1317	1779	1607
1623711	ST BALL 25	0.1	1.38	1.74	0.10	0.10	2.00	1317	1779	1607
33212009	NUTS TH M10	0.1	1.30	1.60	0.10	0.10	2.00	1332	1860	1683
37216009	SXT WASHER MTH 10	0.1	1.30	1.60	0.10	0.10	2.00	1332	1860	1683
1022111	SPINDLE MK25	0.1	1.38	1.74	0.10	0.10	2.00	1317	1779	1607
31240009	ORING R4052	0.1	0.92	1.13	0.10	0.10	2.00	2664	3719	3367
1725111	SPINDLE MK50	0.1	3.01	3.01	0.10	0.10	2.00	382	477	477
1829511	STD HANDLE 50	0.1	3.04	3.04	0.10	0.10	2.00	382	477	477
163311	ST BALL 50	0.1	3.00	3.00	0.10	0.10	2.00	382	477	477
045/3LD	SEAT V/B 50	0.1	2.15	2.15	0.10	0.10	2.00	764	954	954
32270009	ORING R8081	0.1	2.17	2.17	0.10	0.10	2.00	764	954	954
31222009	NUT TH M12	0.1	3.07	3.07	0.10	0.10	2.00	382	477	477
39226009	SXT WASHER MTH 12	0.1	3.07	3.07	0.10	0.10	2.00	382	477	477
34291009	ORING 4.5x95	0.1	3.07	3.07	0.10	0.10	2.00	382	477	477
1039701	CAP LP 50	2	2.93	2.93	2.00	2.00	2.00	1708	3608	3608
13188009	45 SPINDLE MNBUSH	0.1	3.06	3.06	0.10	0.10	2.00	382	477	477

Raw Materials		Lead Time in Months	Cycle Time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock	Reorder Point (In Units)	
Drawing No	Raw Material Type		High Period	Low Period	High Period	Low Period			High Period	Low Period
39303XE	ECC CASING 5466	2	0.79	0.87	0.42	0.26	2.00	7766	13758	10771
513631	M12 x 75 BOLT	0.1	0.80	0.88	0.10	0.10	2.00	1737	3147	2892
483631	NUT MPC12	0.1	0.80	0.88	0.10	0.10	2.00	1737	3147	2892
MWL4601LP	PULLEY 200	2	1.79	1.94	0.21	0.06	2.00	2328	2855	2455
WL520/04LB	SPINDLE 200	0.1	2.77	3.40	0.10	0.10	2.00	428	538	501
2970CC	INT CIRCLIP 55	0.1	1.73	1.86	0.10	0.10	2.00	556	852	815
SR72702600B	BEARING GSR72500	0.1	1.22	1.30	0.10	0.10	2.00	1112	1705	1630
661MN	NUT M16	0.1	1.21	1.29	0.10	0.10	2.00	1116	1727	1653
MWL0052PPS	PSWL HANDLE 250	0.1	2.02	2.23	0.10	0.10	2.00	500	709	672
910/20BL	HINGE PIN x 44	0.1	1.86	2.02	0.10	0.10	2.00	523	779	741
442MN	NUT M24	0.1	1.21	1.29	0.10	0.10	2.00	1116	1727	1653
15249	DISC FF01	0.1	2.07	2.28	0.10	0.10	2.00	500	709	672
L1001PD	DOWEL PIN 25	0.1	1.90	2.07	0.10	0.10	2.00	521	767	730
GR5 L12061CN	GRD5 L120LLE61CN	0.1	7.87525	8.92364	0.1	0.1	2	473	642	604
510/04LB	SPINDLE 200 CCB	0.1	4.15	4.15	0.10	0.10	2.00	196	245	245
GR TST 081/82	PIN/H DIA 20x60 PCR	0.1	4.20	4.20	0.10	0.10	2.00	196	245	245
3900/LF FB	BLANK PLATE 05077	0.1	4.25	4.25	0.10	0.10	2.00	196	245	245
240/22LB	SOLID TAIL/P 100	0.1	4.22	4.22	0.10	0.10	2.00	196	245	245
M5052-061APS	SPC HANDLE 60-50	0.1	4.13	4.13	0.10	0.10	2.00	196	245	245
0152-061PD	DOW PIN C 40-20	0.1	4.25	4.25	0.10	0.10	2.00	196	245	245
37403XE	ECC CASTING 6342	2	1.54	1.54	0.46	0.46	2.00	3770	5426	5426
916	GASKET KNB 25	0.1	1.57	1.57	0.10	0.10	2.00	843	1204	1204
34250009	ORING R120	0.1	2.61	2.71	0.10	0.10	2.00	396	528	518
1629602	DISC MACH P/P 200	2	3.81	3.99	2.00	2.00	2.00	816	1930	1835

Raw Materials		Lead Time in Months	Cycle Time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock	Reorder Point (In Units)	
Drawing No	Raw Material Type		High Period	Low Period	High Period	Low Period			High Period	Low Period
1725142	WAF B/F SPINDLE 50	0.1	3.64	3.78	0.10	0.10	2.00	198	264	259
45236009	P/W CIRCLIPS 12018	0.1	3.69	3.83	0.10	0.10	2.00	198	264	259
39275009	M6 x15 CAP SCREW	0.1	2.54	2.63	0.10	0.10	2.00	400	539	529
1022912	HANDLE BFSTF 50	0.1	5.15	5.57	0.10	0.10	2.00	135	168	163
1222422	RETAINING WASHER 200	0.1	3.68	3.82	0.10	0.10	2.00	198	198	198
1623142	TNFB SPINDLE 501	0.1	5.00	5.41	0.10	0.10	2.00	135	168	163
39211009	SELLOCK PIN 5 x25	0.1	3.69	3.83	0.10	0.10	2.00	198	198	198
28206009	WASHER PN M10	0.1	5.19	5.61	0.10	0.10	2.00	135	168	163
524211	BODY BV 4215	2	1.93	2.20	0.07	2.00	2.00	2242	2397	5772
614211	BV HANDLE 2589	2	1.95	2.23	0.05	2.00	2.00	2242	2347	5772
744211	BV BONNET 6935	2	1.96	2.24	0.04	2.00	2.00	2242	2322	5772
894211	SPINDLE BV 7012	0.1	1.96	2.24	0.10	0.10	2.00	501	730	678
964211	SEAL 50BV	0.1	1.39	1.59	0.10	0.10	2.00	1003	1461	1356
105211	ST BALL 30	0.1	1.97	2.25	0.10	0.10	2.00	501	730	678
312/11131	TENSION PIN 5142	0.1	1.62	1.76	0.10	0.10	2.00	629	971	919
2652	GASKET SNB50	0.1	1.35	1.35	0.10	0.10	2.00	973	1461	1461
80802XE	ECC CASTING 6563	2	2.72	2.72	2.00	2.00	2.00	1092	3304	3304
67203XE	ECC CASTING 7420	2	2.78	2.78	2.00	2.00	2.00	1092	3304	3304
77203XE	ECC CASTING 780	2	2.78	2.78	2.00	2.00	2.00	1092	3304	3304
6002	GASKET NBE 320	0.1	2.83	2.83	0.10	0.10	2.00	244	355	355
M10131	PROT CAP DER 6151	0.1	2.84	2.84	0.10	0.10	2.00	244	355	355
0880CC	INT CIRCLIP 550	0.1	9.73	9.73	0.10	0.10	2.00	46	55	55
SR02703600B	BEARING SR580	0.1	6.75	6.75	0.10	0.10	2.00	91	110	110
300/04LB	SPINDLE 605	0.1	9.51	9.51	0.10	0.10	2.00	46	55	55

Raw Materials		Lead Time in Months	Cycle Time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock	Reorder Point (In Units)	
Drawing No	Raw Material Type		High Period	Low Period	High Period	Low Period			High Period	Low Period
370/02LB	TAIL PIECE SS 200	0.1	9.71	9.71	0.10	0.10	2.00	46	55	55
WL41320W	WL PL ND 150	0.1	9.46	9.46	0.10	0.10	2.00	46	55	55
WL220/04LB	SPINDLE 100 SWL	0.1	2.50	2.50	0.10	0.10	2.00	297	433	433
HS9052PPS	HANDLE NSLB 150	0.1	4.76	4.76	0.10	0.10	2.00	144	182	182
240/02LB	TAIL PIECE BB	0.1	1.90	2.06	0.10	0.10	2.00	521	767	730
0190X02NB	10 x 80 BOLT & NUT	0.1	3.13	3.13	0.10	0.10	2.00	341	432	432
553631	M10 x 30 BOLT	0.1	1.29	1.60	0.10	0.10	2.00	1055	1595	1402
396211	VN BODY 15	2	2.70	2.70	2.00	2.00	2.00	1698	3961	3961
877311	VST SPINDLE 15	0.1	2.77	2.77	0.10	0.10	2.00	380	493	493
85311	ST VALVE HOLDER 15	0.1	2.80	2.80	0.10	0.10	2.00	380	493	493
51/12131	LONG SPLIT PIN 4001	0.1	2.81	2.81	0.10	0.10	2.00	380	493	493
30/11141	GLAND RUBBER 10	0.1	2.81	2.81	0.10	0.10	2.00	380	493	493
33/11141	ORING R959	0.1	2.81	2.81	0.10	0.10	2.00	380	493	493
GR5 L12061 CN	CHAIN 61120	0.1	4.04	4.04	0.10	0.10	2.00	195	249	249
1901424	60 BODY 1465	0.1	9.35	9.35	0.10	0.10	2.00	42	52	52
315411	EXT PIPE 784	0.1	3.98	3.98	0.10	0.10	2.00	179	235	235
280161	TABLE C FLANGE 417	0.1	6.89	6.89	0.10	0.10	2.00	53	71	71
4505-1324	STAND FT 2541	0.1	4.82	4.82	0.10	0.10	2.00	105	142	142
197203	KFTCB VALVE 50x50	2	8.93	8.93	2.00	2.00	2.00	187	381	381
471/10751	RED SOCKET IBC 25x50	0.1	9.52	9.52	0.10	0.10	2.00	42	52	52
360/30751	BARREL NIPPEL HW 140	0.1	9.57	9.57	0.10	0.10	2.00	42	52	52
419203	LKT COMBI VALVE 15	2	3.75	3.75	2.00	2.00	2.00	801	1917	1917
500361	STICKER 7848	0.1	7.01	7.01	0.10	0.10	2.00	53	71	71
1524702	DISC MACH SS 100	2	15.28	15.28	2.00	2.00	2.00	128	198	198

Raw Materials		Lead Time in Months	Cycle Time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock	Reorder Point (In Units)	
Drawing No	Raw Material Type		High Period	Low Period	High Period	Low Period			High Period	Low Period
1323422	RETAINING WASHER 100	0.1	15.97	15.97	0.10	0.10	2.00	29	32	32
1425242	SPINDLE ACTUA FC 100	0.1	15.66	15.66	0.10	0.10	2.00	29	32	32
1826242	WFB BOT SPINDLE 200	0.1	15.88	15.88	0.10	0.10	2.00	29	32	32
20380009	ORING R3210	0.1	7.16	7.16	0.10	0.10	2.00	143	161	161
36221009	SELLOCK PIN 2x50	0.1	16.00	16.00	0.10	0.10	2.00	29	32	32
39295009	CAP SCREW M8 4512	0.1	8.00	8.00	0.10	0.10	2.00	115	129	129
42746009	P/W CIRCLIPS 252	0.1	16.00	16.00	0.10	0.10	2.00	29	32	32
12218609	ACTUATOR 451S5	0.1	14.00	14.00	0.10	0.10	2.00	29	32	32
3125512	LOCKING DEVICE BFWH	0.1	15.99	15.99	0.10	0.10	2.00	29	32	32
300131	SPRING WASHER M10 21	0.1	8.01	8.01	0.10	0.10	2.00	115	129	129
791/11131	TENSION PIN 8745	0.1	16.00	16.00	0.10	0.10	2.00	29	32	32
1523712	BF SPRING 150	0.1	5.23	5.23	0.10	0.10	2.00	145	178	178
66206009	WASHER 854	0.1	5.24	5.24	0.10	0.10	2.00	145	178	178
37264009	CAP SCREW M6 989	0.1	3.71	3.71	0.10	0.10	2.00	291	356	356
3822512	MSTOP PLATE FB 23	0.1	5.21	5.21	0.10	0.10	2.00	145	178	178
1924142	SPINDLE MS 640	0.1	5.06	5.06	0.10	0.10	2.00	145	178	178
50236009	EXT CIRCLIP 15	0.1	5.24	5.24	0.10	0.10	2.00	145	178	178
1700424	B0DY 5021	0.1	10.00	10.00	0.10	0.10	2.00	32	40	40
359411	EXT PIPE 038	0.1	7.18	7.18	0.10	0.10	2.00	64	81	81
311/10751	RED SOCKET IBC 65x20	0.1	10.18	10.18	0.10	0.10	2.00	32	40	40
470/30751	BARREL NIPPEL HW 701	0.1	10.22	10.22	0.10	0.10	2.00	32	40	40
96421XE	CASTING LM 595	2	3.57	3.57	2.00	2.00	2.00	986	2268	2268
2407121	DISC MACH 084	2	8.45	8.45	2.00	2.00	2.00	343	545	545

Table 16: Proposed Order Quantities for Orders Placed at the Suppliers in China

Joint Order No	Drawing No	Optimal Order Quantity				Weight in Kg	Total Weight per Raw Material in Kg		Total Weight per Container in Kg	
		Joint Order		Individual Raw Materials						
		High Period	Low Period	High Period	Low Period		High Period	Low Period	High Period	Low Period
1	68403XE	19913.31	17494.89	1235.70	1406.38	0.23	284.21	323.47	4317.79	3789.92
	45811XE			3469.08	2534.78	0.08	277.53	202.78		
	14002XE			10143.28	9202.29	0.13	1318.63	1196.30		
	100729			725.91	826.18	0.17	123.41	140.45		
	794901			4194.99	3360.96	0.50	2097.49	1680.48		
	34603			144.35	164.29	1.50	216.53	246.44		
2	GSM171A0P	2541.24	2541.24	2136.06	2136.06	6.60	14098.01	14098.01	17379.93	17379.93
	M24910P			405.17	405.17	8.10	3281.92	3281.92		
3	1829301	11540.74	9511.21	978.60	1169.44	3.44	3366.39	4022.87	13627.33	13641.95
	1423101			4756.84	3573.73	0.76	3615.20	2716.03		
	1633701			4756.84	3573.73	0.31	1474.62	1107.86		
	1721232			677.13	750.59	6.56	4441.97	4923.87		
	12313320			35.93	42.93	13.48	484.30	578.75		
	25262120			335.39	400.79	0.73	244.83	292.58		
4	GR3 L132L61	2992.21	2992.21	1362.57	1362.57	9.50	12944.40	12944.40	19462.97	19462.97
	GR3 L563L10			1629.64	1629.64	4.00	6518.58	6518.58		

Joint Order No	Drawing No	Optimal Order Quantity				Weight in Kg	Total Weight per Raw Material in Kg		Total Weight per Container in Kg	
		Joint Order		Individual Raw Materials						
		High Period	Low Period	High Period	Low Period		High Period	Low Period	High Period	Low Period
5	LWLE47011C	10225.17	9574.01	925.55	987.40	4.90	4535.18	4838.24	47223.04	44333.65
	WL94110C			209.65	223.66	6.30	1320.80	1409.06		
	M122A0C			552.63	589.56	6.20	3426.33	3655.29		
	202A0C			552.63	589.56	6.20	3426.33	3655.29		
	452A0S			552.63	589.56	2.80	1547.37	1650.77		
	A71110FS			702.43	749.37	2.20	1545.34	1648.61		
	3611CFS			2153.33	1852.41	2.39	5146.46	4427.26		
	WLE87011C			1825.39	1502.55	4.90	8944.39	7362.50		
	MWLE17011C			504.08	537.76	6.30	3175.70	3387.91		
	MWLE87011C			2246.85	1952.18	6.30	14155.15	12298.74		
6	C33516	16967.37	16056.11	3624.95	3828.07	0.30	1087.48	1148.42	6702.10	6557.02
	151			2649.25	2269.10	0.35	927.24	794.19		
	281			1558.23	1122.40	0.20	311.65	224.48		
	34401			1080.55	1141.10	1.15	1242.63	1312.27		
	11497			1681.23	1775.44	0.15	252.18	266.32		
	972521			3247.65	3024.14	0.37	1201.63	1118.93		
	26901			1619.54	1305.49	0.20	323.91	261.10		
	10375EX11493			1505.97	1590.36	0.90	1355.37	1431.32		

Table 17: Current Order Quantities for Orders Placed at the Suppliers in China

Joint Order No	Raw Materials	Used in Products		Company's Current Order Policy			
	Drawing No	Rank of Product	Article No	Forecasted Order Amount per Month	Order Cycle Time in Months	Order Quantity	Joint Order Quantity
1	68403XE	20	5800010	3200	2	6400	57460
	45811XE	24	1600010	6600	2	13200	
	14002XE	1	2200020	16400	2	32800	
	100729	25	250010	1100	2	2200	
	794901	25	250010	1100	2	2200	
	34603	30	1390010	330	2	660	
2	GSM171A0P	8	1650010	450	2	900	1200
	M24910P	18	4540010	150	2	300	
3	1829301	4	24301	1550	2	3100	27360
	1423101	3	23303	5500	2	11000	
	1633701	3	23303	5500	2	11000	
	1721232	10	281312	350	2	700	
		29	2431	250	2	500	
		30	1390010	110	2	220	
	12313320	28	2030	60	2	120	
	25262120	29	2431	250	2	500	
		30	1390010	110	2	220	
4	GR3 L132L61	19	7421010	350	2	700	1900
	GR3 L563L10	21	8911010	600	2	1200	
5	LWLE47011C	19	7421010	350	2	700	18900
		21	8911010	600	2	1200	
	WL94110C	18	4540010	300	2	600	
	M122A0C	8	1650010	450	2	900	
	202A0C	8	1650010	450	2	900	
	452A0S	8	1650010	450	2	900	
	A71110FS	18	4540010	150	2	300	
		26	6251010	700	2	1400	
	3611CFS	6	7341010	900	2	1800	
		19	7421010	350	2	700	
		21	8911010	600	2	1200	
	WLE87011C	6	7341010	900	2	1800	
		26	6251010	700	2	1400	
	MWLE17011C	21	7341010	600	2	1200	
	MWLE87011C	6	7341010	900	2	1800	
		19	7421010	350	2	700	
		26	6251010	700	2	1400	
6	C33516	13	1700010	5100	2	10200	55400
	151	15	2600010	4600	2	9200	
	281	23	3000010	2400	2	4800	
	34401	22	4100010	1700	2	3400	
	11497	14	4900010	2600	2	5200	
	972521	7	1800010	5400	2	10800	
	26901	17	2300030	3000	2	6000	
	10375EX11493	11	1800030	2900	2	5800	

Table 18: Safety Stock Levels and Reorder Points for Orders Placed at the Suppliers in China

Raw Materials			Joint Order								Raw Materials			
Joint Order No	Drawing No	Demand Standard Deviation	Lead Time in Months	Cycle Time in Months		Cycle time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock		Reorder Point in Units	
				High Period	Low Period	High Period	Low Period	High Period	Low Period		High Period	Low Period	High Period	Low Period
1	68403XE	1125.80	3	0.6417	0.7304	12.83	14.61	0.4331	0.4016	2	3900	3900	4734	4673
	45811XE	1667.52									5776	5776	8118	7170
	14002XE	3342.42									11578	11578	18424	16638
	100729	600.51									2080	2080	2570	2534
	794901	600.51									2080	2080	4911	3928
	34603	195.17									676	676	774	766
2	GSM171A0P	309.23	3	4.3095	4.3095	86.19	86.19	3	3	2	1071	1071	2558	2558
	M24910P	72.06									250	250	532	532
3	1829301	603.73	3	1.0642	1.2910	21.28	25.82	0.8716	0.4179	2	2091	2091	2920	2488
	1423101	2082.58									7214	7214	11240	8428
	1633701	2082.58									7214	7214	11240	8428
	1721232	313.13									1085	1085	1658	1340
	12313320	45.37									157	157	188	172
	25262120	229.81									796	796	1080	932
4	GR3 L132L61	227.83	3	3.6045	3.6045	72.09	72.09	3	3	2	789	789	1923	1923
	GR3 L563L10	269.83									935	935	2291	2291

Raw Materials			Joint Order								Raw Materials			
Joint Order No	Drawing No	Demand Standard Deviation	Lead Time in Months	Cycle Time in Months		Cycle time in Days		Lead Time Effective		97.5% Order Fill Rate	Safety Stock		Reorder Point in Units	
				High Period	Low Period	High Period	Low Period	High Period	Low Period		High Period	Low Period	High Period	Low Period
5	LWLE47011C	353.15	3	1.1149	1.1894	22.3	23.79	0.7701	0.6211	2	1223	1223	1863	2378
	WL94110C	144.12									499	499	644	761
	M122A0C	309.23									1071	1071	1453	1761
	202A0C	309.23									1071	1071	1453	1761
	452A0S	309.23									1071	1071	1453	1761
	A71110FS	316.77									1097	1097	1583	1974
	3611CFS	763.17									2644	2644	4131	5098
	WLE87011C	743.55									2576	2576	3837	4621
	MWLE17011C	269.83									935	935	1283	1564
	MWLE87011C	777.67									2694	2694	4246	5265
6	C33516	1539.18	3	0.7431	0.7848	14.86	15.7	0.0275	0.6457	2	5332	5332	5466	8482
	151	1001.79									3470	3470	3568	5337
	281	700.19									2426	2426	2483	3349
	34401	588.02									2037	2037	2077	2976
	11497	897.18									3108	3108	3170	4569
	972521	1258.35									4359	4359	4479	6847
	26901	690.96									2394	2394	2453	3468
	10375EX11493	674.85									2338	2338	2393	3646

Comparing the Total Cost per Month of the Order Policies

Table 19: Total Cost per Month of Order Policies for Raw Materials Ordered from Local Suppliers

Raw Materials		Total Cost per Month		
Drawing No	**Raw Material Type**	**Proposed Order Policy Cost for the High Demand Period**	**Current Order Policy Cost for the High Demand Period**	**Cost Saving when Proposed Order Policy is Implemented**
5803631	BOLT 10 x 50	R 15 910.37	R 15 961.59	R 51.22
453631	NUT M10	R 12 585.25	R 12 909.81	R 324.57
46411XE	ECC CASTING 4411	R 73 130.25	R 79 841.20	R 6 710.95
21602XE	ECC CASTING 2602	R 28 147.98	R 34 685.92	R 6 537.95
32602XE	ECC CASTING 3602	R 30 532.05	R 37 079.15	R 6 547.11
3831	GASKET ENB 25	R 9 930.03	R 16 398.03	R 6 468.00
190131	RIVET 830	R 9 268.77	R 28 268.27	R 18 999.50
1529121	SEAL DR94112	R 27 371.01	R 41 465.52	R 14 094.52
C4XX052HB	HANDLE G9259	R 10 566.44	R 11 022.66	R 456.22
1623711	ST BALL 25	R 39 518.93	R 39 965.27	R 446.34
33212009	NUTS TH M10	R 5 133.93	R 5 477.54	R 343.61
37216009	SXT WASHER MTH 10	R 4 869.91	R 5 213.59	R 343.68
1022111	SPINDLE MK25	R 35 705.66	R 36 153.29	R 447.63
31240009	ORING R4052	R 6 580.71	R 6 590.75	R 10.04
1725111	SPINDLE MK50	R 18 859.92	R 19 707.70	R 847.78
1829511	STD HANDLE 50	R 9 015.80	R 9 875.39	R 859.59
163311	ST BALL 50	R 20 990.28	R 21 835.53	R 845.26
045/3LD	SEAT V/B 50	R 18 406.52	R 21 666.64	R 3 260.11
32270009	ORING R8081	R 2 707.37	R 3 185.74	R 478.37
31222009	NUT TH M12	R 2 029.02	R 2 897.12	R 868.11
39226009	SXT WASHER MTH 12	R 1 924.29	R 2 792.53	R 868.23
34291009	ORING 4.5x95	R 2 409.83	R 3 277.46	R 867.64
1039701	CAP LP 50	R 45 264.14	R 46 667.23	R 1 403.09
13188009	45 SPINDLE MNBUSH	R 2 819.20	R 3 686.33	R 867.14
39303XE	ECC CASING 5466	R 155 615.63	R 174 447.20	R 18 831.57
513631	M12 x 75 BOLT	R 24 391.21	R 24 419.08	R 27.87
483631	NUT MPC12	R 10 845.43	R 10 873.90	R 28.48
MWL4601LP	PULLEY 200	R 158 454.78	R 160 921.37	R 2 466.59
WL520/04LB	SPINDLE 200	R 33 329.26	R 36 153.55	R 2 824.30
2970CC	INT CIRCLIP 55	R 7 367.14	R 8 601.47	R 1 234.32
SR72702600B	BEARING GSR72500	R 51 527.40	R 53 327.10	R 1 799.70
661MN	NUT M16	R 7 506.16	R 8 042.83	R 536.67
MWL0052PPS	PSWL HANDLE 250	R 48 131.46	R 49 511.65	R 1 380.19
910/20BL	HINGE PIN x 44	R 10 186.91	R 11 425.71	R 1 238.80
442MN	NUT M24	R 15 827.86	R 16 362.02	R 534.16
15249	DISC FF01	R 4 614.58	R 6 031.05	R 1 416.47
L1001PD	DOWEL PIN 25	R 3 022.44	R 4 357.70	R 1 335.26

Raw Materials		Total Cost per Month		
Drawing No	Raw Material Type	Proposed Order Policy Cost for the High Demand Period	Current Order Policy Cost for the High Demand Period	Cost Saving when Proposed Order Policy is Implemented
GR5 L12061CN	GRD5 L120LLE61CN	R 21 507.99	R 24 736.09	R 3 228.09
510/04LB	SPINDLE 200 CCB	R 11 758.18	R 11 793.19	R 35.00
GR TST 081/82	PIN/H DIA 20x60 PCR	R 6 609.14	R 9 534.60	R 2 925.46
3900/LF FB	BLANK PLATE 05077	R 1 509.65	R 4 446.90	R 2 937.25
240/22LB	SOLID TAIL/P 100	R 4 089.23	R 7 020.50	R 2 931.27
M5052-061APS	SPC HANDLE 60-50	R 14 441.99	R 17 349.63	R 2 907.64
0152-061PD	DOW PIN C 40-20	R 1 320.77	R 4 258.46	R 2 937.69
37403XE	ECC CASTING 6342	R 73 372.96	R 77 705.31	R 4 332.36
916	GASKET KNB 25	R 10 761.23	R 14 890.67	R 4 129.44
34250009	ORING R120	R 2 167.48	R 3 357.34	R 1 189.86
1629602	DISC MACH P/P 200	R 28 685.84	R 28 858.38	R 172.54
1725142	WAF B/F SPINDLE 50	R 9 214.48	R 10 810.35	R 1 595.87
45236009	P/W CIRCLIPS 12018	R 1 675.60	R 3 284.83	R 1 609.22
39275009	M6 x15 CAP SCREW	R 2 310.28	R 3 017.42	R 707.14
1022912	HANDLE BFSTF 50	R 3 347.81	R 5 915.37	R 2 567.56
1222422	RETAINING WASHER 200	R 3 276.97	R 4 883.34	R 1 606.37
1623142	TNFB SPINDLE 501	R 12 837.15	R 15 378.18	R 2 541.03
39211009	SELLOCK PIN 5 x25	R 1 846.94	R 3 455.86	R 1 608.92
28206009	WASHER PN M10	R 1 062.52	R 3 636.61	R 2 574.09
524211	BODY BV 4215	R 52 152.04	R 55 512.26	R 3 360.22
614211	BV HANDLE 2589	R 27 184.64	R 30 445.66	R 3 261.02
744211	BV BONNET 6935	R 15 400.08	R 18 614.41	R 3 214.33
894211	SPINDLE BV 7012	R 17 417.67	R 18 048.85	R 631.18
964211	SEAL 50BV	R 15 674.54	R 23 314.74	R 7 640.20
105211	ST BALL 30	R 7 558.95	R 8 196.26	R 637.31
312/11131	TENSION PIN 5142	R 5 106.97	R 6 459.13	R 1 352.15
2652	GASKET SNB50	R 8 854.09	R 14 191.30	R 5 337.21
80802XE	ECC CASTING 6563	R 50 788.46	R 51 837.69	R 1 049.24
67203XE	ECC CASTING 7420	R 26 140.99	R 27 117.39	R 976.40
77203XE	ECC CASTING 780	R 26 140.99	R 27 117.39	R 976.40
6002	GASKET NBE 320	R 6 657.24	R 7 576.79	R 919.55
M10131	PROT CAP DER 6151	R 2 622.98	R 3 980.05	R 1 357.07
0880CC	INT CIRCLIP 550	R 816.34	R 2 632.68	R 1 816.34
SR02703600B	BEARING SR580	R 4 683.82	R 4 742.82	R 59.00
300/04LB	SPINDLE 605	R 2 878.77	R 4 683.84	R 1 805.07
370/02LB	TAIL PIECE SS 200	R 968.67	R 2 784.17	R 1 815.50
WL41320W	WL PL ND 150	R 3 318.66	R 3 318.86	R 0.21
WL220/04LB	SPINDLE 100 SWL	R 30 988.56	R 32 300.02	R 1 311.46
HS9052PPS	HANDLE NSLB 150	R 9 190.30	R 12 165.30	R 2 975.00
240/02LB	TAIL PIECE BB	R 11 298.31	R 11 299.85	R 1.54
0190X02NB	10 x 80 BOLT & NUT	R 6 412.61	R 6 481.93	R 69.32

Raw Materials		Total Cost per Month		
Drawing No	**Raw Material Type**	**Proposed Order Policy Cost for the High Demand Period**	**Current Order Policy Cost for the High Demand Period**	**Cost Saving when Proposed Order Policy is Implemented**
553631	M10 x 30 BOLT	R 6 074.83	R 6 377.95	R 303.12
396211	VN BODY 15	R 45 688.25	R 45 689.03	R 0.78
877311	VST SPINDLE 15	R 17 755.19	R 17 755.95	R 0.76
85311	ST VALVE HOLDER 15	R 7 442.86	R 7 443.61	R 0.75
51/12131	LONG SPLIT PIN 4001	R 2 025.98	R 2 026.73	R 0.75
30/11141	GLAND RUBBER 10	R 3 748.51	R 3 749.26	R 0.75
33/11141	ORING R959	R 2 411.29	R 2 412.03	R 0.75
GR5 L12061 CN	CHAIN 61120	R 7 400.13	R 7 447.90	R 47.76
1901424	60 BODY 1465	R 2 978.23	R 3 051.58	R 73.35
315411	EXT PIPE 784	R 3 928.00	R 4 056.29	R 128.29
280161	TABLE C FLANGE 417	R 3 853.94	R 3 915.58	R 61.64
4505-1324	STAND FT 2541	R 11 232.85	R 11 321.01	R 88.15
197203	KFTCB VALVE 50x50	R 7 631.52	R 7 708.37	R 76.85
471/10751	RED SOCKET IBC 25x50	R 1 303.47	R 1 375.51	R 72.05
360/30751	BARREL NIPPEL HW 140	R 856.18	R 927.88	R 71.70
419203	LKT COMBI VALVE 15	R 37 005.42	R 37 141.58	R 136.17
500361	STICKER 7848	R 873.08	R 933.66	R 60.58
1524702	DISC MACH SS 100	R 1 937.74	R 1 990.79	R 53.05
1323422	RETAINING WASHER 100	R 428.92	R 479.69	R 50.77
1425242	SPINDLE ACTUA FC 100	R 1 077.35	R 1 129.11	R 51.76
1826242	WFB BOT SPINDLE 200	R 616.77	R 667.82	R 51.06
20380009	ORING R3210	R 768.56	R 881.77	R 113.21
36221009	SELLOCK PIN 2x50	R 358.43	R 409.09	R 50.66
39295009	CAP SCREW M8 4512	R 720.84	R 822.12	R 101.28
42746009	P/W CIRCLIPS 252	R 357.73	R 408.38	R 50.66
12218609	ACTUATOR 451S5	R 5 356.98	R 5 414.88	R 57.90
3125512	LOCKING DEVICE BFWH	R 383.10	R 433.80	R 50.70
300131	SPRING WASHER M10 21	R 681.56	R 782.82	R 101.25
791/11131	TENSION PIN 8745	R 365.48	R 416.15	R 50.67
1523712	BF SPRING 150	R 1 506.50	R 1 602.48	R 95.97
66206009	WASHER 854	R 1 189.57	R 1 285.45	R 95.87
37264009	CAP SCREW M6 989	R 1 542.67	R 1 678.20	R 135.53
3822512	MSTOP PLATE FB 23	R 2 882.05	R 2 978.46	R 96.41
1924142	SPINDLE MS 640	R 12 294.66	R 12 393.99	R 99.33
50236009	EXT CIRCLIP 15	R 1 094.82	R 1 190.66	R 95.84
1700424	B0DY 5021	R 2 639.46	R 2 657.63	R 18.17
359411	EXT PIPE 038	R 2 427.81	R 2 453.11	R 25.30
311/10751	RED SOCKET IBC 65x20	R 1 174.19	R 1 192.03	R 17.85
470/30751	BARREL NIPPEL HW 701	R 883.67	R 901.45	R 17.78
96421XE	CASTING LM 595	R 30 435.66	R 30 553.70	R 118.03
2407121	DISC MACH 084	R 12 029.25	R 12 311.17	R 281.92

Table 20: Total Cost per Month of Order Policies for Raw Materials Ordered from the Suppliers in China

Raw Materials		Total Cost per Month of Joint Order		
Joint Order No	**Drawing No**	**Proposed Order Policy Cost for the High Demand Period**	**Company's Current Order Policy Cost for the High Demand Period**	**Cost Saving when Proposed Order Policy is**
1	68403XE	R 250 669.77	R 293 772.96	R 43 103.18
	45811XE			
	14002XE			
	100729			
	794901			
	34603			
2	GSM171A0P	R 59 957.00	R 63 030.19	R 3 073.19
	M24910P			
3	1829301	R 502 971.99	R 520 247.41	R 17 275.43
	1423101			
	1633701			
	1721232			
	12313320			
	25262120			
4	GR3 L132L61	R 89 181.62	R 90 488.56	R 1 306.94
	GR3 L563L10			
5	LWLE47011C	R 613 276.37	R 621 117.36	R 7 841.00
	WL94110C			
	M122A0C			
	202A0C			
	452A0S			
	A71110FS			
	3611CFS			
	WLE87011C			
	MWLE17011C			
	MWLE87011C			
6	C33516	R 337 669.65	R 385 142.03	R 47 472.38
	151			
	281			
	34401			
	11497			
	972521			
	26901			
	10375EX11493			

5 Chapter 5 Validation of the Proposed Solution

5.1 The Statistical Analysis of the Sales Data

The nature of the demand of the products, Table 6, was validated through the expert opinion of the Managing Director of MineEquip. According to the Managing Director the results of the nature of the products demands correspond with what he experiences in practice.

5.2 The Inventory Control Model

The results of the proposed ordering policy was compared to MineEquip's current ordering policy to be able to recognize if the proposed ordering policy is more economic while providing the same level of customer service. In Table 19 the total cost per month of the proposed order policy and the current order policy for orders placed locally is displayed. The predicted saving per month if the proposed order policy replaces the current order policy is also illustrated. Table 20 lists the total cost per month of the proposed and current order policies for raw materials that are ordered in joint orders from suppliers in China. The anticipated cost saving if the proposed order policy substitutes the current order policy is also displayed.

The objective of this project is to improve the inventory management policies at MineEquip and the aim throughout the project is to reduce costs. By comparing the proposed ordering policies to the current ordering policies it is illustrated that the proposed ordering policies are most likely the more economical policies.

6 Recommendations and Final Conclusion

6.1 Recommendations

6.1.1 Sales Analysis

It is recommended to MineEquip to keep their number of sales and return products separately on their information system. With the return products included in the number of sales it is inaccurate to estimate the Company's demand for their products based on the sales figures.

6.1.2 Ordering Policy

Joint Orders from Suppliers in China

In Table 16 the proposed order quantities for the raw materials ordered from suppliers in China are listed together with the weight calculations for the raw materials and the joint orders. Amongst the joint orders, it is proposed to fill the twenty ton containers that will ship joint orders one, two, three and six with raw materials from class B and class C products. This will reduce the Company's raw material holding cost. It is more expensive to keep more raw materials from the class A products than from the other classes, because the class A products are usually the products with the highest unit costs. Joint order four nearly fills a twenty ton container. This container could also be filled with raw materials from other class products than class A's products. Joint order five will approximately fill two containers, the remainder could be filled with raw materials from non class A products.

The Proposed Ordering Policy Compared to the Current Ordering Policy

The proposed order policy is compared to the current order policy and it is most likely that the proposed ordering policy is more economical than the current order policy. MineEquip is advised to adapt the proposed ordering policy.

One of the advantages of adapting the proposed ordering policies are that the order cycle times will be greatly shorter than the current order cycle times for the foundries and the local suppliers who supplies the custom made orders. This will result in smaller order quantities and lower inventory costs.

The biggest advantage of adapting the proposed ordering policy is the large cost savings predicted if this ordering policy substitutes the current ordering policy.

Further Investigation

The Company is advised to investigate the matter of balancing holding cost against the cost of stores personnel for the orders placed locally. The reason why this is recommended is, because the only ordering cost incurred for orders placed locally are administration costs. Unfortunately this was discovered at a very late stage in the project and therefore this study is excluded from the scope of this project.

6.2 Final Conclusion

The class A products of MineEquip were identified with the use of ABC analysis, and the criterion used was the sum of the products respective Gross Profit values over the previous 12 months. This resulted in 33 products that accounts for only 5.5% of the total amount of products which contributes 51% to MineEquip's profit.

The results obtained from the sales analysis were used to identify the nature of the class A products. The results stated that the products' demands could be divided into two classes; class 1 consists of 11 products which are likely to have a step function in their demand and class 2 consists of 21 products whose demands are due to pure randomness.

The proposed inventory control model is the basic economic order quantity model with lead times. This model is chosen for the Company's unique circumstances based on the results obtained from the literature study and MineEquip's sales analysis. This model was applied to all of the raw materials used in the class A products.

The results obtained were a proposed order policy for each of these raw materials. This order policy consists of an economic order quantity, a reorder point (which gives notice when the stock has reached the amount of units when another order has to be placed) and a safety stock level according to the Company's required order fulfilment rate.

The proposed order policy displayed a monthly saving for each raw material when compared to the Company's current order policy.

There are nine out of the 119 raw materials ordered locally whose proposed order policy expects a cost saving of less than R10.00 per month when compared to the current order policy. If the proposed order policy is implemented it predicts that it could have cost savings of over a R 1000.00 per month for 46 of the raw materials. The remaining raw materials' proposed order policy has a cost saving between R10.00 and a R 1000.00 per month when compared to the current order policy. The total saving predicted by the proposed order policy for these 119 raw materials is R 192 712.01 per month.

For the raw materials ordered from suppliers in China the smallest anticipated cost saving, when the proposed order policy replaces the current order policy, is R 1 306.94 per month, and the largest is R 47 472.38 per month. The predicted total saving for these 34 raw materials if the proposed order policy substitutes the current order policy is R 120 072.11 per month.

The final conclusion made is that it will be more economical for all of MineEquip's raw materials of the class A products to implement the proposed order policies. The Company will still be able to maintain their 97.5% order fulfilment rate with the proposed order policies. The total saving achieved for all 153 raw materials of the class A products is R 312 784.12 per month.

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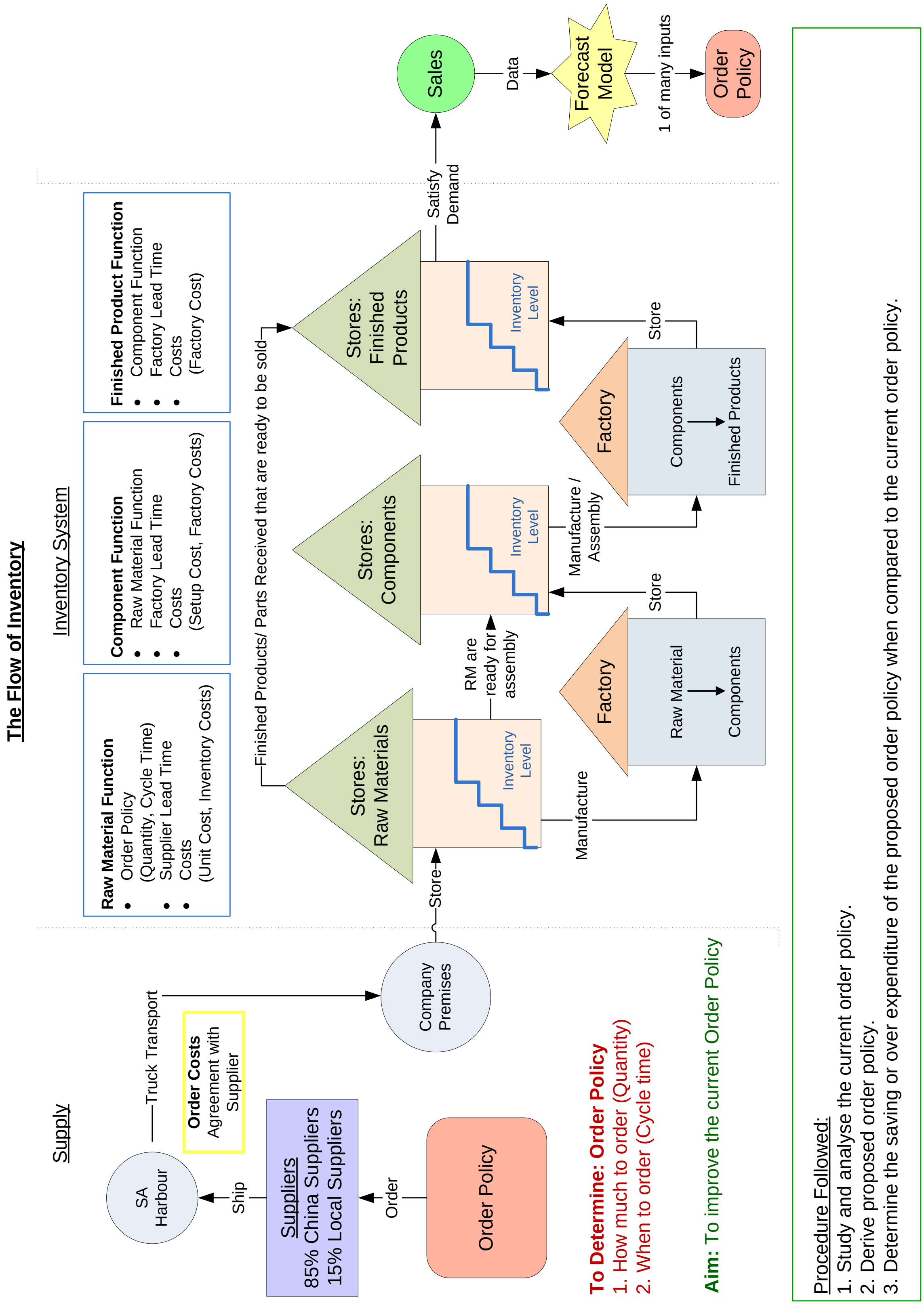
Appendixes

Appendix A: The Flow of Inventory

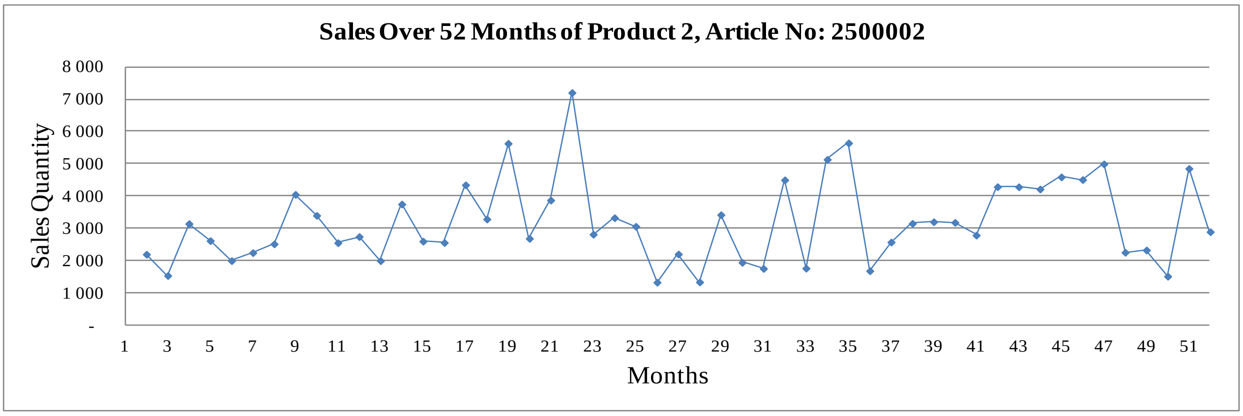


Appendix B: GP Values of the Class A Products

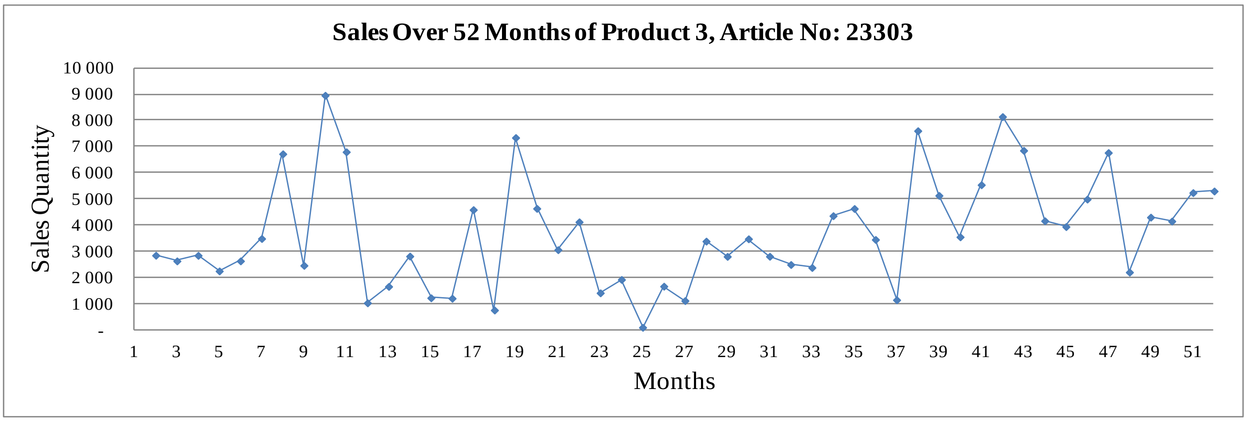
GP Values used to Rank the Class A Products		
Product Ranking	**Article No**	**GP Value**
1	2200020	R 2 097 754.42
2	2500002	R 1 518 500.97
3	23303	R 1 284 696.73
4	24301	R 1 218 130.08
5	1000	R 997 061.38
6	7341010	R 937 913.57
7	1800010	R 910 006.95
8	1650010	R 845 390.93
9	1300020	R 812 065.12
10	281312	R 768 222.01
11	1800030	R 701 493.38
12	9110020	R 692 089.79
13	1700010	R 647 158.00
14	4900010	R 639 404.60
15	2600010	R 627 361.11
16	1400020	R 621 109.80
17	2300030	R 607 430.30
18	4540010	R 592 526.24
19	7421010	R 550 830.47
20	5800010	R 550 473.90
21	8911010	R 541 880.27
22	4100010	R 508 947.68
23	3000010	R 472 615.28
24	1600010	R 444 803.36
25	250010	R 428 813.92
26	6251010	R 426 900.45
27	2790010	R 413 590.93
28	2030	R 410 339.34
29	2431	R 405 763.67
30	1390010	R 400 332.59
31	6200010	R 397 232.13
32	8600030	R 394 901.75
33	2335	R 394 602.90

Appendix C: Sales Data of the Class A Products

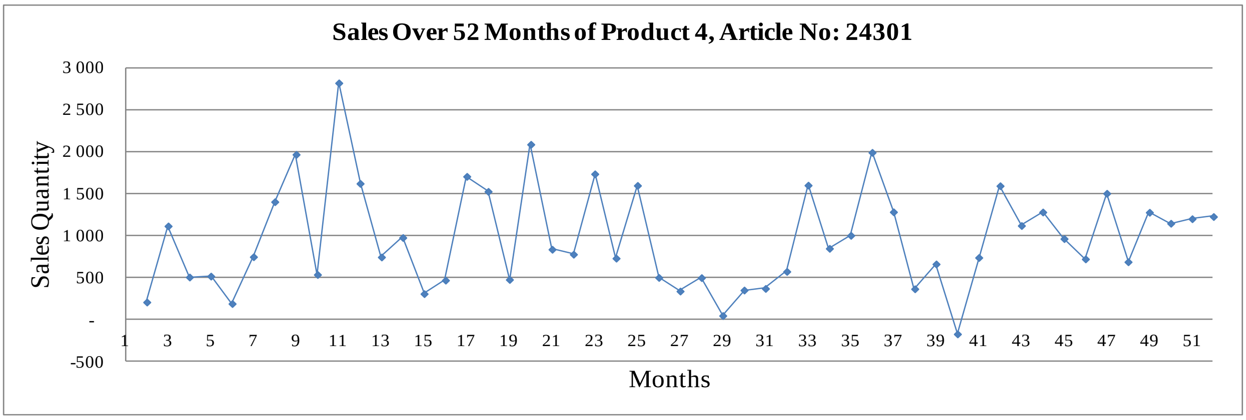
The products are in the order of their Gross Profit Product Ranking. Thus Product 1 has the highest GP value and Product 33 the lowest GP value.



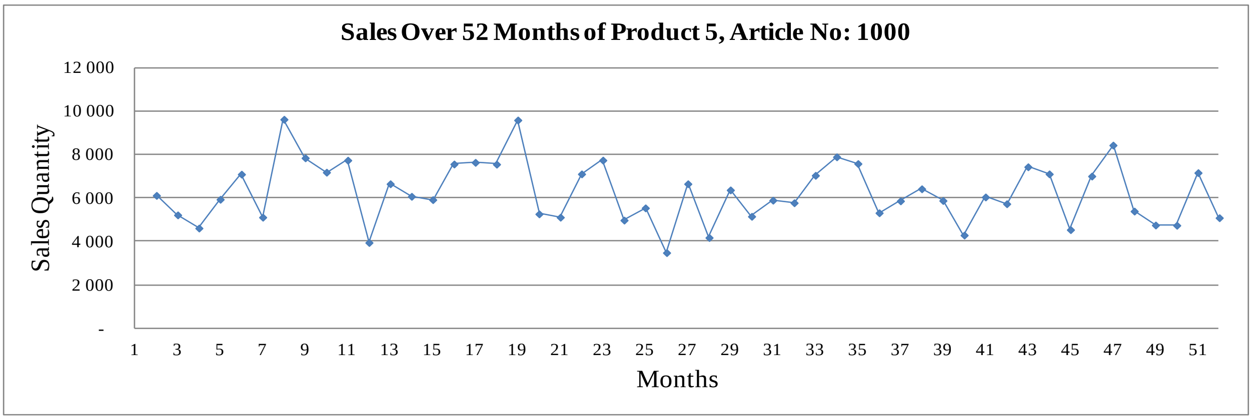
From this figure the sales of Product 2 appear to not have a trend.



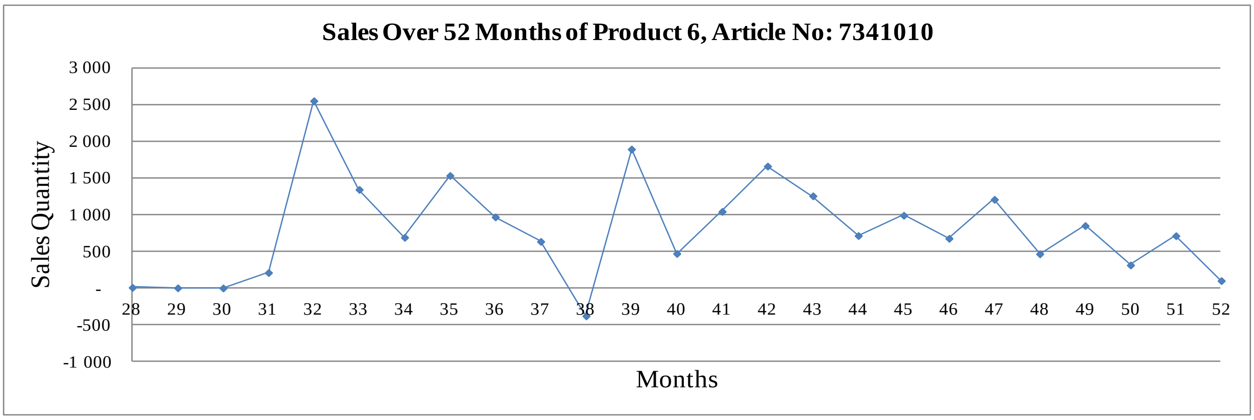
From this figure the sales of Product 3 appear to not have a trend.



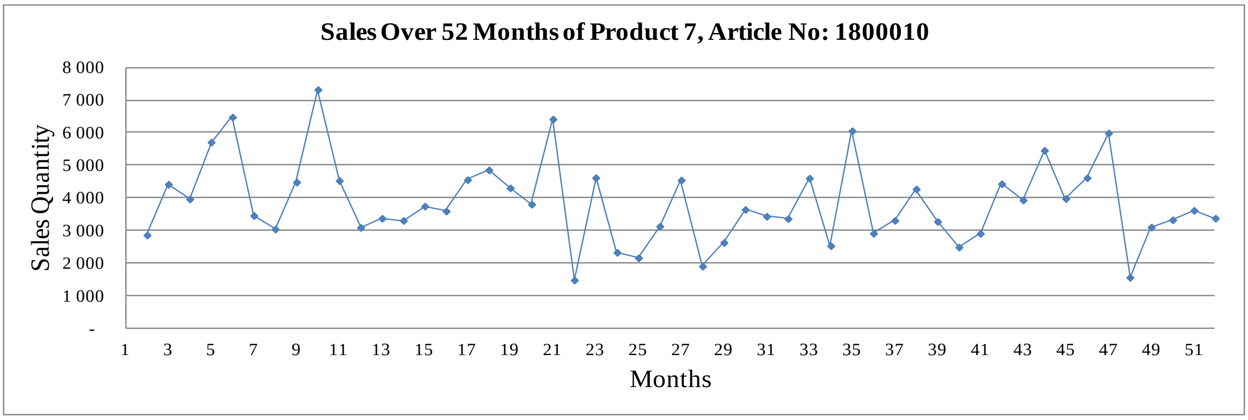
From this figure the sales of Product 4 appear to not have a trend.



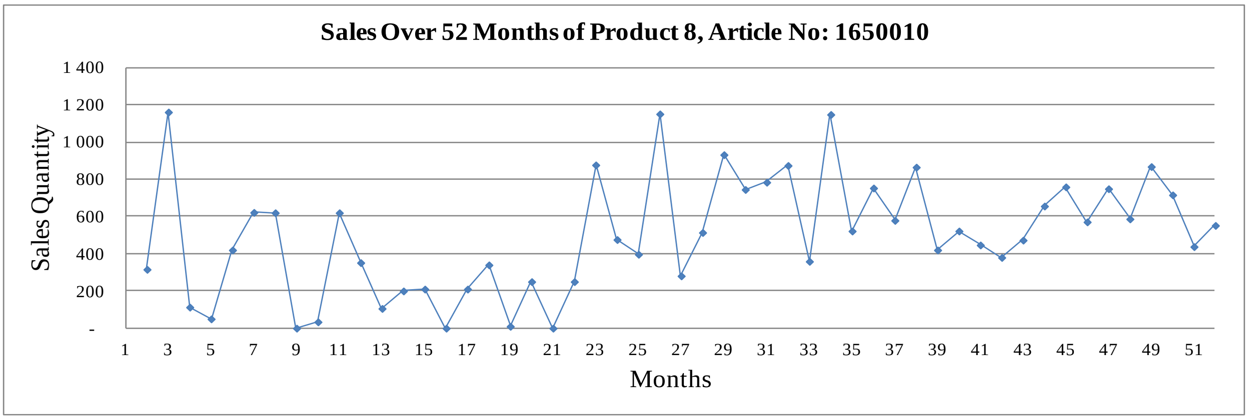
From this figure the sales of Product 5 appear to not have a trend.



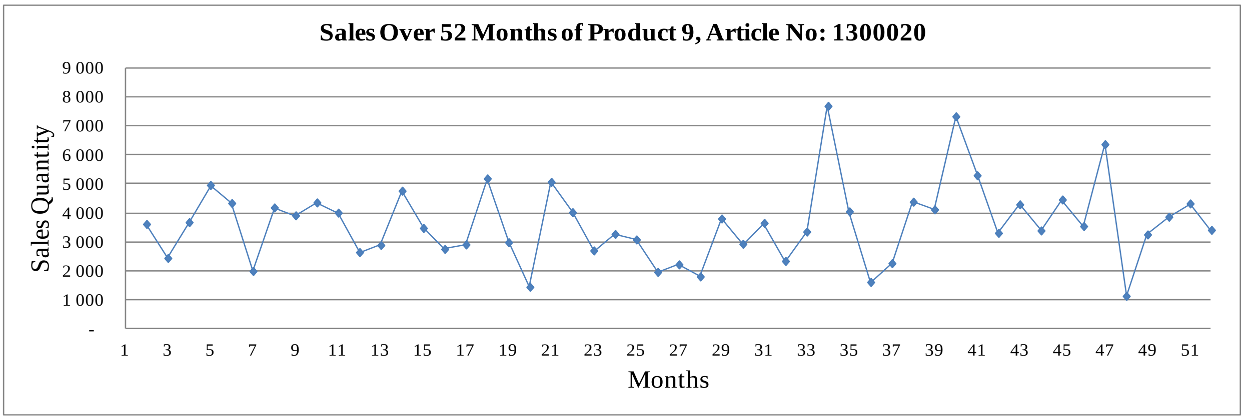
From this figure the sales of Product 6 appear to not have a trend.



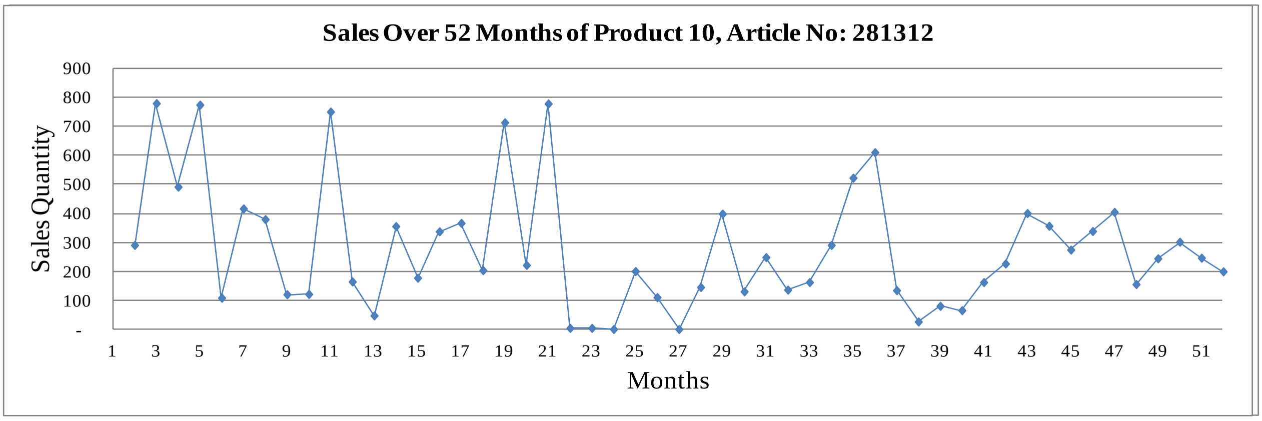
From this figure the sales of Product 7 appear to not have a trend.



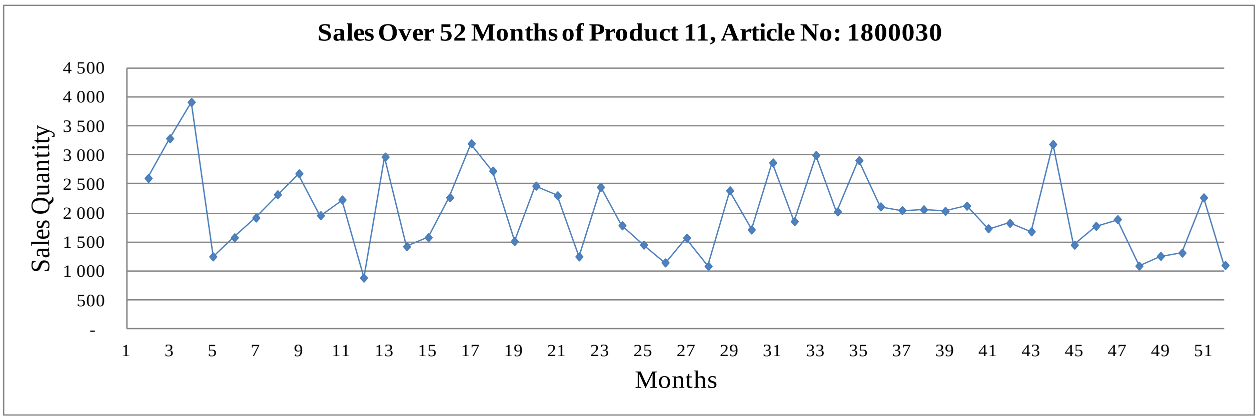
From this figure the sales of Product 8 appear to not have a trend.



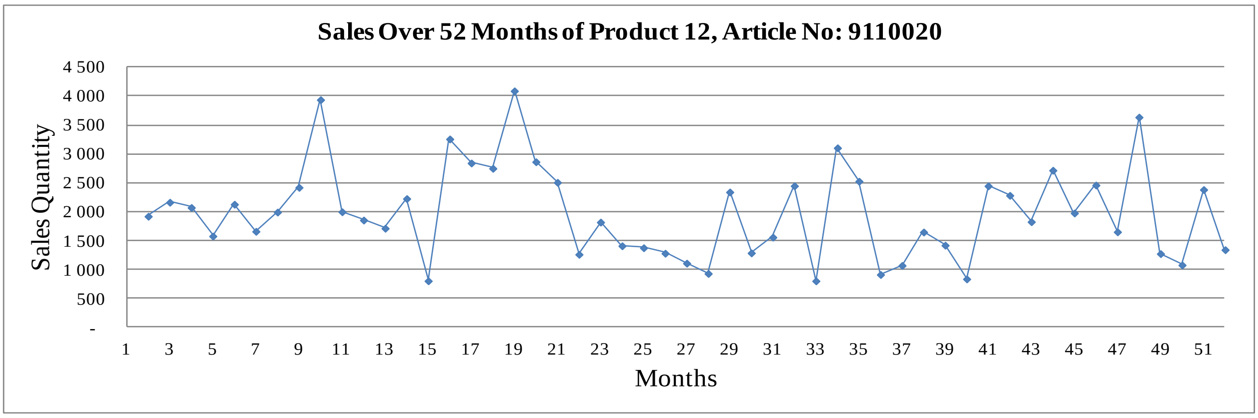
From this figure the sales of Product 9 appear to not have a trend.



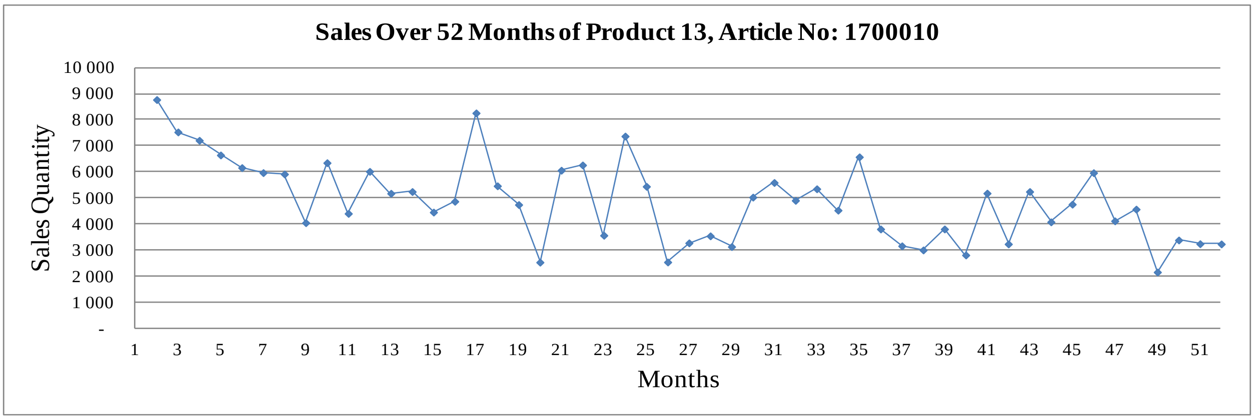
From this figure the sales of Product 10 appear to not have a trend.



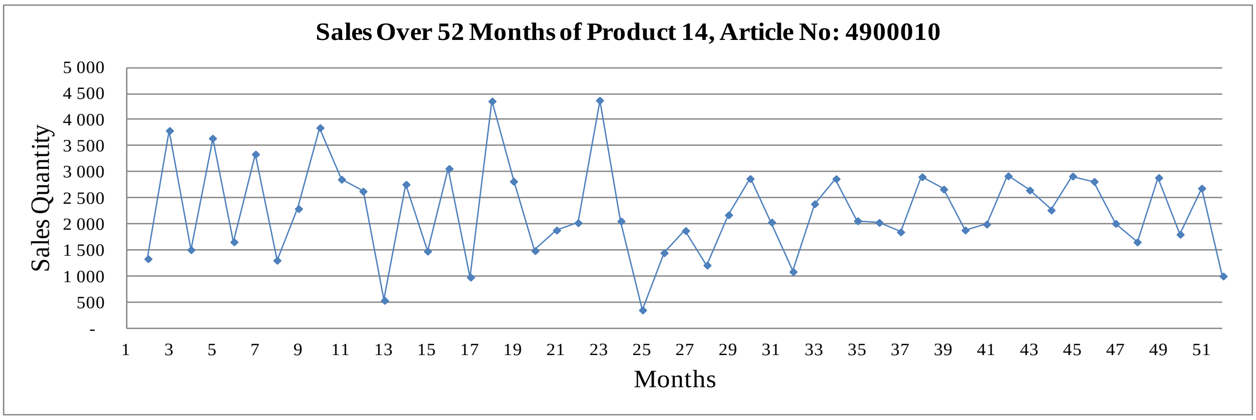
From this figure the sales of Product 11 appear to not have a trend.



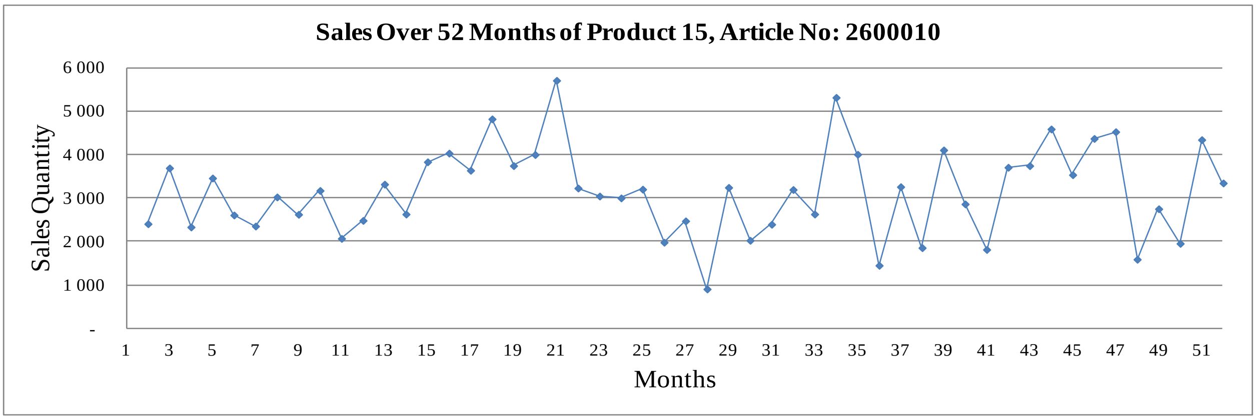
From this figure the sales of Product 12 appear to not have a trend.



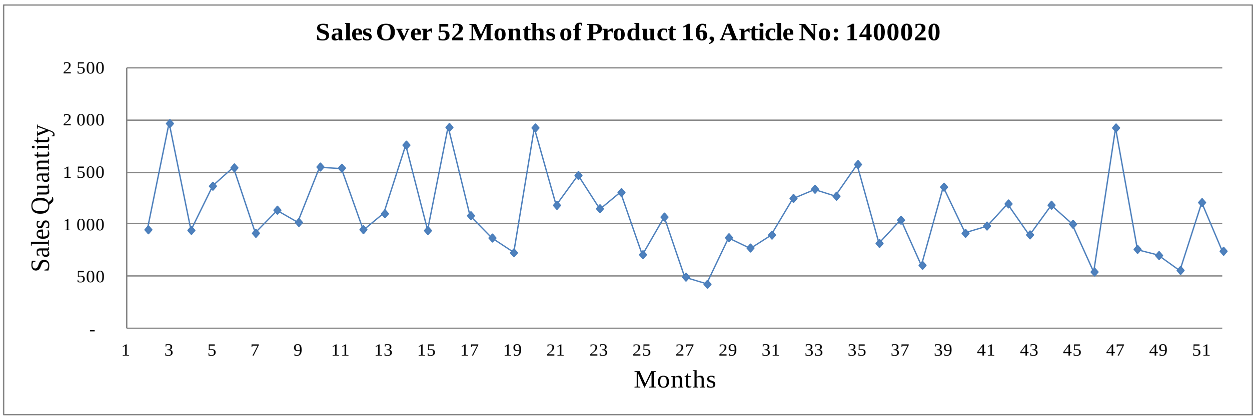
From this figure the sales of Product 13 appear to not have a trend.



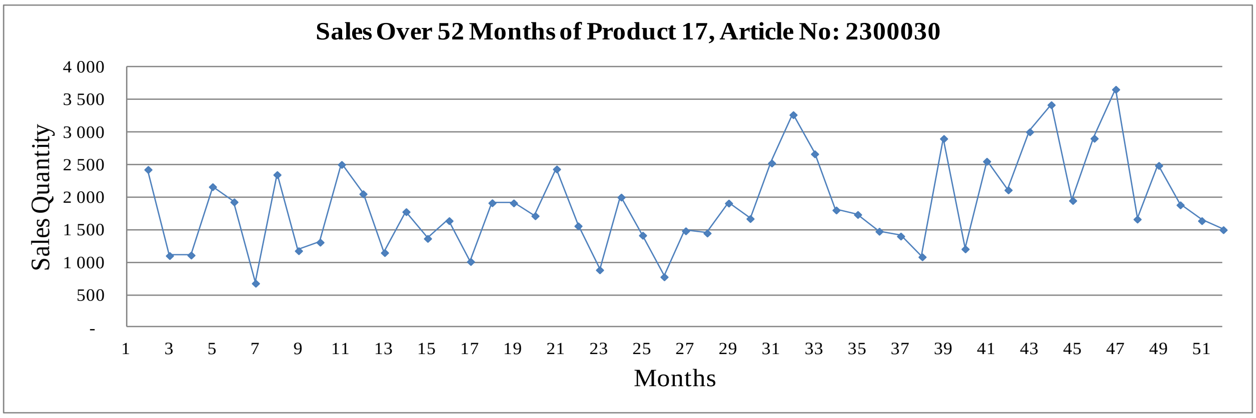
From this figure the sales of Product 14 appear to not have a trend.



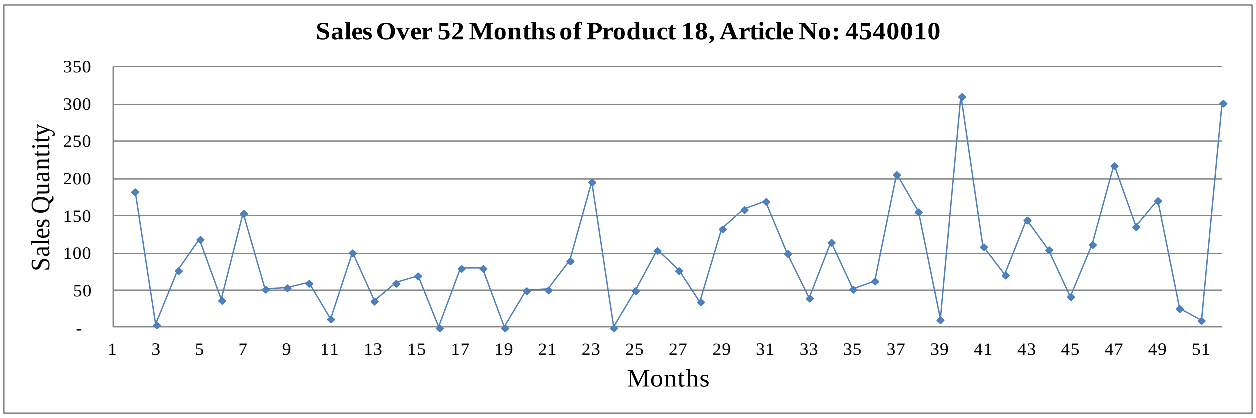
From this figure the sales of Product 15 appear to not have a trend.



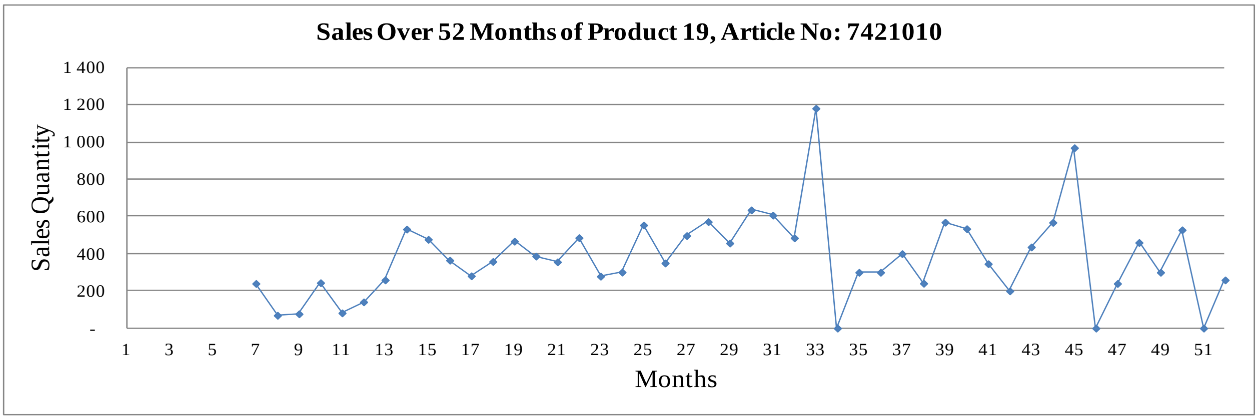
From this figure the sales of Product 16 appear to not have a trend.



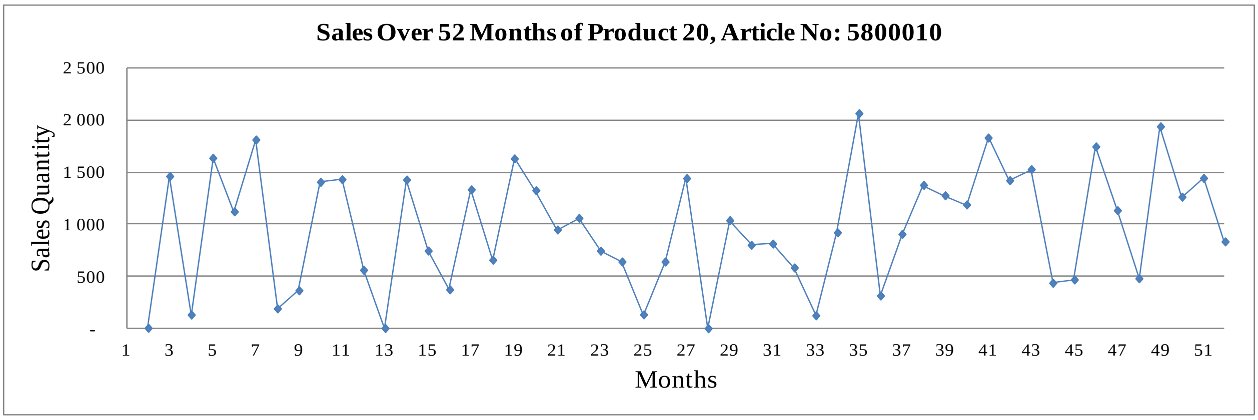
From this figure the sales of Product 17 appear to not have a trend.



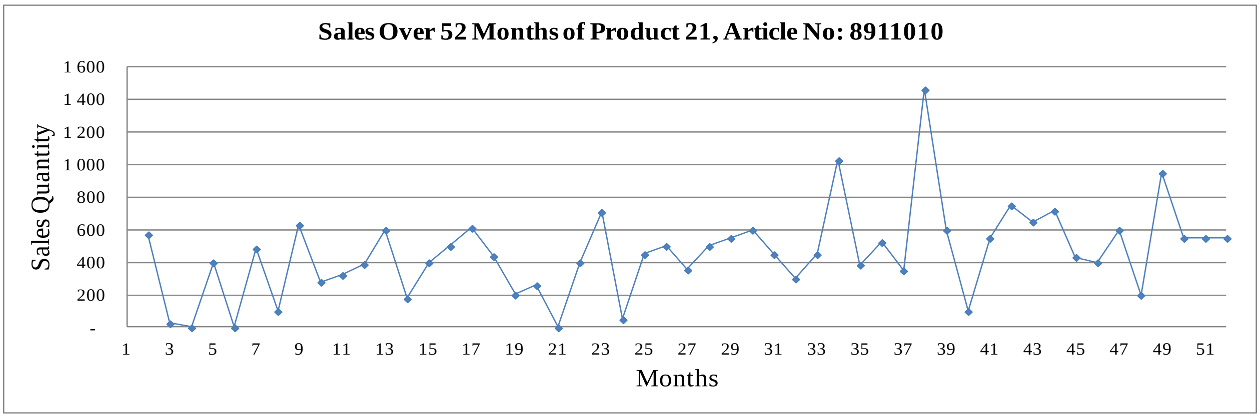
From this figure the sales of Product 18 appear to not have a trend.



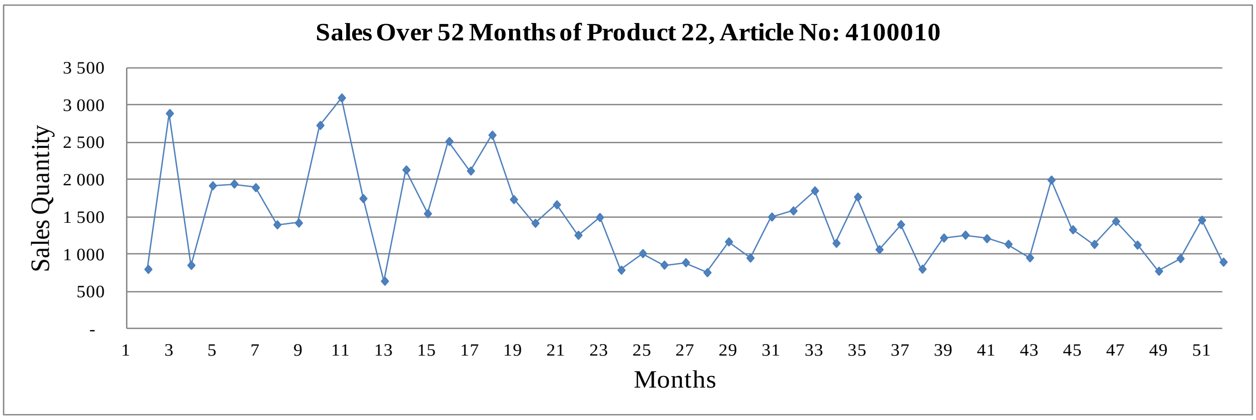
From this figure the sales of Product 19 appear to not have a trend.



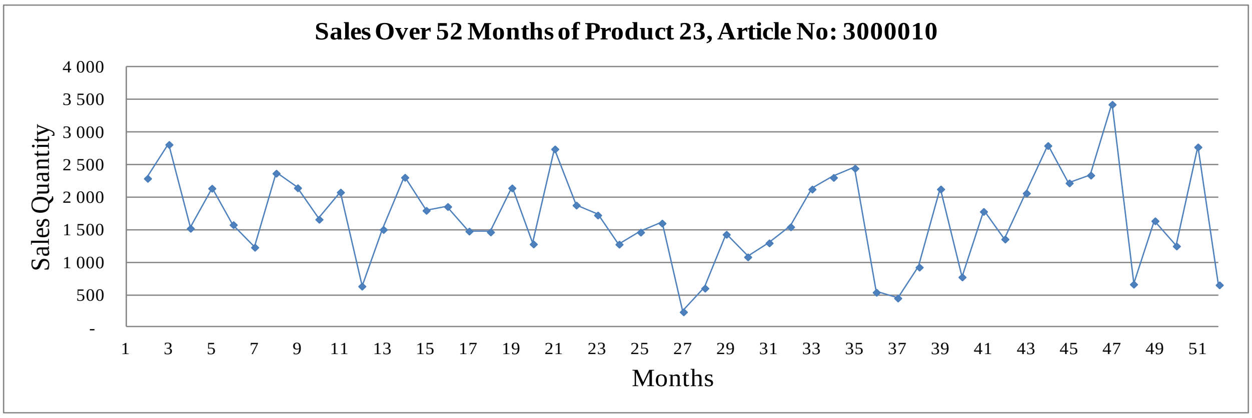
From this figure the sales of Product 20 appear to not have a trend.



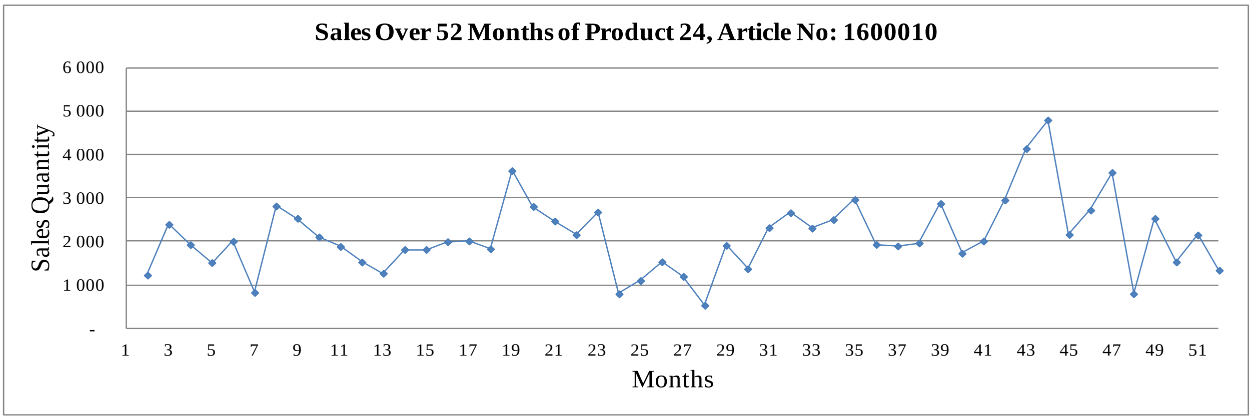
From this figure the sales of Product 21 appear to not have a trend.



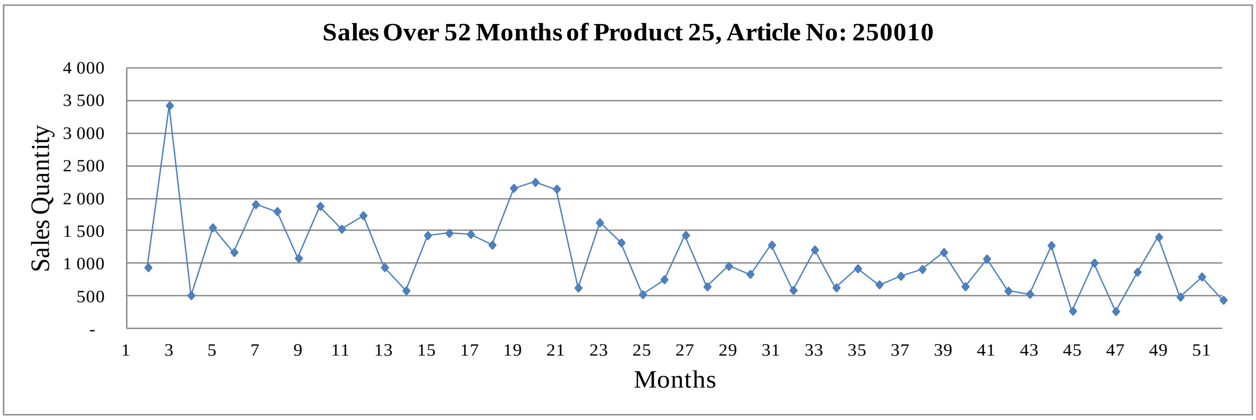
From this figure the sales of Product 22 appear to not have a trend.



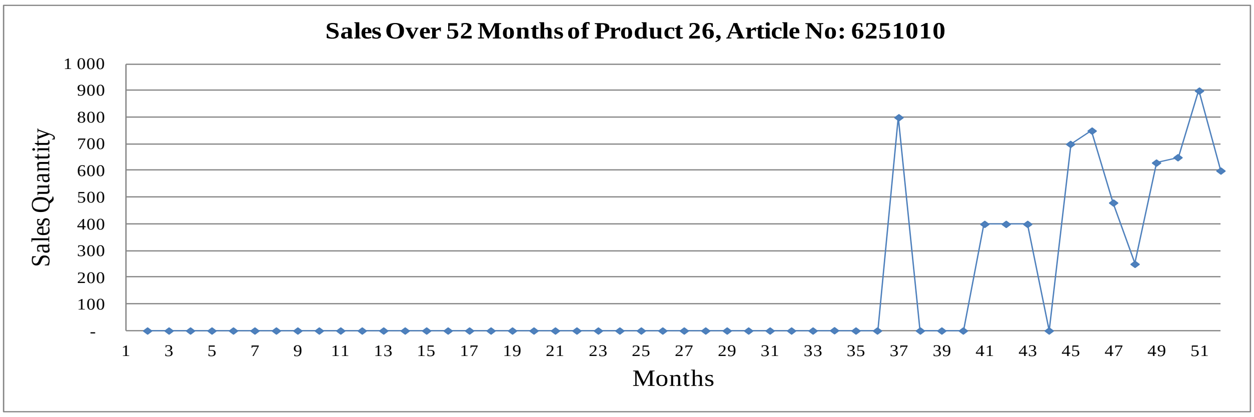
From this figure the sales of Product 23 appear to not have a trend.



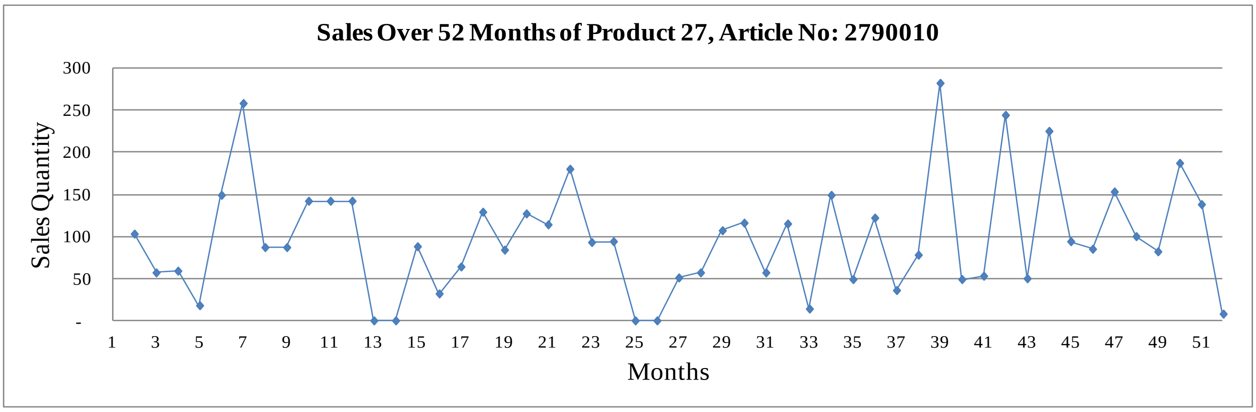
From this figure the sales of Product 24 appear to not have a trend.



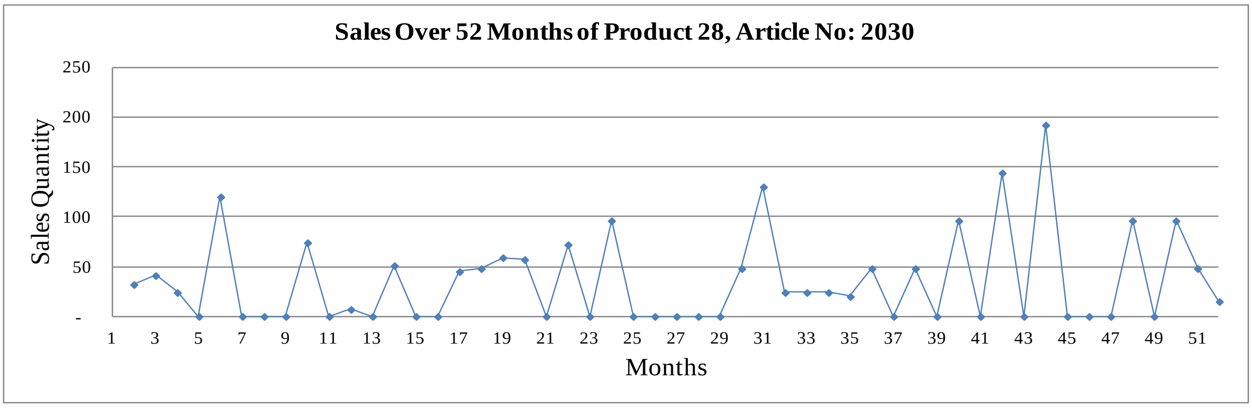
From this figure the sales of Product 25 appear to not have a trend.



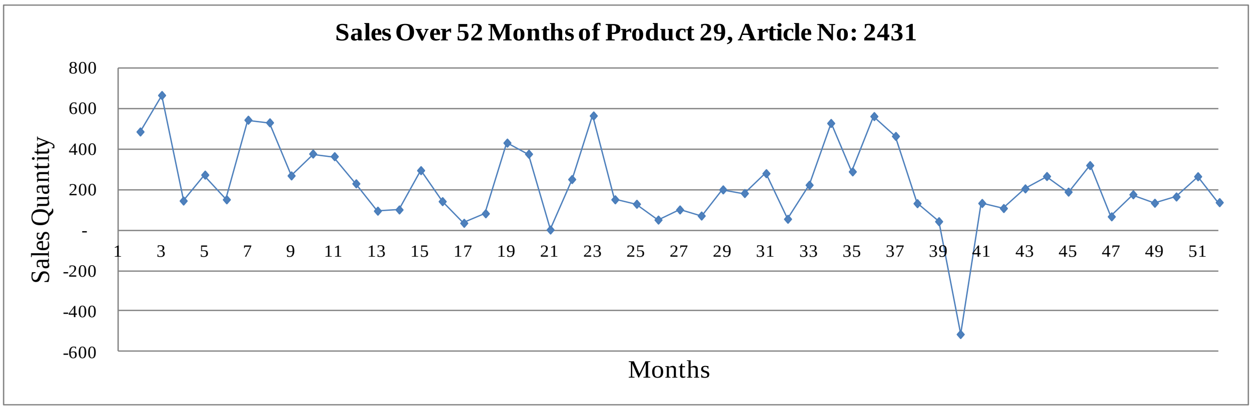
From this figure the sales of Product 26 appear to have a trend.



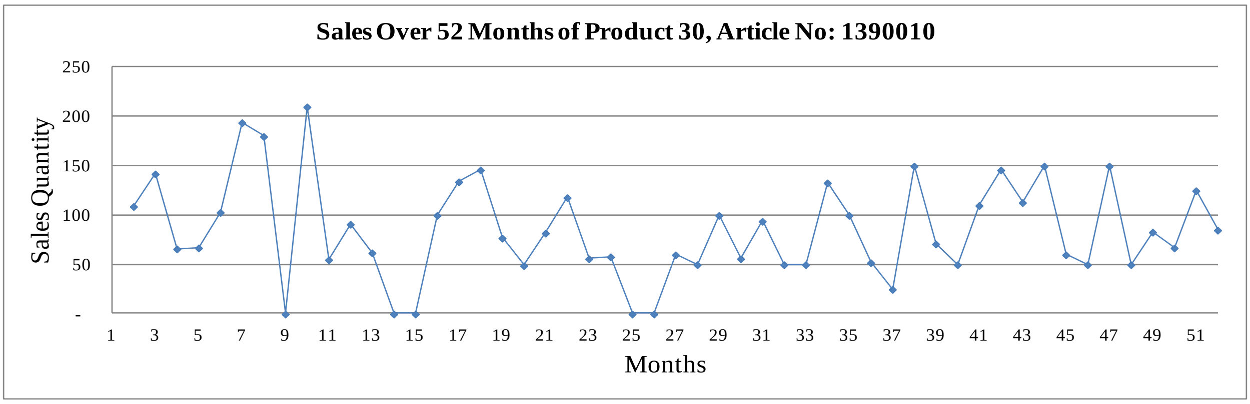
From this figure the sales of Product 27 appear to not have a trend.



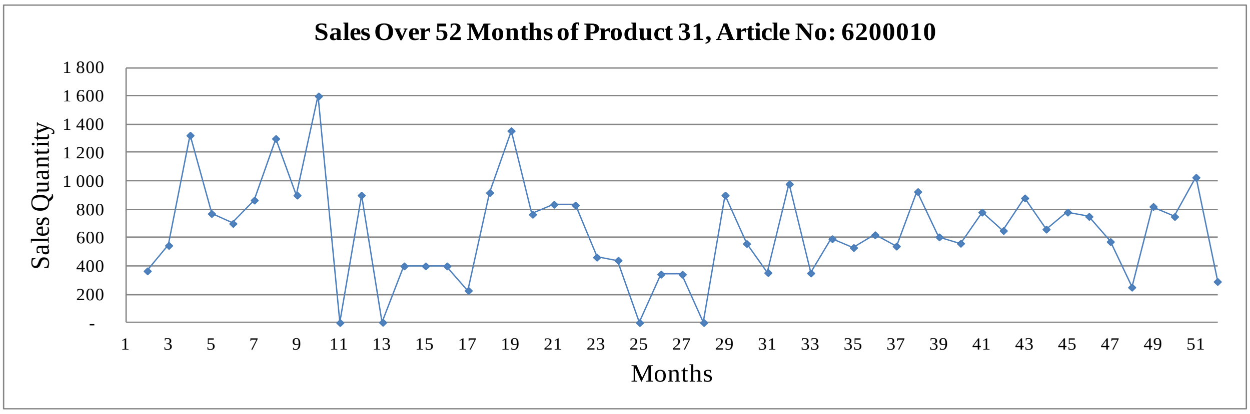
From this figure the sales of Product 28 appear to not have a trend.



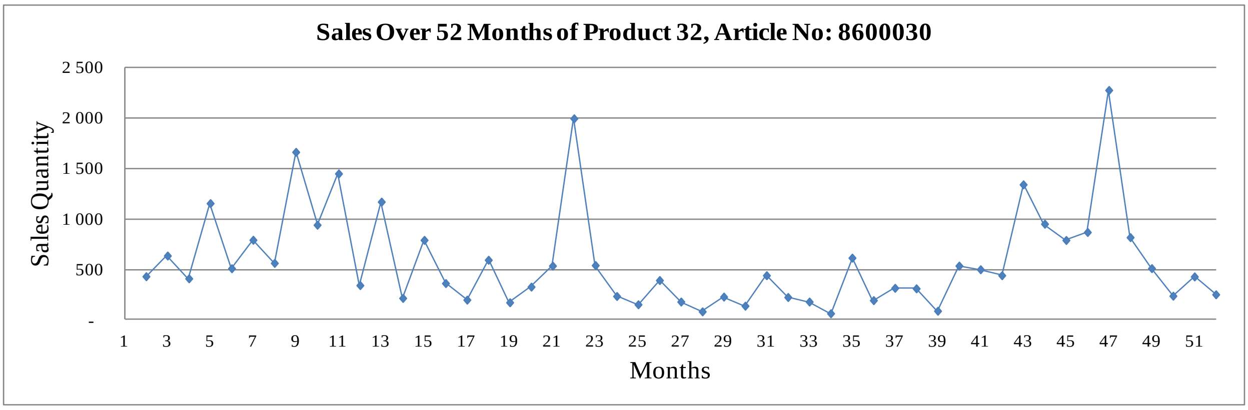
From this figure the sales of Product 29 appear to not have a trend.



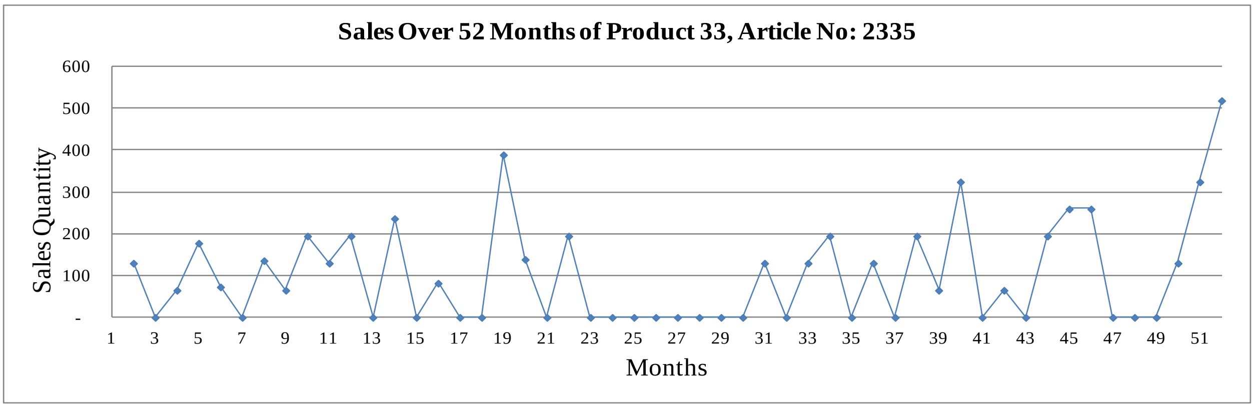
From this figure the sales of Product 30 appear to not have a trend.



From this figure the sales of Product 31 appear to not have a trend.

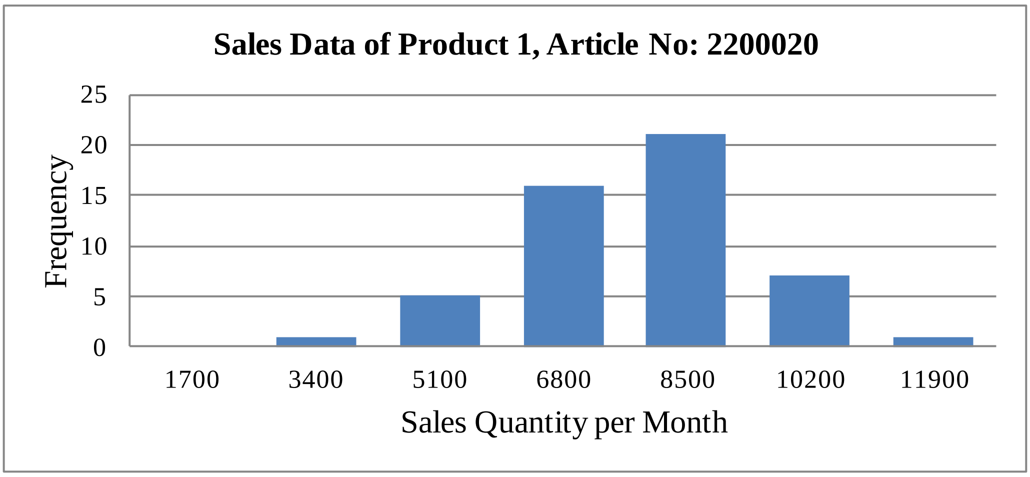


From this figure the sales of Product 32 appear to not have a trend.

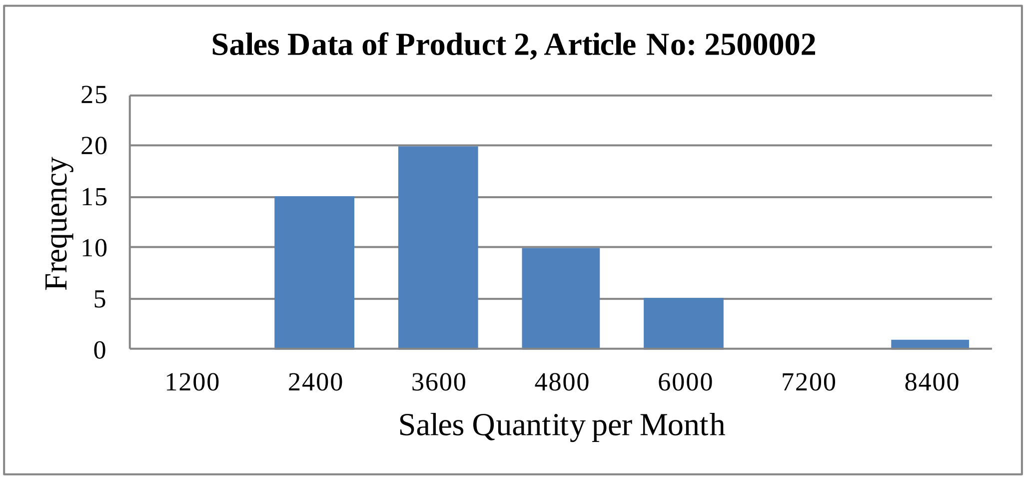


From this figure the sales of Product 33 appear to not have a trend.

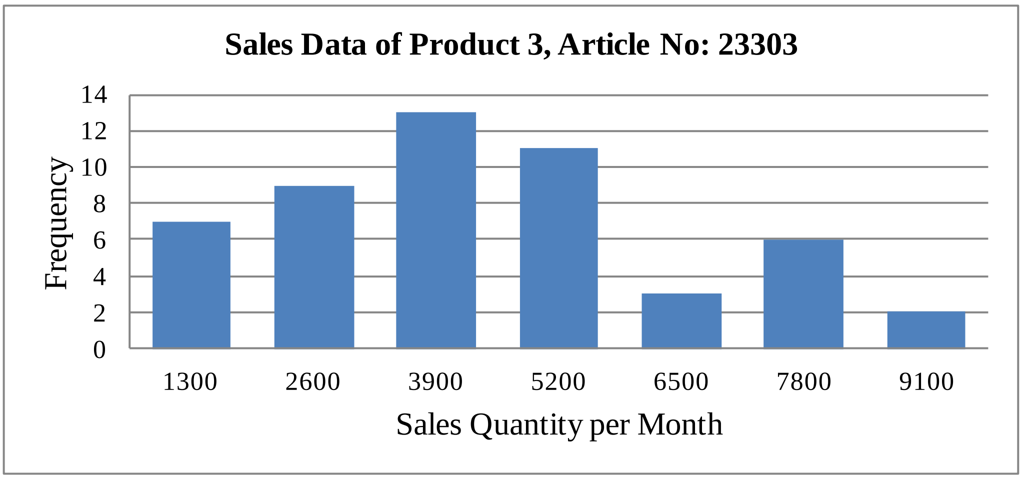
Appendix D: Histogram, Kurtosis and Skewness Results for the Sales Data of the Class A Products



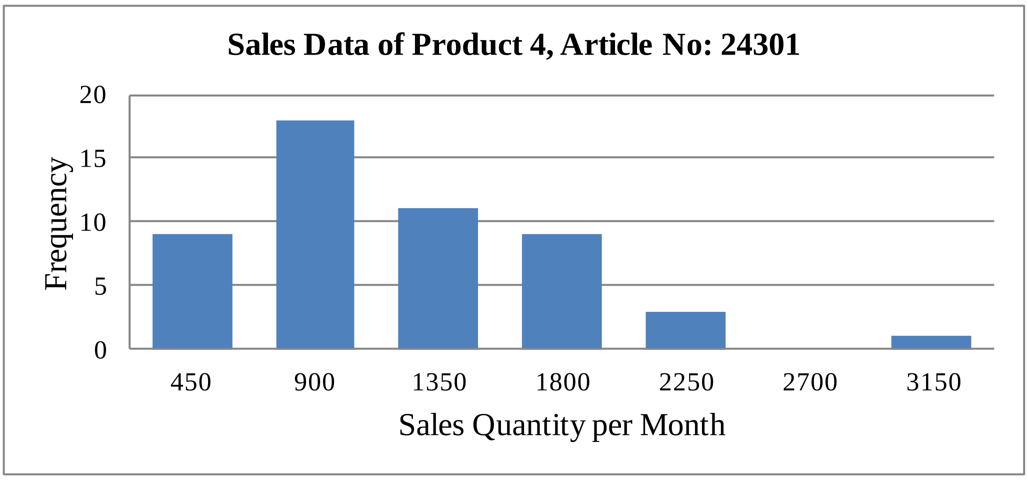
Summary Statistics of Product 1, Article No: 2200020					
Mean	6919.9608	Sample Variance	2792934.9984	Minimum	3157.0000
Standard Error	234.0159	**Kurtosis**	**0.1954**	Maximum	11450.0000
Median	7101.0000	**Skewness**	**-0.0665**	Sum	352918.0000
Standard Deviation	1671.2076	Range	8293.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



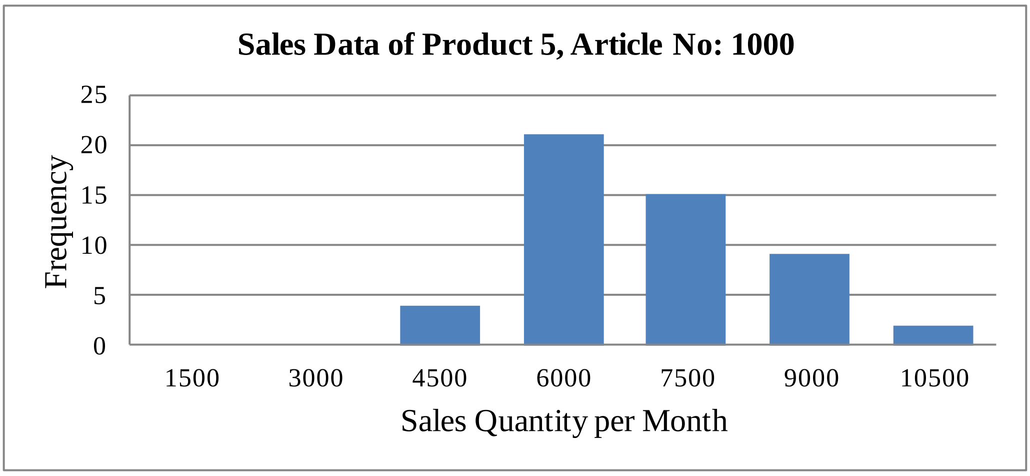
Summary Statistics of Product 2, Article No: 2500002					
Mean	3183.7647	Sample Variance	1613904.5835	Minimum	1326.0000
Standard Error	177.8909	**Kurtosis**	**0.6830**	Maximum	7205.0000
Median	2892.0000	**Skewness**	**0.8533**	Sum	162372.0000
Standard Deviation	1270.3954	Range	5879.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



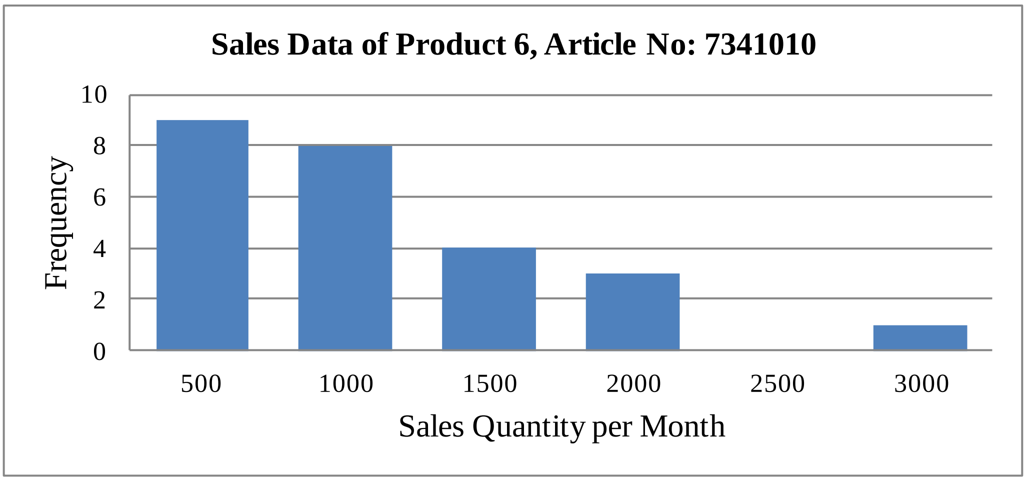
Summary Statistics of Product 3, Article No: 23303					
Mean	3706.9216	Sample Variance	4337121.3137	Minimum	95.0000
Standard Error	291.6189	**Kurtosis**	**-0.1912**	Maximum	8955.0000
Median	3449.0000	**Skewness**	**0.6135**	Sum	189053.0000
Standard Deviation	2082.575644	Range	8860	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



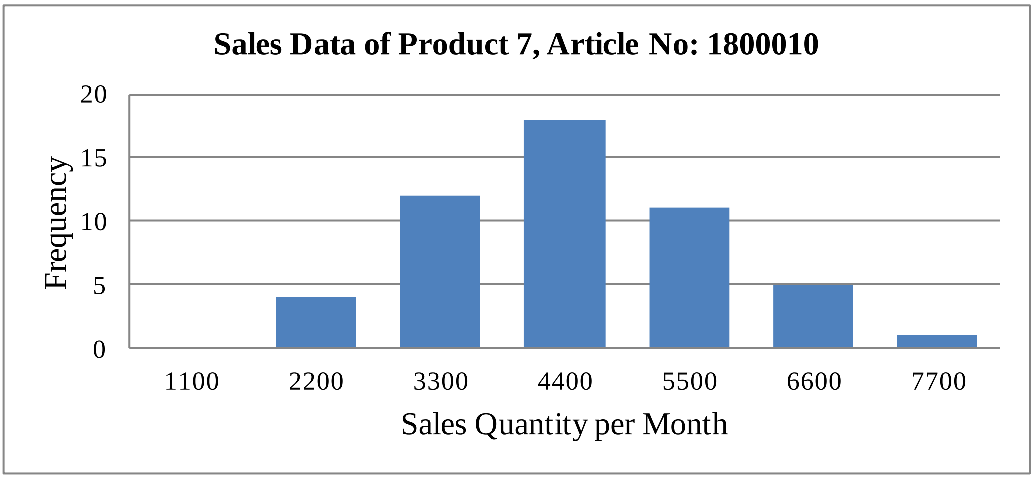
Summary Statistics of Product 4, Article No: 24301					
Mean	965.4314	Sample Variance	364487.3302	Minimum	-174.0000
Standard Error	84.5388	**Kurtosis**	**0.4199**	Maximum	2818.0000
Median	835.0000	**Skewness**	**0.6633**	Sum	49237.0000
Standard Deviation	603.7279	Range	2992.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



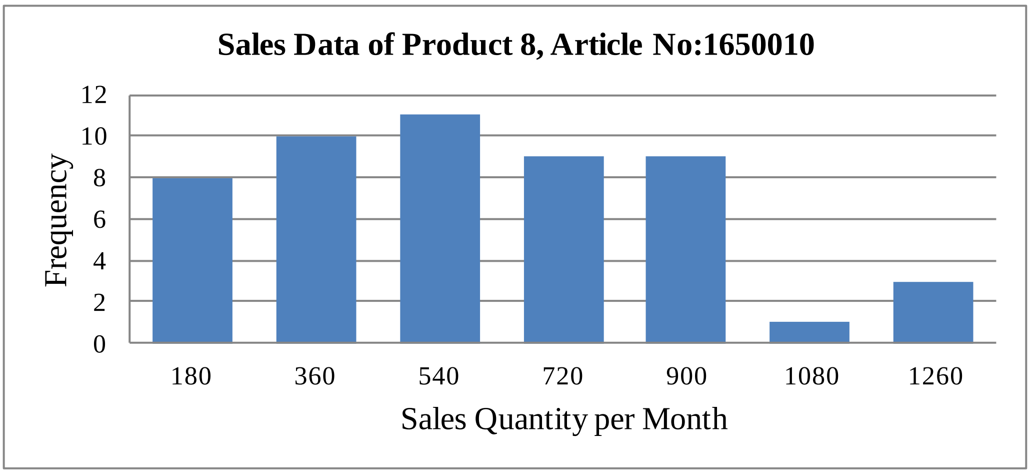
Summary Statistics of Product 5, Article No: 1000					
Mean	6243.2941	Sample Variance	1884820.8118	Minimum	3482.0000
Standard Error	192.2427	**Kurtosis**	**-0.1535**	Maximum	9621.0000
Median	6044.0000	**Skewness**	**0.3247**	Sum	318408.0000
Standard Deviation	1372.8878	Range	6139.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



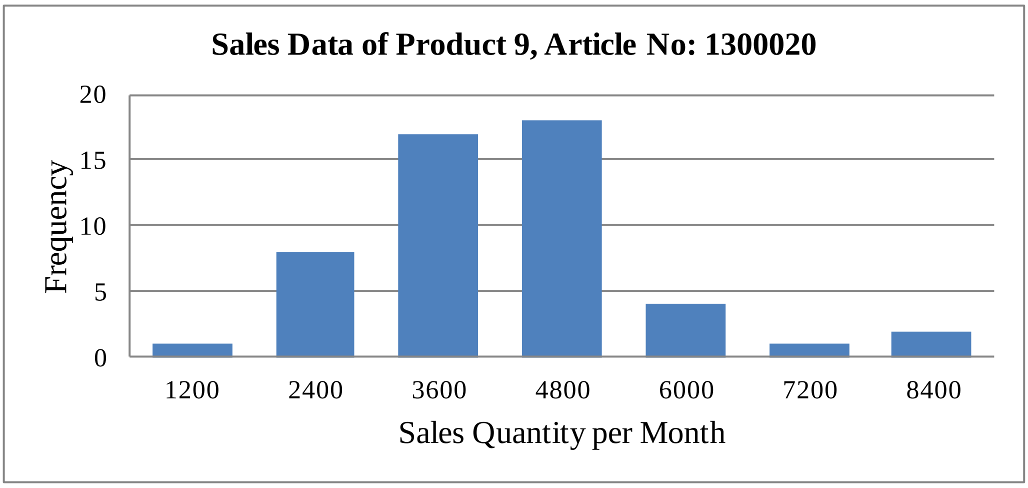
Summary Statistics of Product 6, Article No: 7341010					
Mean	796.1200	Sample Variance	457723.1933	Minimum	-380.0000
Standard Error	135.3105	**Kurtosis**	**0.5328**	Maximum	2550.0000
Median	712.0000	**Skewness**	**0.6227**	Sum	19903.0000
Standard Deviation	676.5524	Range	2930.0000	Count	25.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



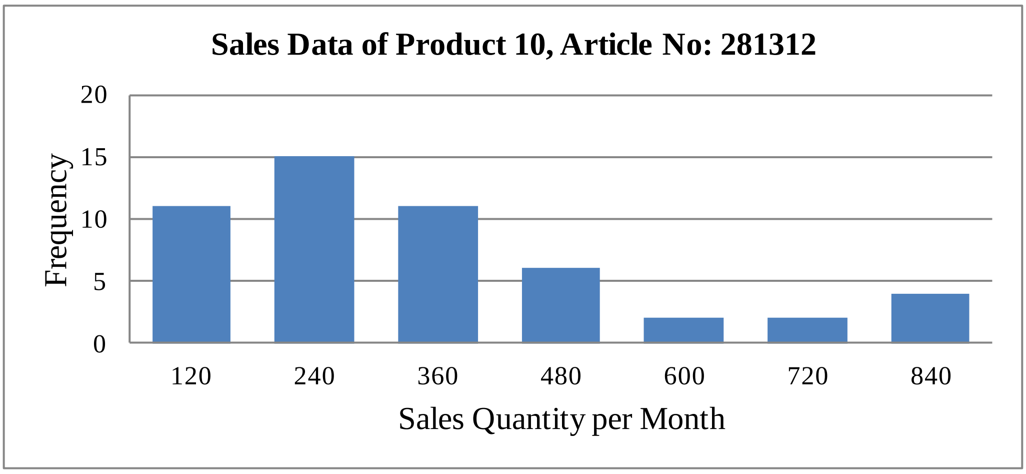
Summary Statistics of Product 7, Article No: 1800010					
Mean	3847.8824	Sample Variance	1583455.2259	Minimum	1476.0000
Standard Error	176.2048	**Kurtosis**	**0.4456**	Maximum	7321.0000
Median	3616.0000	**Skewness**	**0.6196**	Sum	196242.0000
Standard Deviation	1258.3542	Range	5845.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



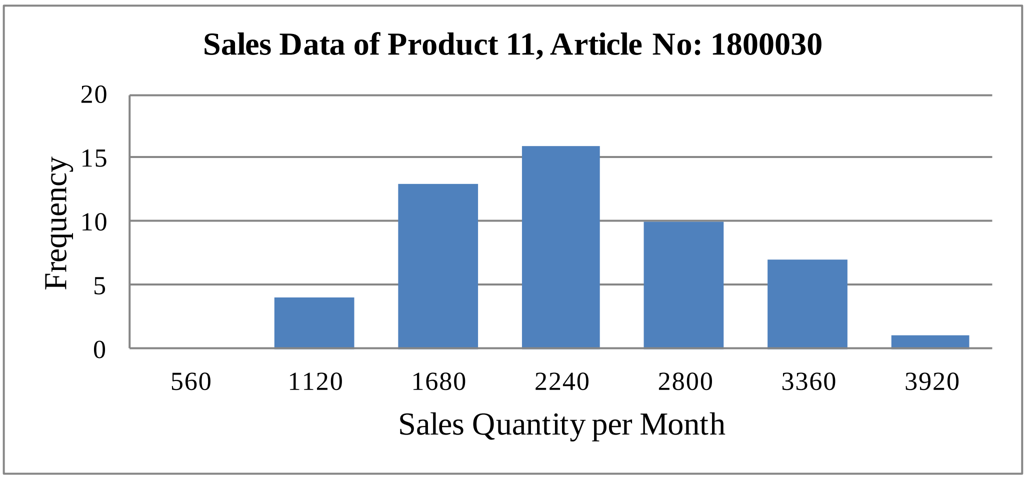
Summary Statistics of Product 8, Article No: 1650010					
Mean	495.6667	Sample Variance	95620.8667	Minimum	0.0000
Standard Error	43.3003	**Kurtosis**	**-0.4649**	Maximum	1161.0000
Median	476.0000	**Skewness**	**0.2458**	Sum	25279.0000
Standard Deviation	309.2262	Range	1161.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



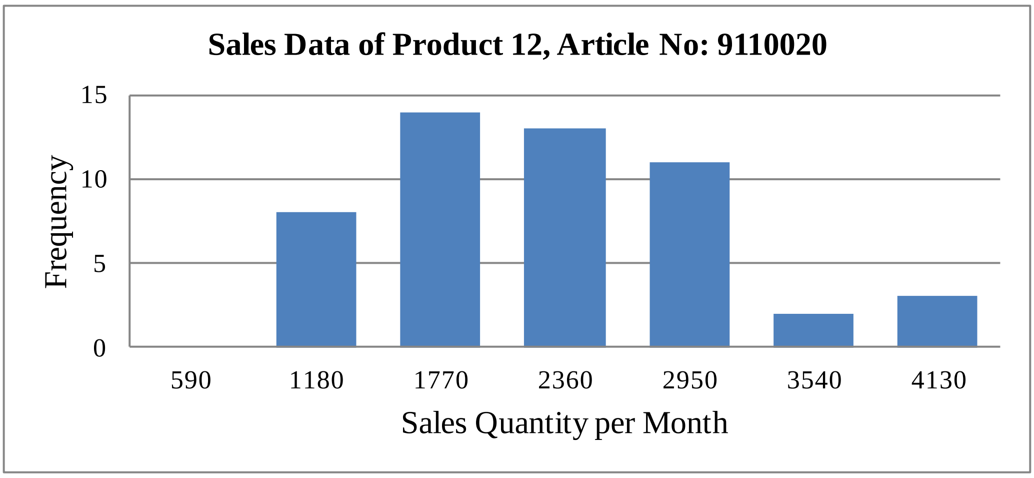
Summary Statistics of Product 9, Article No: 1300020					
Mean	3613.4314	Sample Variance	1776254.8102	Minimum	1120.0000
Standard Error	186.6240	**Kurtosis**	**1.5592**	Maximum	7683.0000
Median	3532.0000	**Skewness**	**0.8377**	Sum	184285.0000
Standard Deviation	1332.7621	Range	6563.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



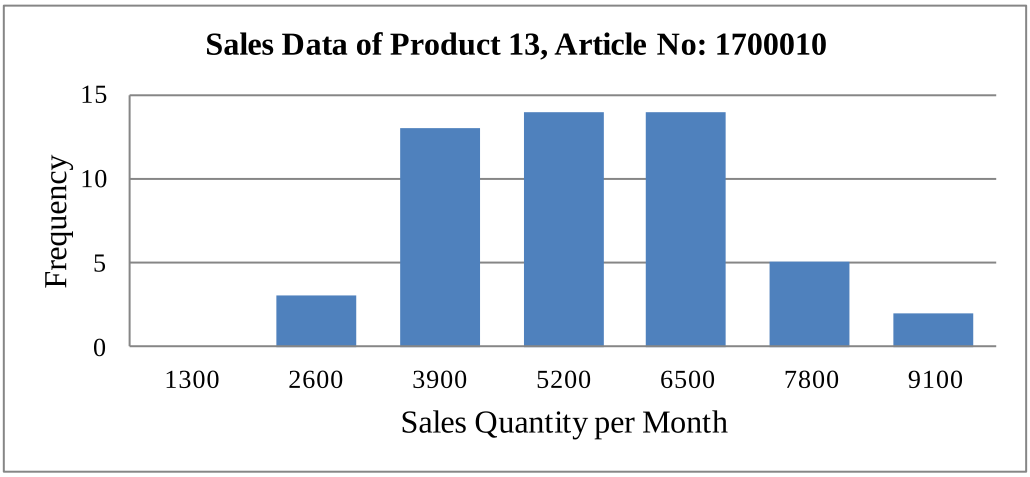
Summary Statistics of Product 10, Article No: 281312					
Mean	277.6078	Sample Variance	45236.6431	Minimum	0.0000
Standard Error	29.7824	**Kurtosis**	**0.4526**	Maximum	779.0000
Median	226.0000	**Skewness**	**1.0101**	Sum	14158.0000
Standard Deviation	212.6891	Range	779.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



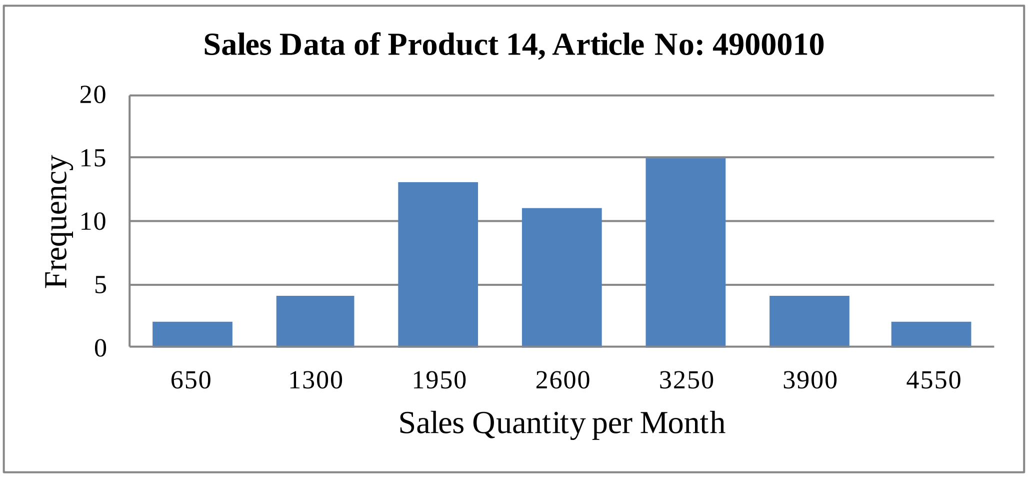
Summary Statistics of Product 11, Article No: 1800030					
Mean	2026.5294	Sample Variance	455428.8141	Minimum	879.0000
Standard Error	94.4986	**Kurtosis**	**-0.0498**	Maximum	3912.0000
Median	1956.0000	**Skewness**	**0.5620**	Sum	103353.0000
Standard Deviation	674.8547	Range	3033.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



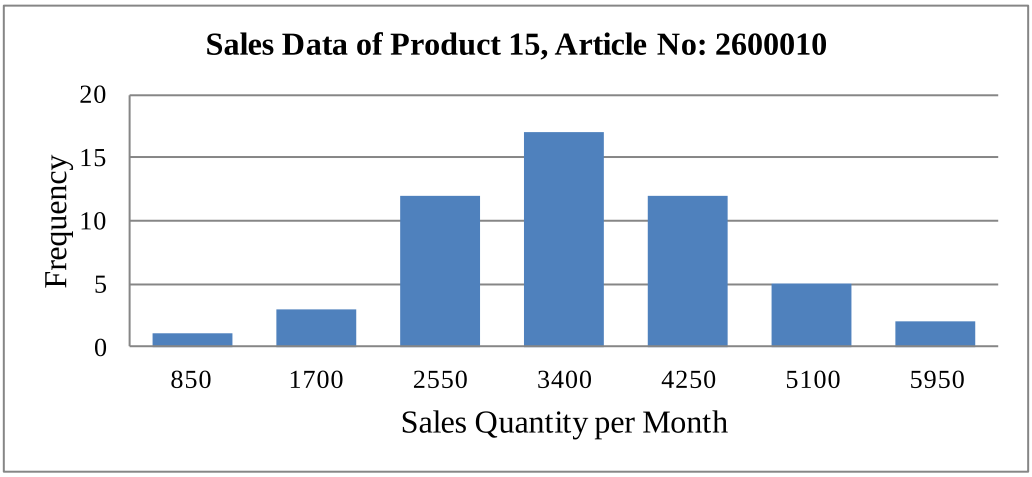
Summary Statistics of Product 12, Article No: 9110020					
Mean	1989.0980	Sample Variance	628240.2102	Minimum	812.0000
Standard Error	110.9884	**Kurtosis**	**0.2358**	Maximum	4098.0000
Median	1930.0000	**Skewness**	**0.6758**	Sum	101444.0000
Standard Deviation	792.6161	Range	3286.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



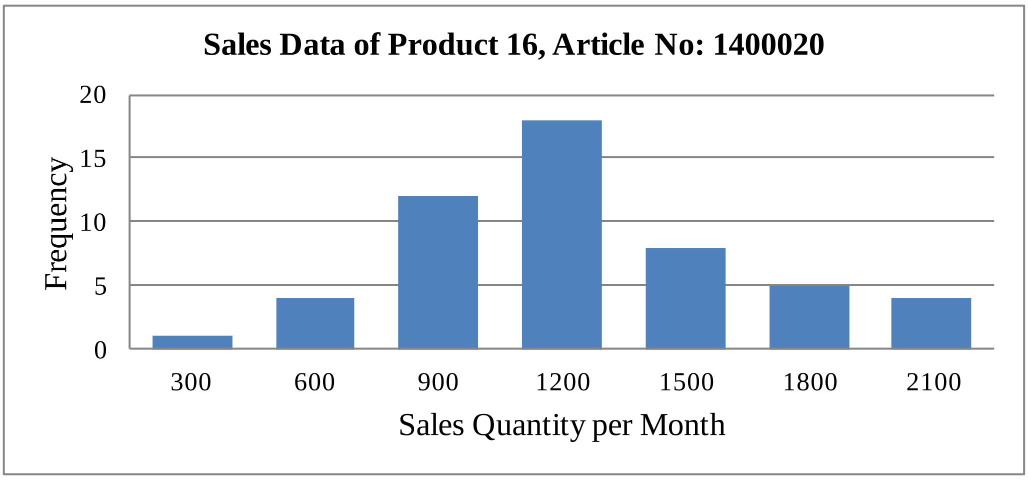
Summary Statistics of Product 13, Article No: 1700010					
Mean	4877.9608	Sample Variance	2369084.9984	Minimum	2157.0000
Standard Error	215.5288	**Kurtosis**	**-0.2814**	Maximum	8774.0000
Median	4871.0000	**Skewness**	**0.4002**	Sum	248776.0000
Standard Deviation	1539.1832	Range	6617.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



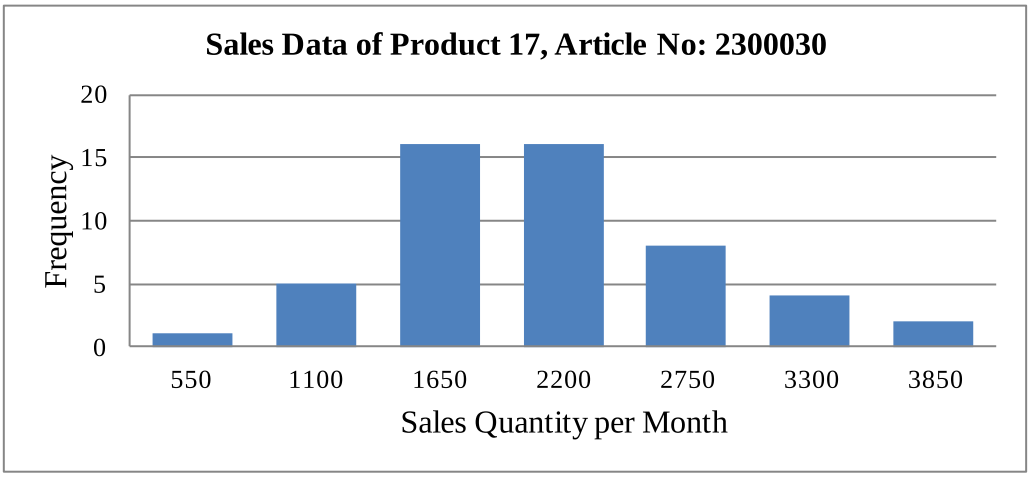
Summary Statistics of Product 14, Article No: 4900010					
Mean	2262.3725	Sample Variance	804939.1984	Minimum	351.0000
Standard Error	125.6309	**Kurtosis**	**0.0148**	Maximum	4374.0000
Median	2062.0000	**Skewness**	**0.2770**	Sum	115381.0000
Standard Deviation	897.1840	Range	4023.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



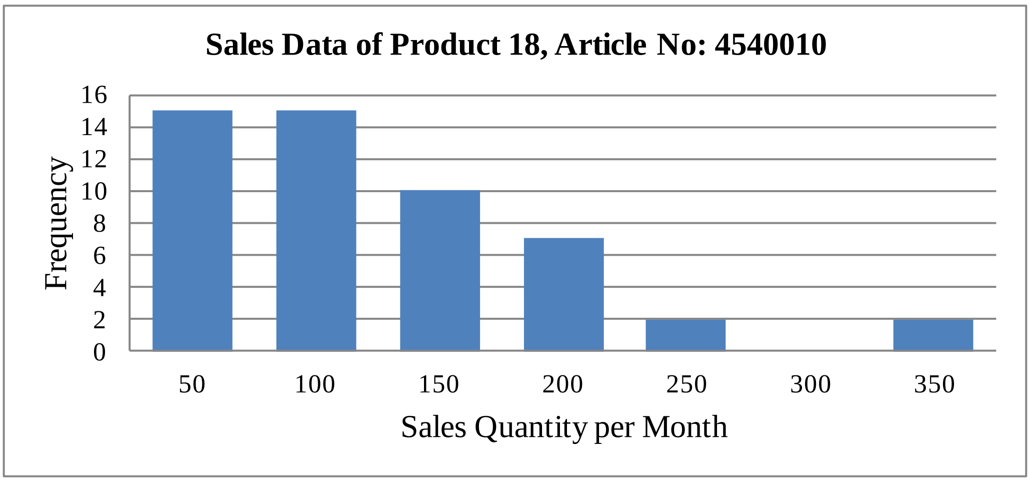
Summary Statistics of Product 15, Article No: 2600010					
Mean	3146.4118	Sample Variance	1003573.2071	Minimum	907.0000
Standard Error	140.2780	**Kurtosis**	**0.0109**	Maximum	5709.0000
Median	3196.0000	**Skewness**	**0.2430**	Sum	160467.0000
Standard Deviation	1001.7850	Range	4802.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



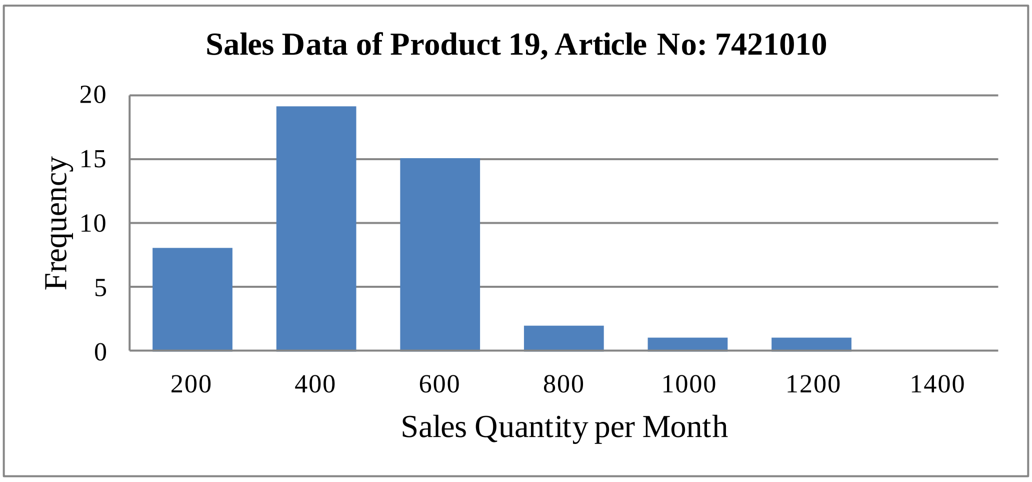
Summary Statistics of Product 16, Article No: 1400020					
Mean	1106.2745	Sample Variance	149018.6431	Minimum	425.0000
Standard Error	54.0549	**Kurtosis**	**-0.1131**	Maximum	1967.0000
Median	1040.0000	**Skewness**	**0.5827**	Sum	56420.0000
Standard Deviation	386.0293	Range	1542.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



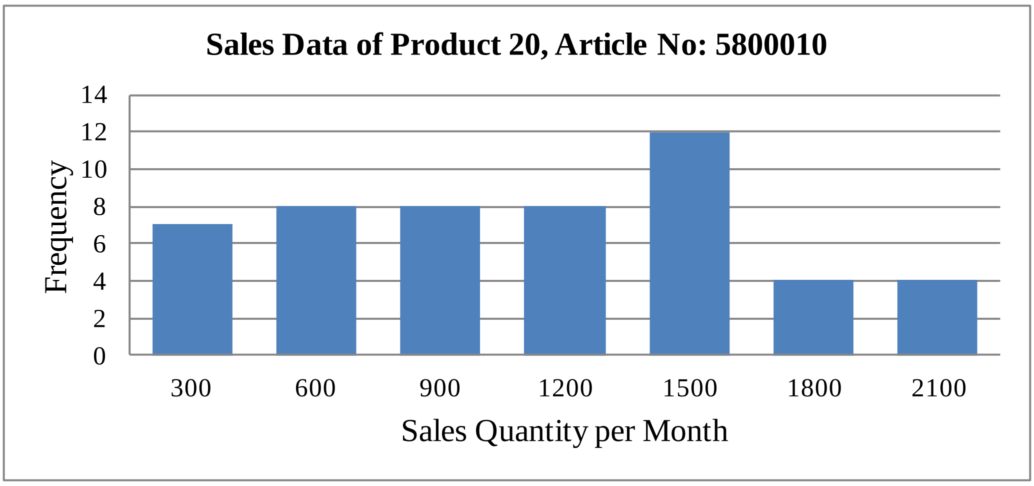
Summary Statistics of Product 17, Article No: 2300030					
Mean	1106.2745	Sample Variance	149018.6431	Minimum	425.0000
Standard Error	54.0549	**Kurtosis**	**-0.1131**	Maximum	1967.0000
Median	1040.0000	**Skewness**	**0.5827**	Sum	56420.0000
Standard Deviation	386.0293	Range	1542.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



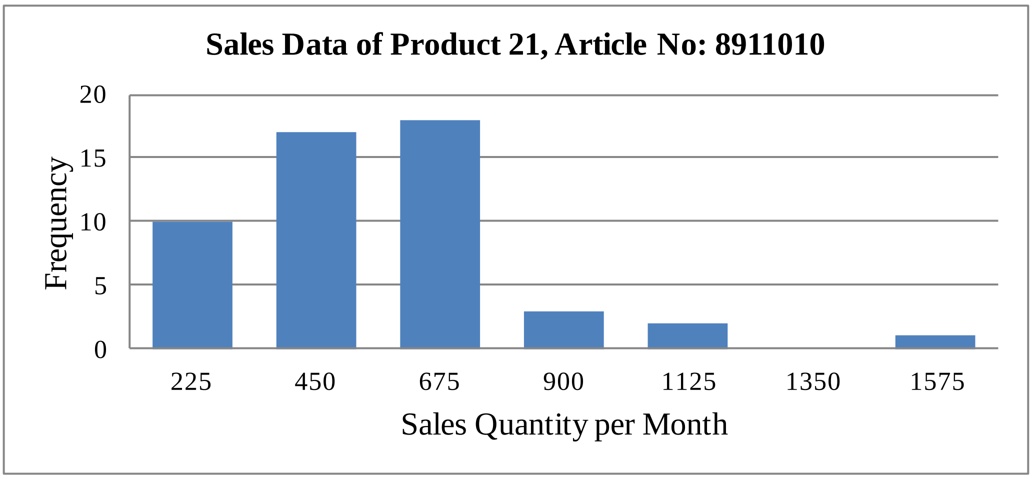
Summary Statistics of Product 18, Article No: 4540010					
Mean	94.0196	Sample Variance	5192.1396	Minimum	0.0000
Standard Error	10.0899	**Kurtosis**	**1.2590**	Maximum	311.0000
Median	77.0000	**Skewness**	**1.0828**	Sum	4795.0000
Standard Deviation	72.0565	Range	311.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



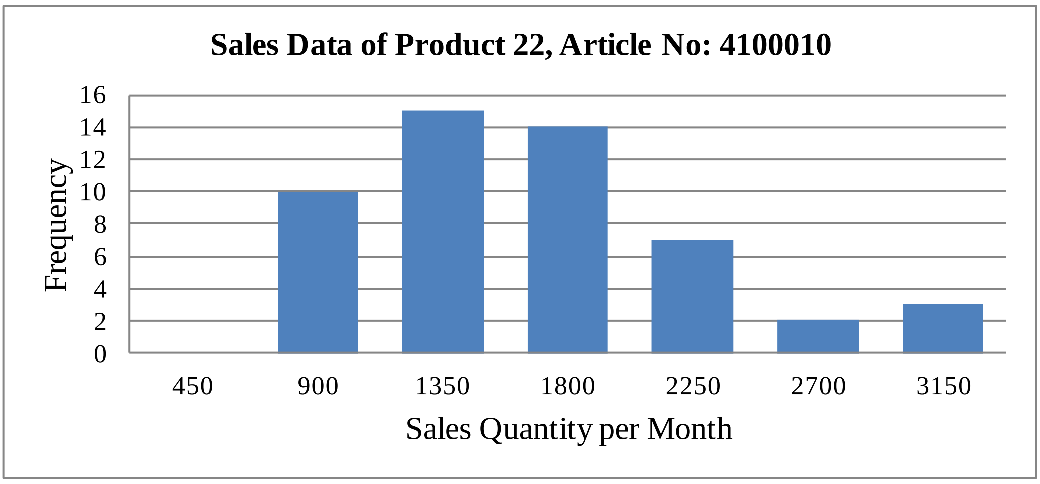
Summary Statistics of Product 19, Article No: 7421010					
Mean	378.0217	Sample Variance	51906.7773	Minimum	0.0000
Standard Error	33.5918	**Kurtosis**	**2.8660**	Maximum	1181.0000
Median	357.0000	**Skewness**	**1.0145**	Sum	17389.0000
Standard Deviation	227.8306	Range	1181.0000	Count	46.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



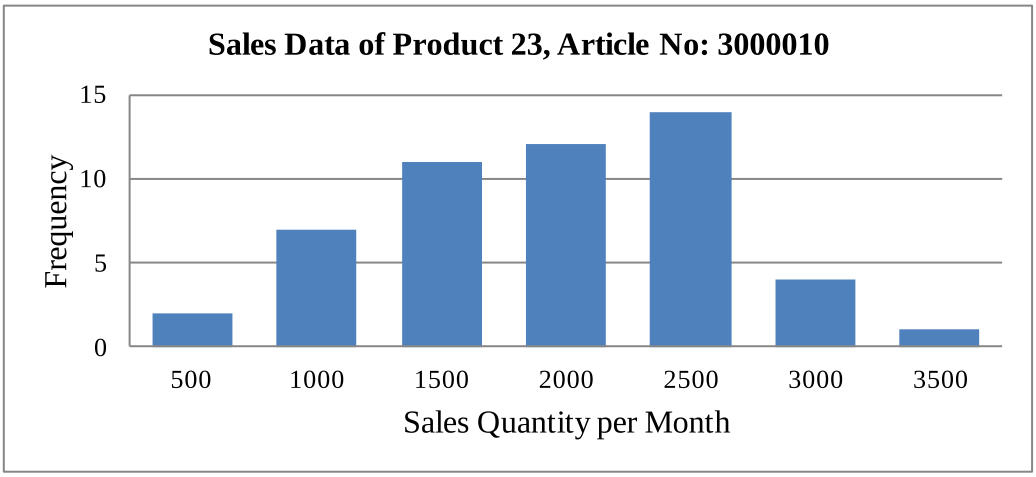
Summary Statistics of Product 20, Article No: 5800010					
Mean	962.7843	Sample Variance	316857.8125	Minimum	0.0000
Standard Error	78.8219	**Kurtosis**	**-0.9857**	Maximum	2063.0000
Median	947.0000	**Skewness**	**-0.0514**	Sum	49102.0000
Standard Deviation	562.9012	Range	2063.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



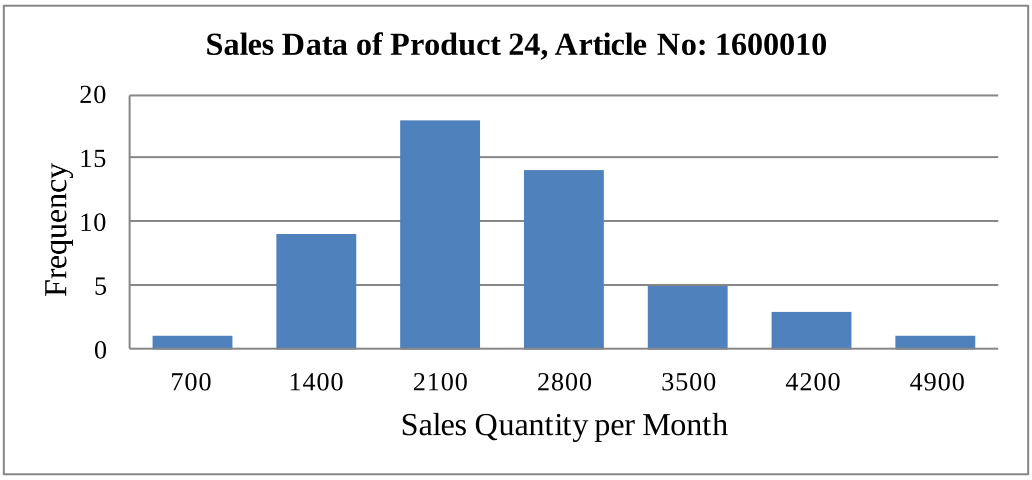
Summary Statistics of Product 21, Article No: 8911010					
Mean	452.1176	Sample Variance	72807.6659	Minimum	0.0000
Standard Error	37.7836	**Kurtosis**	**3.0702**	Maximum	1463.0000
Median	450.0000	**Skewness**	**0.9177**	Sum	23058.0000
Standard Deviation	269.8290	Range	1463.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



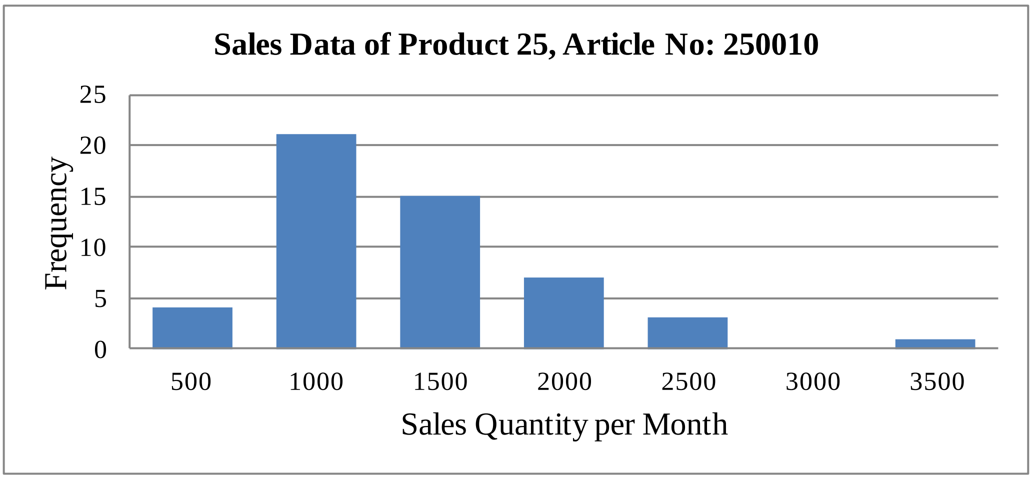
Summary Statistics of Product 22, Article No: 4100010					
Mean	1454.0588	Sample Variance	345764.9365	Minimum	638.0000
Standard Error	82.3390	**Kurtosis**	**0.6104**	Maximum	3099.0000
Median	1395.0000	**Skewness**	**1.0032**	Sum	74157.0000
Standard Deviation	588.0178	Range	2461.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



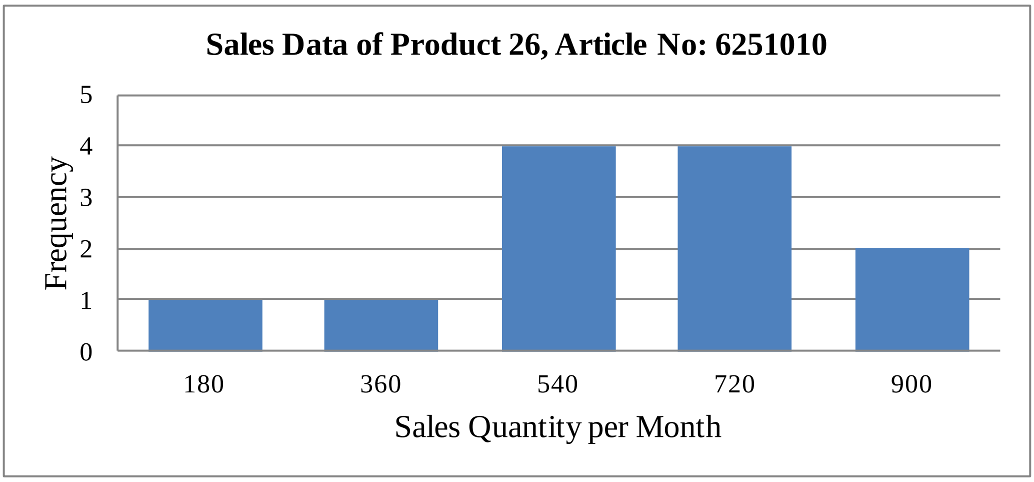
Summary Statistics of Product 23, Article No: 3000010					
Mean	1688.8039	Sample Variance	490259.2008	Minimum	244.0000
Standard Error	98.0455	**Kurtosis**	**-0.2711**	Maximum	3434.0000
Median	1643.0000	**Skewness**	**0.0181**	Sum	86129.0000
Standard Deviation	700.1851	Range	3190.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



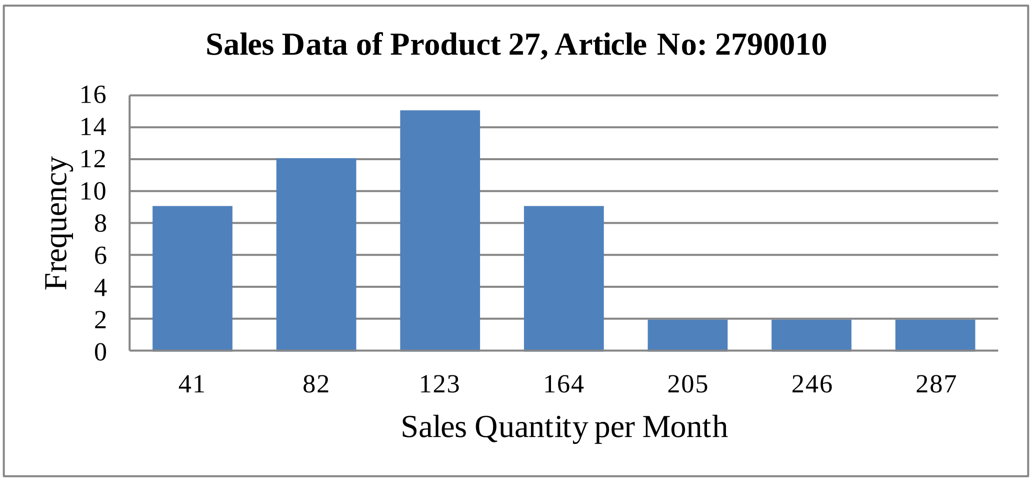
Summary Statistics of Product 24, Article No: 1600010					
Mean	2108.1961	Sample Variance	695160.0408	Minimum	531.0000
Standard Error	116.7501	**Kurtosis**	**1.4992**	Maximum	4796.0000
Median	2004.0000	**Skewness**	**0.8028**	Sum	107518.0000
Standard Deviation	833.7626	Range	4265.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



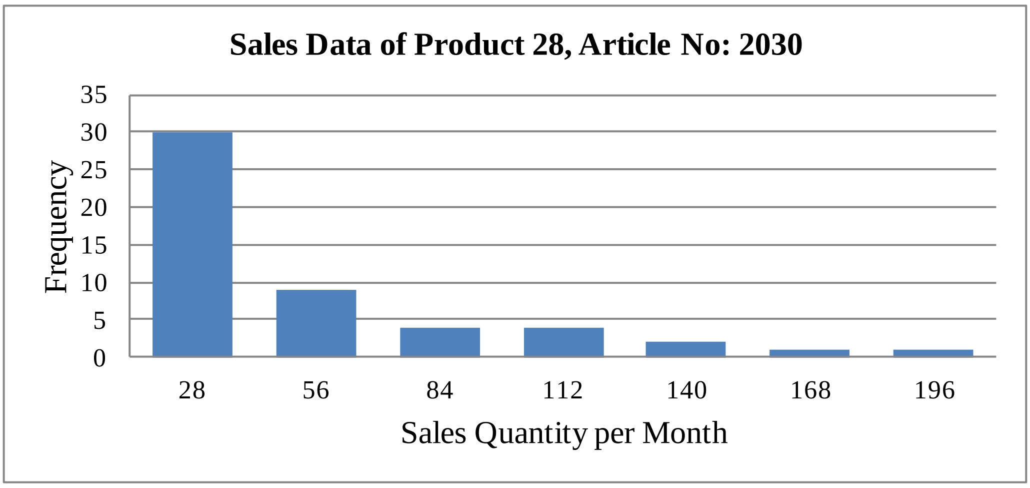
Summary Statistics of Product 25, Article No: 250010					
Mean	1131.1765	Sample Variance	360607.5082	Minimum	263.0000
Standard Error	84.0877	**Kurtosis**	**2.8724**	Maximum	3422.0000
Median	1006.0000	**Skewness**	**1.2908**	Sum	57690.0000
Standard Deviation	600.5060	Range	3159.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



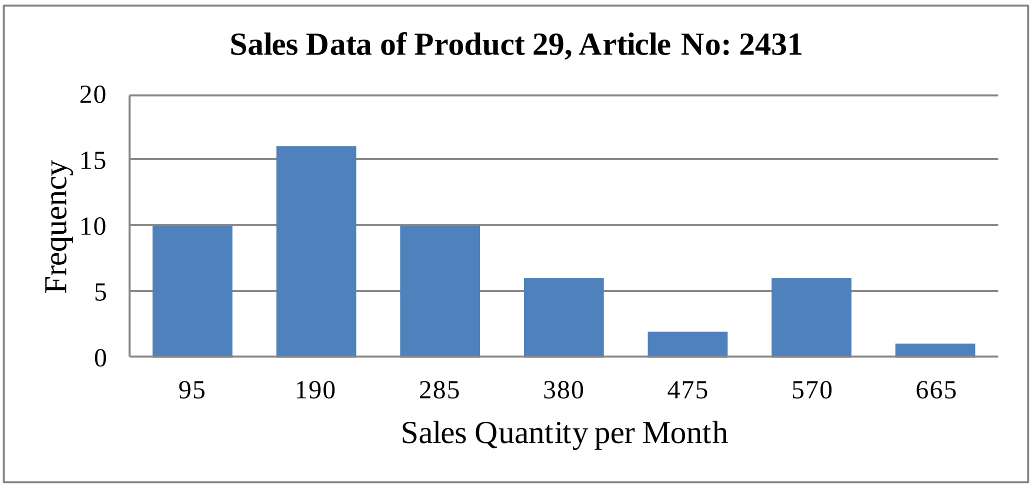
Summary Statistics of Product 26, Article No: 6251010					
Mean	513.3333333	Sample Variance	59333.33333	Minimum	0
Standard Error	70.3167437	**Kurtosis**	**0.533925698**	Maximum	900
Median	540	**Skewness**	**-0.570421974**	Sum	6160
Standard Deviation	243.5843454	Range	900	Count	12
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



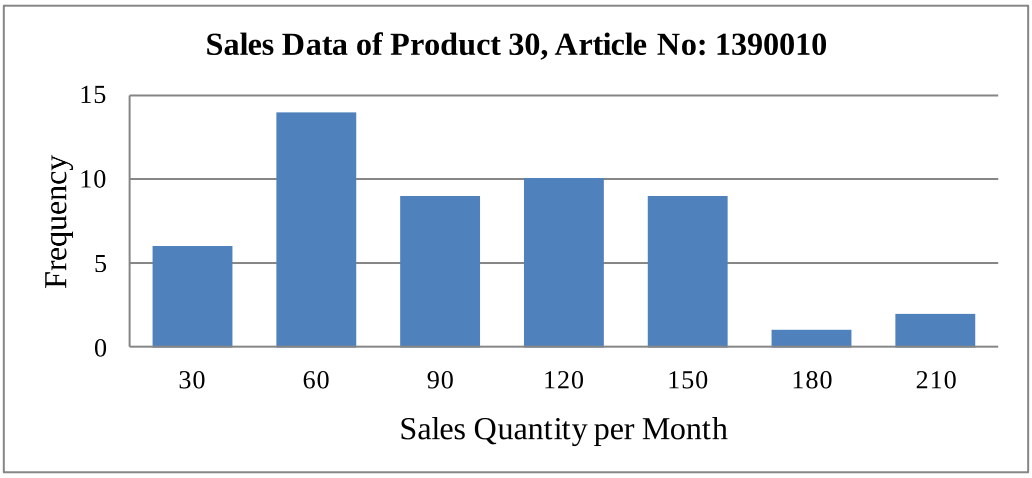
Summary Statistics of Product 27, Article No: 2790010					
Mean	97.0588	Sample Variance	4382.8965	Minimum	0.0000
Standard Error	9.2703	**Kurtosis**	**0.6865**	Maximum	282.0000
Median	88.0000	**Skewness**	**0.8038**	Sum	4950.0000
Standard Deviation	66.2034	Range	282.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



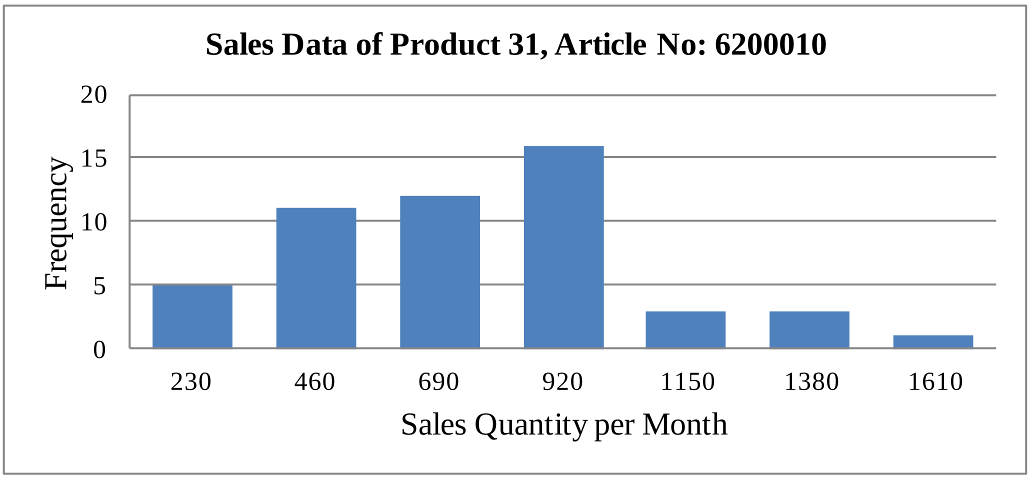
Summary Statistics of Product 28, Article No: 2030					
Mean	34.882	Sample Variance	2058.546	Minimum	0.000
Standard Error	6.353	**Kurtosis**	**2.033**	Maximum	192.000
Median	20.000	**Skewness**	**1.495**	Sum	1779.000
Standard Deviation	45.371	Range	192.000	Count	51.000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



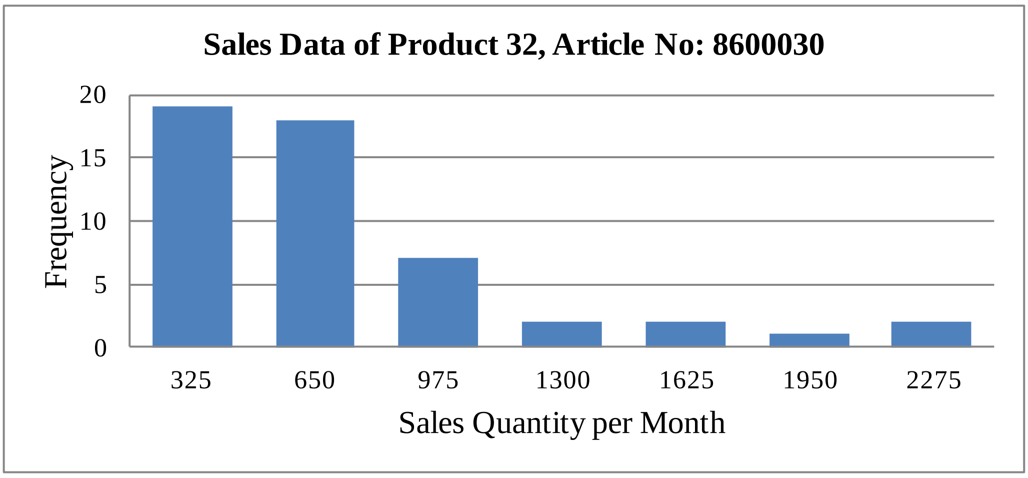
Summary Statistics of Product 29, Article No: 2431					
Mean	224.9412	Sample Variance	38089.4565	Minimum	-515.0000
Standard Error	27.3286	**Kurtosis**	**3.2071**	Maximum	665.0000
Median	188.0000	**Skewness**	**-0.4578**	Sum	11472.0000
Standard Deviation	195.1652	Range	1180.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



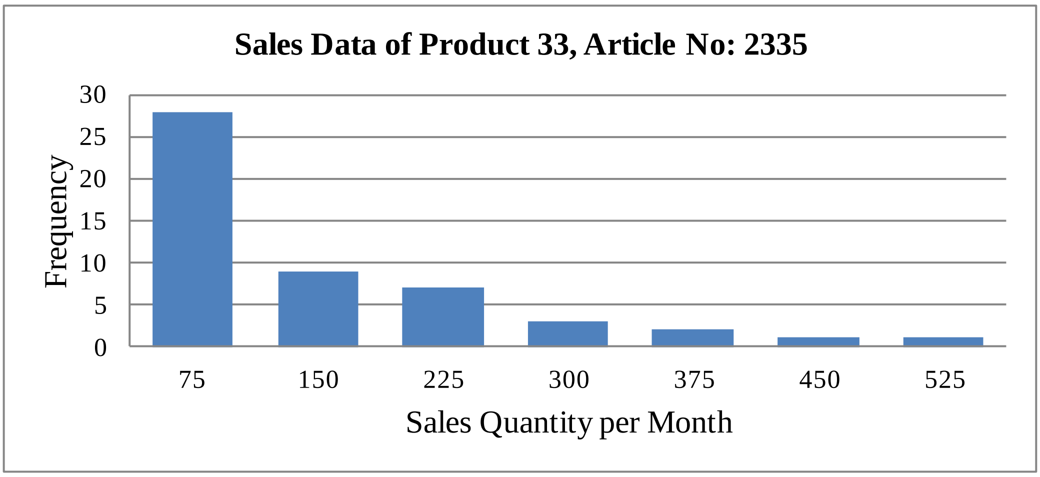
Summary Statistics of Product 30, Article No: 1390010					
Mean	84.8824	Sample Variance	2524.4659	Minimum	0.0000
Standard Error	7.0356	**Kurtosis**	**-0.1242**	Maximum	210.0000
Median	77.0000	**Skewness**	**0.3647**	Sum	4329.0000
Standard Deviation	50.2441	Range	210.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



Summary Statistics of Product 31, Article No: 6200010					
Mean	641.2549	Sample Variance	121464.2737	Minimum	0.0000
Standard Error	48.8022	**Kurtosis**	**0.4372**	Maximum	1600.0000
Median	620.0000	**Skewness**	**0.3366**	Sum	32704.0000
Standard Deviation	348.5173	Range	1600.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



Summary Statistics of Product 32, Article No: 8600030					
Mean	577.3529	Sample Variance	234502.2329	Minimum	61.0000
Standard Error	67.8092	**Kurtosis**	**3.0969**	Maximum	2273.0000
Median	438.0000	**Skewness**	**1.7269**	Sum	29445.0000
Standard Deviation	484.2543	Range	2212.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					



Summary Statistics of Product 33, Article No: 2335					
Mean	100.6863	Sample Variance	14721.9796	Minimum	0.0000
Standard Error	16.9902	**Kurtosis**	**1.7542**	Maximum	520.0000
Median	65.0000	**Skewness**	**1.3191**	Sum	5135.0000
Standard Deviation	121.3342	Range	520.0000	Count	51.0000
The Kurtosis and Skewness is almost 0. Thus this Product probably has a fairly Normal distribution.					