Enduring Value

ITC Limited

Roll no 51607

A PROJECT REPORT

On

"TO DETERMINE AN OPTIMAL PROCUREMENT POLICY"

Submitted in partial fulfillment of the requirements for the award of the degree of
MASTER OF OPERATIONAL RESEARCH

for

ITC LIMITED MODINAGER

GHAZIABAD

NOIDA (U.P.)

SUBMITTED BY:

Ravi Kumar Kuril

MSc. Operational Research (Sem 4)

In

Partial fulfillment of the requirement of the Degree of

Master of science in Operational Research

To

Department of Operational Research

Faculty of Mathematical Sciences

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CERTIFICATE

This is to certify that the project entitled "**To determine optimal procurement policy**" submitted in partial fulfillment of the Degree Of Master Of Science-Opeartional Research, done by **Mr. Ravi Kumar Kuril** is an authentic work carried out by her at **ITC LTD., modinagar** under my guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

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(Ravi Kumar Kuril)

Master of science (Semester 4)
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OPERATIONAL Research

Operational Research Definition “a method of mathematically based analysis for providing a quantitive basis for management decisions.”

Or

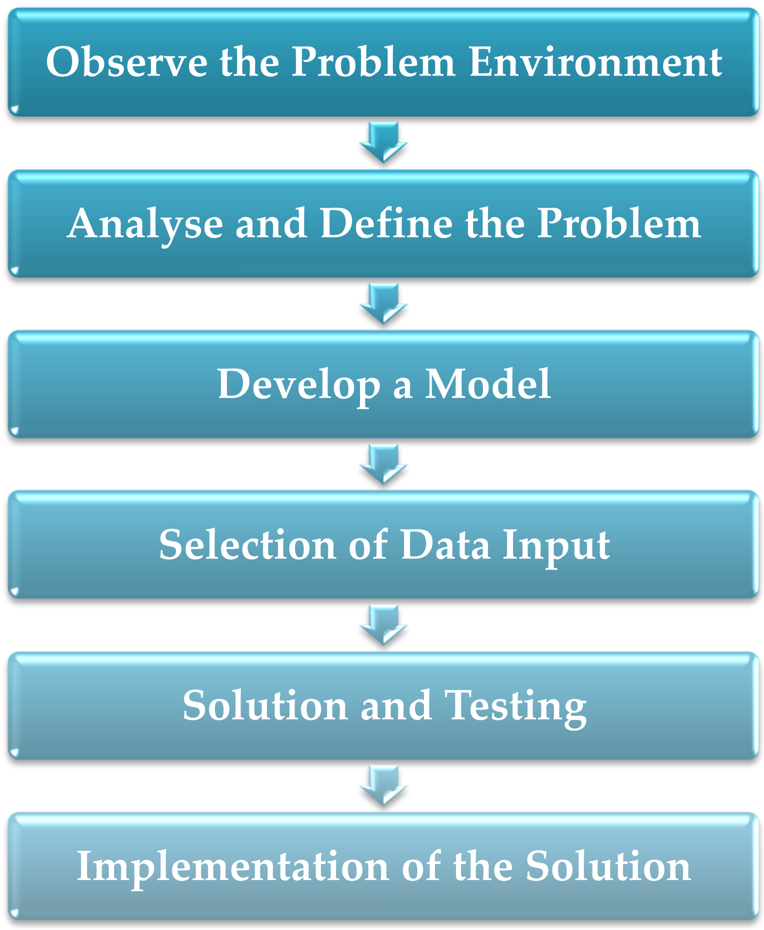
“Operational Research is the application of the methods of science to complexproblems arising in the direction andmanagementof large systemsof men,machines, materials and money in industry, business, government anddefense.The distinctive approachisto develop a scientific model of the system,incorporating measurementsof factors, such aschanceand risk, with which tocompare the outcome of alternative decisions, strategies and controls. Thepurposeisto help management determine its policies and actions scientificall.**”**

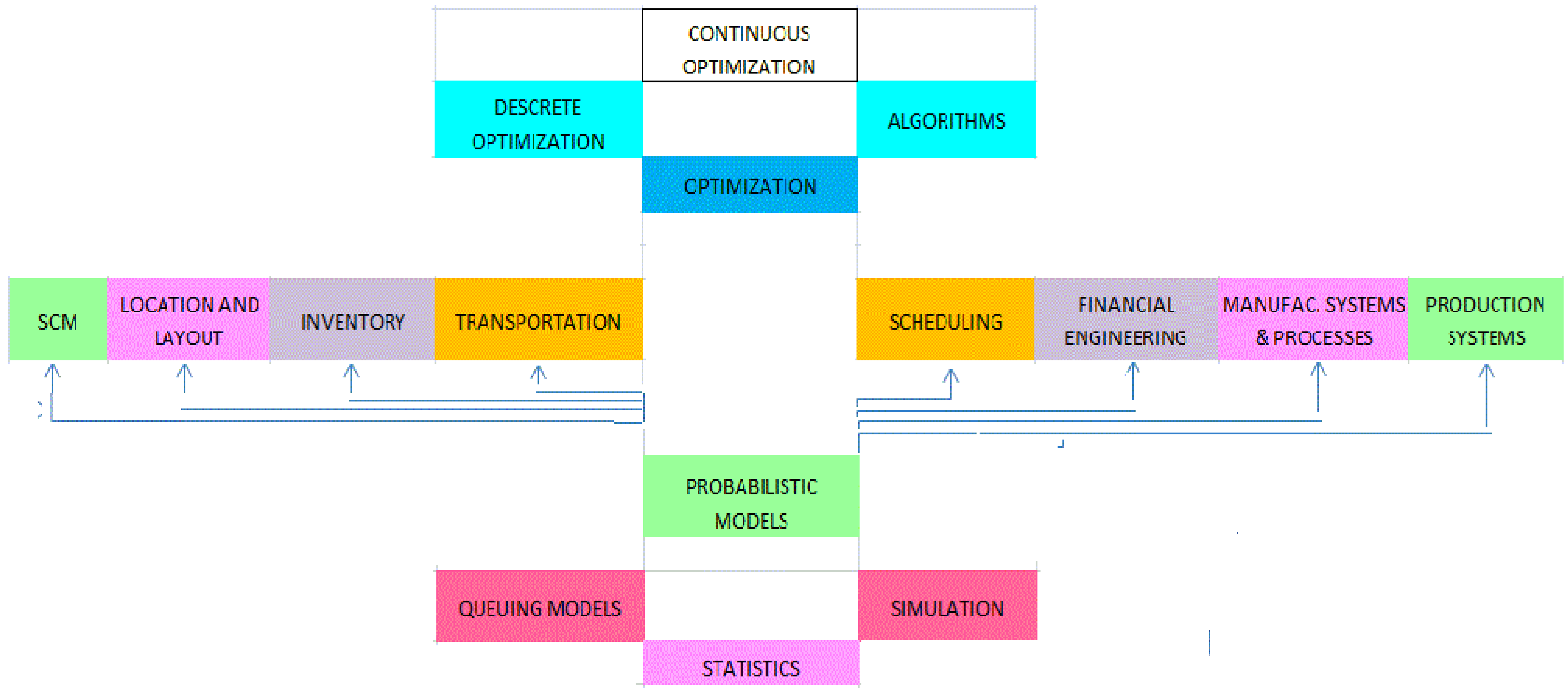
Operational Research definition from Wikipedia

“Employing techniques from other mathematical sciences, such as mathematical modeling, statistical analysis, and mathematical optimization, operations research arrives at optimal or near-optimal solutions to complex decision-making problems. Because of its emphasis on human-technology interaction and because of its focus on practical applications, operations research has overlap with other disciplines, notably industrial engineering and operations management, and draws on psychology and organization science. Operations research is often concerned with determining the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost) of some real-world objective. Originating in military efforts before World War II, its techniques have grown to concern problems in a variety of industries.”

Operations research encompasses a wide range of problem-solving techniques and methods applied in the pursuit of improved decision-making and efficiency, such as simulation, mathematical optimization, queuing theory, Markov decision processes, economic methods, data analysis, statistics, neural networks, expert systems, and decision analysis. Nearly all of these techniques involve the construction of mathematical models that attempt to describe the system. Operational Research in practice is a team effort, requiring close cooperation among the decision-makers, the skilled OR analyst and the people who will be affected by the management action.

There are mainly six phases that are carried out in the study





AREAS OF OPERATIONAL RESEARCH

❖ **Marketing:**

As in Finance, the opportunities to gain a competitive edge through qualitative analysis are multiplying in marketing. These opportunities arise, first, in strategic marketing. Strategic applications include general planning, sales forecasting, market selection, market measurement, segmentation and targeting, and product portfolio analysis.

- **Revenue Management:**

Revenue Management, also called Yield Management, entails accurately forecasting demand and then adjusting process over time to profitably allocate fixed capacity. This can be termed as super intelligent pricing. It shares much in common with the application of competitive bidding. Developed originally for pricing and booking of airline seats, the approach has spread to hotels, rental car firms, broadcasting, and more recently to manufacturing.

- **Manufacturing and Service Operations, & supply chain Management:**

  Supply Chain decisions dictate the who-what-when-where all the way from purchasing and transporting materials and parts through manufacturing products, and finally distributing and delivering products to customers. The prime management goal might be to reduce overall costs, very large in many companies, while filling customer orders even faster than before.

  The myriad applications include scheduling of all kinds, routing, and improvement of work flow and elimination of bottlenecks, inventory control, business process re-engineering, site selection, facility planning and general operational planning. Manufacturing companies make heavy use of Simulation. Transportation and Telecommunication companies make heavy use of optimization.

- **Finance and Control:**

Finance problems are an excellent application area for OR researchers. OR techniques are used to value financial instruments, identify market imperfections, design securities, regulate markets, evaluate and control risks, model strategic problems, and understand the functioning of financial markets etc. Much publicity surrounds the investment applications, especially in connection with newer investment media like financial derivatives. The index fund was invented by OR people, so were key advances in investment performance measurement.

- **Computing & Information Technology:**

The impact of OR in IT sector is growing. OR techniques are being used in the form of softwares such as Decision Support Systems (DSS), Online Analytical processing (OLAP), SAS OR, Oracle Project Suite, Optimization Components of Enterprise Resource Planning (ERP) Systems etc. OR also assists in developing stages of softwares, precisely in software testing and accounting software reliability. With such interdependence of OR and IT, having professionals with knowledge of both is an advantage to the organization.

- **Engineering:**

The OR techniques such as decision analysis, the analytical hierarchy process and mathematical programming can assist in engineering decisions, for example, in making choices in design and testing.

INTRODUCTION

ITC - Creating Enduring Value for India

As a Company deeply rooted in India's soil, ITC is inspired by the opportunity to serve a larger national purpose and create enduring value for its stakeholders. This abiding vision has spurred innovation, creativity and vitality to ensure a substantial and growing contribution to the Indian Economy, whilst simultaneously contributing significantly to enhancing environmental capital and sustainable livelihoods.

ITC's aspiration to create enduring value has been powered by strategies that have focused on:

- Leveraging enterprise strengths to create **Multiple Drivers of Growth** with a robust portfolio of future ready businesses
- Building world-class Indian brands that **Create, Capture and Retain Growing Value in India**
- Making **Societal Value Creation** an integral part of its journey of growth
- Investing in **Creating Assets for the Nation** in the critical areas of agriculture, manufacturing and services

ITC Limited or **ITC** is an Indian conglomerate headquartered in Kolkata, West Bengal. Its diversified business includes five segments: Fast Moving Consumer Goods (FMCG), Hotels, Paperboards & Packaging, Agri Business & Information Technology.

Established in 1910 as the Imperial Tobacco Company of India Limited, the company was renamed as the Indian Tobacco Company Limited in 1970 and further to I.T.C. Limited in 1974. The periods in the name were removed in September 2001 for the company to be renamed as ITC Ltd.The company completed 100 years in 2010 and as of 2012-13, had an annual turnover of US$8.31 billion and a market capitalization of US$45 billion. It employs over 25,000 people at more than 60 locations across India and is part of Forbes 2000 list.

The success of competitive domestic brands in gaining larger franchise in the Indian global market has multiplier effects. On the one hand, it creates national assets that are more anchored in the country vis-à-vis manufacturing investments of foreign brands that can cross borders seeking cost advantages. On the other hand, it reduces precious outgo on account of royalties as well as consumption of foreign brands.

Most importantly, when national and corporate energies align to create world-class Indian brands, they build valuable intellectual property assets that help make the country and its institutions globally competitive. Driven by its mission to create world-class Indian brands, ITC has organically built several brands, which have attained considerable market standing in a relatively short period of time. Brands created by ITC in the last 10 years currently represent over Rs 10,000 crores in terms of annualized consumer spend, a feat perhaps unrivalled in the Indian FMCG industry.

Some of ITC's brands that have gained significant market standing among consumers are **Aashirvaad, Sunfeast, Bingo!, Yippee!, Candyman, mint-o** and **Kitchens** of India in the Branded Foods space; **Essenza Di Wills, Fiama Di Wills, Vivel** and **Superia** in the Personal Care products segment; **Classmate** and **Paperkraft** in Education & Stationery products; **Wills Lifestyle** and **John Players** in the Lifestyle Apparel business; **Mangaldeep** in **Agarbattis** as well as **Aim** in Matches.

Multiple Drivers of Growth

ITC's unique and multi-faceted enterprise strengths including deep consumer insights, brand building capability, cutting-edge Research & Development, globally benchmarked manufacturing infrastructure, agri-sourcing advantages and extensive rural linkages, trade marketing & distribution network, committed and competent human resources, constitute a robust and formidable foundation that has enabled the

Company to create multiple drivers of growth in its chosen portfolio of businesses that spans **FMCG, Hotels, Paperboards and Packaging, Agri-Business** and Information Technology. These enterprise strengths coupled with the opportunities arising out of rising disposable incomes, urbanization, a favorable demographic dividend and growth in rural areas provide competitiveness to ITC's strategy of creating enduring value for its stakeholders and the nation. ITC continues to blend its diverse competencies residing in various businesses to enhance the competitive power of the portfolio and position each business to attain leadership on the strength of world-class standards in quality and costs. The Company has also crafted an effective strategy of organization and governance processes to not only enable focus on each business but also harness the

diversity of its portfolio to create unique sources of competitive advantage. ITC's Foods business, for example, gains competitive advantage from enterprise synergies existing in **ITC e-Choupal's agri-sourcing** capabilities, cuisine expertise of its Hotels business, brand building capabilities, in-house packaging competencies as well as an unmatched distribution network.

Triple Bottom Line Contribution

ITC's abiding vision to serve a larger societal purpose lies at the heart of its corporate strategy. ITC believes that enterprises possess the unique capacity to create game-changing transformation amongst the most disadvantaged in society by channelising the power of entrepreneurial vitality, innovation and creativity. ITC's mission to create enduring value for society is manifest in many ways — whether it is in empowering 4 million farmers, ensuring soil and moisture conservation for nearly 150,000 hectares, providing livelihood opportunities to 40,000 women or greening

over 160,000 hectares. The Triple Bottom Line commitment of the Company to simultaneously build economic, social and environmental capital has spurred innovation to orchestrate a symphony of efforts that addresses some of the most challenging societal issues including widespread poverty and environmental degradation. These concerted efforts of the Company over several years have led to the creation of sustainable livelihoods for around 6 million people, many of whom represent the most disadvantaged in society. ITC is a global exemplar in sustainability practices. It is the only organisation of comparable dimensions in the world to be carbon positive for 9 years, water positive for 12 years and solid waste recycling positive for the past 7 years. Its environmental stewardship is also reflected in all its luxury hotels being LEED® Platinum Certified green buildings and in the fact that over 38% of the Company's energy consumption comes from renewable sources.

Investing in India's Future

Building Infrastructural Assets

ITC's commitment to India's progress and prosperity is also manifest in the enduring value created by building assets for the future that ncompass state-of-the-art manufacturing facilities, luxury hotels, logistics hubs, R&D centres, office and residential complexes across India. It has, in the pipeline, almost 60 infrastructure projects that will not only enhance the level of investment in the Indian economy but create precious brick and mortar assets in the country.

Cutting-edge R&D

ITC's R&D organisation led by the ITC Life Sciences & Technology Centre (LSTC) is mandated to develop unique sources of competitive advantage by harnessing contemporary developments in science and technology, blending them with science-led product innovation and leveraging cross-business synergies. A convergence of ITC's R&D capabilities is being utilised to develop future products in nutrition, health and well-being. In agri sciences, ITC efforts are aimed at developing new crop varieties with higher yields, better quality and other traits relevant to the Company's businesses. Presently, the LSTC team has evolved with over 300 world-class scientists augmented by world-class experimental andmeasurement system capabilities.

Future-ready Talent

ITC's agenda of enhancing competitiveness and creating new engines of growth is powered by its future-ready talent bank. ITC succeeds in attracting and retaining talent through initiatives that focus on enhancing personal development and growth, an empowering work culture that facilitates high levels of engagement and performance and an enabling professional work environment. ITC’s talent management programme strives to deliver its unique talent promise of “Building Winning Businesses. Building Business Leaders. Creating Value for India.”

The ITC Vision

“Sustain ITC's position as one of India's most valuable corporations through world class performance, creating growing value for the Indian economy and the Company's stakeholders”

The ITC Mission

“To enhance the wealth generating capability of the enterprise in a globalising environment, delivering superior and sustainable stakeholder value”

Core Values

ITC's Core Values are aimed at developing a customer-focused, high-performance organisation which creates value for all its stakeholders:

Trusteeship

As professional managers, we are conscious that ITC has been given to us in "trust" by all our stakeholders. We will actualise stakeholder value and interest on a long term sustainable basis.

Customer Focus

We are always customer focused and will deliver what the customer needs in terms of value, quality and satisfaction.

Respect For People

We are result oriented, setting high performance standards for ourselves as individuals and teams.

We will simultaneously respect and value people and uphold humanness and human dignity.

We acknowledge that every individual brings different perspectives and capabilities to the team and that a strong team is founded on a variety of perspectives.

We want individuals to dream, value differences, create and experiment in pursuit of opportunities and achieve leadership through teamwork.

Excellence

We do what is right, do it well and win. We will strive for excellence in whatever we do.

Innovation

We will constantly pursue newer and better processes, products, services and management practices.

Nation Orientation

We are aware of our responsibility to generate economic value for the Nation. In pursuit of our goals, we will make no compromise in complying with applicable laws and regulations at all levels.

- **Foods**: ITC's major food brands include *Kitchens of India*; *Aashirvaad*, *Mint-o*, gum-o, B natural, *Sunfeast*, *Candyman*, *Bingo!* and *Yippee!*.[ITC is India's largest seller of branded foods with sales of over Rs. 4,600 crore in 2012-13.It is present across 5 categories in the Foods business namely Staples, Snack Foods, Ready-To-Eat Foods, Juices and Confectionery.

- **Lifestyle apparel**: ITC sells its products under the *Wills Lifestyle* and *John Players* brands. Wills Lifestyle was accorded the ‘Superbrand’ status and John Players was included in the top 10 ‘Most Trusted Apparel Brands 2012’ by The Economic Times.

- **Personal care products** include perfumes, haircare and skincare categories. Major brands are *Fiama Di Wills*, *Vivel*, *Essenza Di Wills*, *Superia* and *Engage*.
- **Stationery**: Brands include *Classmate*, *PaperKraft* and *Colour Crew*.Launched in 2003, *Classmate* went on to become India's largest notebook brand in 2007.
- **Safety Matches and Agarbattis**: *Ship*, *i Kno* and *Aim* brands of safety matches and the *Mangaldeep* brand of agarbattis (Incense Sticks).
- **Hotels**: ITC's Hotels division (under brands including *WelcomHotel*) is India's second largest hotel chain with over 90 hotels throughout India.[42] ITC is also the exclusive franchisee in India of two brands owned by Sheraton International Inc. Brands in the hospitality sector owned and operated by its subsidiaries include *Fortune Park Hotels and* Welcom Heritage Hotels.
- **Paperboard**: Products such as specialty paper, graphic and other paper are sold under the ITC brand by the ITC Paperboards and Specialty Papers Division.
- **Packaging and Printing**: ITC's Packaging and Printing division operates manufacturing facilities at Haridwar and Chennai and services domestic and export markets.
- **Information Technology**: ITC operates through its fully owned subsidiary ITC Infotech India Limited, which is a SEI CMM Level 5 company.

Production planning & control (PPC)

Key Responsibly of PPC departments are as below-

- Implementation of process based on Release note, engineering drawing & documents
- Utilization of resources
- Procurement part information to purchase & in-house component shops based on bill of material which is generated by R&D.
- Daily production planning & achievement
- Monthly production target
- Inventory control
- System Control –flow of process
- On time manufacturing
- On time delivery

Purchase Department

The key responsibly of purchase departments are as below

- Release purchase order to vendor
- Scheduling for procurements based on PPC requirements & last 3 month AMC
- Inventory control
- New Vendor development
- Vendor process visit

Production

Production department divided in two major parts

1 Components manufacturing

2-Finish goods production

Quality Departments

Quality departments divided in the following sub division

Receiving quality**: -** after receiving of raw material & components, receiving store make MRIN & offer to quality for inspection.

Key responsibly of receiving quality inspection of material & informs to store departments about the goods either is ok or not ok.

Process Quality: - testing & visual inspection of finish goods as per testing specification

Maintenance

Key responsibility of maintenance is utility supply, machine repairing, new machine installation.

Store Department

Key responsibility of store department as below

- Daily material receiving & issuance to production shops
- Storage of material One item one location
- First In First Out (FIFO SYSTEM)
- Inventory Control
- Physical verification of raw material

Logistics & supply Chain

Key responsibly of logistics department is as below

- Receiving of finish goods from assembly shop
- One item one location
- Order execution as per schedule
- Arrangement of transportation
- Physical verification of finish goods

Order processing Hierarchy:

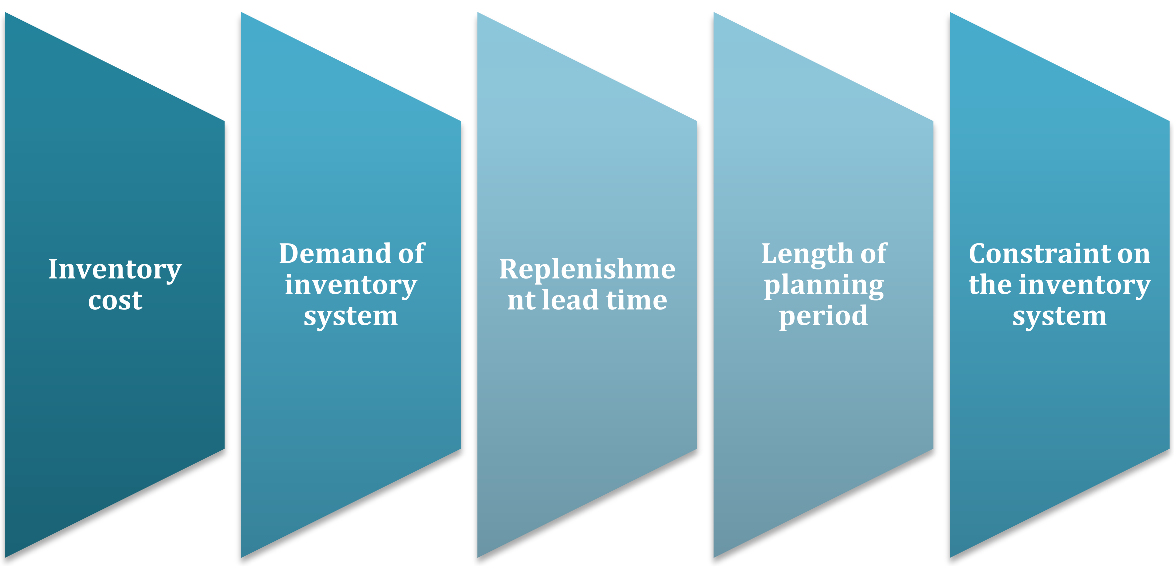
Inventory management

The overseeing and controlling of the ordering, storage and use of components that a company will use in the production of the items it will sell as well as the overseeing and controlling of quantities of finished products for sale. A business's inventory is one of its major assets and represents an investment that is tied up until the item is sold or used in the production of an item that is sold. It also costs money to store, track and insure inventory. Inventories that are mismanaged can create significant financial problems for a business, whether the mismanagement results in an inventory glut or an inventory shortage.

The control and maintenance of inventories of physical goods is a problem common to all enterprises in any sector of a given economy. There are many reasons why organizations should maintain inventories of goods. The fundamental reason in doing so is that it is either physically impossible or economically unsound to have goods arrive in a given system precisely when demand arrives for them. Without inventories customer would have to wait until there orders were fulfilled from a source or where manufactured. In general, however customer will not wait for long period. There are other reasons too for holding inventories. For example, the price of some raw materials used by manufacturer may exhibit considerable seasonal fluctuations. When the price is, low it is profitable for him to procure a sufficient quantity of it to last through a high priced season and to keep in inventory to be used as needed in production.

Features of Inventory system

There are certain features of an inventory system which influence the control policy :



Inventory Cost

The performance of an inventory system is related to the inventory costs.These costs are often not directly reflected in the firm’s financial statement .They are measured in terms of inventory turnover. However there are certain costs which are not reflected by the inventory turnover such as ordering cost, shortage cost etc. Fundamentally, the relevant costs associated with inventory control policy are classified as follows:

- Ordering/Set up cost: This cost originates from expenses of placing a purchases order to an outside supply or from an internal production setup. This cost is usually assumed to vary directly with the number of orders or setups and not in the size of the order.

- In case of ***procurement***, this cost includes such as making requisition, analyzing vendors, writing purchase cost, securing material and transportation cost, inspecting materials, following up orders, and doing the paper work necessary for making transactions.
- In case of ***production***, set up cost includes cost of changing over production process; produce the order item, preparing shop orders, scheduling the work, pre-production set up, expediting and quality acceptance.

- **Unit production cost or unit purchase Cost:** Such a cost is of special interest when ―quantity discounts‖ can be availed for orders above certain quantity or large production runs may result in a decrease in the production cost.
  - Under these conditions, the order quantity must be adjusted to take advantage of these rebates.

- Inventory carrying/ holding cost: This cost includes real out of pocked cost such as costs of insurance, taxes, breakage and pilferage at the storage side, warehouse rental if the management does not own warehouse, and the cost of operating the warehouse such as light, heat, night watchman etc. It also includes ***opportunity cost***, which is an important component of this cost. This is the incurred by having capital tied up in inventory rather than having it invested elsewhere, and it is equal to the largest rate of return which the system could obtain from alternative investments. By having funds invested in inventory, one forgoes this rate of return and hence, it represents a cost of carrying inventory. The cost is assumed to be varying directly with the level of inventory as well as the length of time the item is held in stock.

- Shortage cost: These are the costs, which are incurred by having demand when the system is out of stock. These are inherently extremely difficult to measure since they can include such as loss of customer goodwill and potential loss in income. Other parts include cost of notifying a customer than an item is not in stock and will be back ordered plus the cost of attempting to find out when the customers'orders can be filled and giving him this information. If the system uses the part, the back order cost may simply be the cost of keeping a machine idle for lack of parts.

  - In case where unfilled demand for the commodity can be, satisfy at a later date (backlog case).
  - These costs are assumed to be usually varying directly with both the shortage quantity and delayed time. On the other hand, if the unfilled demand is lost (lost sale case), the shortage cost becomes proportional to shortage quantity only.

Demand of inventory system

The understanding of nature of demand (i.e. its size and pattern) is very essential to determine the optimal inventory policy for that item.

The size of demand refers to the number of item required in each period. The size of demand may be either deterministic or probabilistic.

The demand pattern of commodity may be either deterministic or probabilistic. In the deterministic case, it is assumed that the quantity needed over subsequent period is known with certainty. This may be expressed over equal period in term of known constant demand or in term of known variable of demand. The two cases are referred to as static and dynamic demand, respectively.

The probabilistic demand occurs when the demand occurs when the demand over certain period is not known with certainly but its pattern can be described by a known probability distribution. In this case, probability distribution may be either stationary or non-stationary over time. These two cases are referred to as static and dynamic demand respectively.

The pattern of demand of an inventory system is the manner in which inventory items are required by the customers.

Replenishment lead time

1. Order cycle-Time period between two continuous replenishments.
2. Lead time/delivery lag-time delay between placing an order and receiving an order. It can be either deterministic or probabilistic.
3. Stock replenishment-instantaneous replenishment is possible when the stock is fulfilled by outside sources, while gradual replenishment is possible due to finite production rate within the firm.

Length of planning period

The length of planning period defines the period over which a particular inventory level will be maintained .this may be finite or infinite depending on the nature of the demand.

Constraint on inventory system

The stock level of various items depends upon the constraints such as limited warehouse space, limited budget available for inventory, degree of management attention towards individual items of inventory, Customer service level etc.

Selective inventory control procedure:

Every organization consumes several items of store. Since all the items are not of equal importance, a high degree control on inventories of each item in neither applicable nor useful. So is becomes necessary to classify the items in-group depending upon their utility importance. Such type of classification is named as the principal of selective control, which is applied to control the inventories.

Classification	*Basis of classification*	*Purpose*
ABC (Always, Better ,Control)	Value of consumption	controlling raw material components & work in progress inventories
VED (Vital, Essential, Dead)	critically of items	Determining the inventory level of spare parts.
HML (High, Medium, Low)	Unit price of the material	Mainly to control purchases
XYZ	Value of items in storage	To review the inventories and their uses at scheduled inventories
FSN (Fast, Slow, Non-moving)	Consumption pattern of the component	To control obsolescence
SDE	Problems faced in procurement	Lead time analysis and purchasing strategies.

ABC ANALYSIS

“ABC” analysis is a basic tool, which helps the management to place their efforts where the results would be useful to the greatest possible extent. This technique involves the classification of inventory items into three categories A, B and C in descending order of annual consumption and annual monetary value of each item.

The ABC analysis is based on Pareto’s law that a few high usage value items constitute a major part of the capital invested in inventories, whereas bulk of items in inventory having low value constitute insignificant part of the capital.

This concept is based on selective control. If there are large no. of items of be analyzed, then sampling technique may be used for ABC analysis.

In ABC analysis the items are classified in three main categories based on their respective usage value:

A – Class items : more costly and valuable items are classified as “A”. Such items have large investments but not much in number, for example say, 10% of items account for 75% of the total capital invested in inventory. So more careful and closer control is needed for such items. The items of this category should be ordered frequently but in small no. A periodic review policy should be followed to minimize the shortage percentage of such items and top inventory staff should control these items. These items have a high carrying cost and frequent orders of small size for these items can results in enormous savings.

B – Class items : the items having average consumption value are classified as “B”. Nearly 15% of items in an inventory account of 15% of the total investment. These items have less importance than a class items, but are much costly to pay more attention on their use. These items cannot be over looked and require less degree of control than those in category A. Statistical sampling is generally useful to control them.

C – Class items : the items having low consumption value are put in class “C”. Nearly 75% of the inventory items account only for 10% of the total invested capital. Such items can be stocked at an operative place where people can help themselves with any requisition formality. These items can be charged to an overhead account. In fact, loose control of C class items increase their investment cost and expenditure on itself wear, obsolescence and wasteful use, but this will not be so much offset for the saving n recording costs.

Significant points of ABC-Analysis

- Whenever the items can be substituted for each other they should be preferably considered as one item.
- More emphasis should be given to the value of consumption and not to the cost per items.
- While classifying as ABC all the items consumed by an organization should be considered together, instead of considering them like: spares, raw material, semi finished, and finished items and then classifying as A, B or C.
- If required, there may be more than three classes and period of consumption need necessarily be one year.

Procedure for ABC – Analysis

The following are the steps of classification of items into A, B and C categories.

Step 1: Determine the no. of unit sold or used in the past one year.

Step 2: Determine the unit cost of each item.

Step 3: Compute the annual usage value (in Rs) of each item constituted by multiplying the annual consumption (of units) by its unit piece.

Annual usage value = annual requirement × cost of one unit

Step 4: Arrange the items in descending order according to their respective usage value computed in **Step 3**.

Step 5: Prepare a table showing unit cost, annual consumption and annual usage value for each item.

Step 6: Calculate the cumulative sum of the no. of items and the usage value for each item obtained in **Step 3**.

Step 7: Find the percentage of the value obtained in step 6 with respect to grand total of the corresponding columns.

Step 8: Draw a graph by taking cumulative percentage of items on x-axis and cumulative % age of annual consumption on y-axis. After plotting various points on the graph, we draw smooth curve.

Step 9: Mark the points x and y where the slop of the curve changes sharply. Such points are called points of inflexion.

Step 10: finally, the usage value and the percentage of items corresponding to these points determine the classification of items as A, B or C.

LIMITATION OF "ABC" ANALYSIS

- ABC analysis does not permit precise consideration of al relevant problems inventory control. For example, never ending problem in inventory management is that of adequately handling thousands of low value "C" class items. Low value purchases frequently require more items, and consequently reduce the time allowance available and purchasing personnel for value analysis, vender investigation, and other "B" class items.
- If "ABC" analysis is not be updated and reviewed periodically the real purpose of control may be defeated for example, "C" class items like diesel oil in a firm will become most high value items during power crisis and therefore should require more attention.
- The periodic consumption value is the basis for "ABC" classification, hence ABC classification can lead to over looking the needs of spare parts whose criticality is high but consumption value is low.

Forecasting

Forecasting helps a company to set inventory targets in order to ensure that their inventory allows them to maximize their operations and output. It also aids companies in optimizing the deployment of their inventory, deal with uncertainties, limitations, and difficulties within their supply chain.

Forecasting is the process of making statements about events whose actual outcomes (typically) have not yet been observed. Forecasting has long been associated with processes that impacts on stock. Such process includes production, procurement and sales. Irrespective of the industry type, whether "*make to sell*" or "*buy to sell*", elements of forecasting springs up. This is because the driving phenomenon of "demand" is inevitable. it is evident that some level of inventory must exist at any point in time. It can be raw materials for production and/or finished goods. The crux of the matter then becomes, what should be the relative inventory level at a particular point in time. In objectively answering this question, some form of forecasting must be made.

Inventory forecasting is a proactive and futuristic strategy aimed at providing estimated stock level to meet demand at a particular point in time. Proactiveness can be interpreted as a step taken, prelude to a known event. Forecasting involves estimating what will be needed based on certain assumptions. It can also be viewed as projections of some sort. In analyzing the subject matter, it is worthy to briefly mention two important concepts namely "over stocking" and "under stocking". Inventory forecasting can give rise to the duo especially when it is faulty and the consequences can be grave as asserted in a prior posting titled: Increasing Profitability through Inventory and Financial Reports.

Forecasting Techniques:

Since forecasting play an important role in decision-making, it is crucial to use the best available technique to minimize the forecast inaccuracy. However, there is no unique method, which can always guarantee the best result, as a natural consequence of the increased emphasis placed on the systematic management, the area of forecasting has been studied extensively and the methods of making predictions with objectivity and reliability have been developed. These techniques vary considerably, according to their sophistication and usefulness.

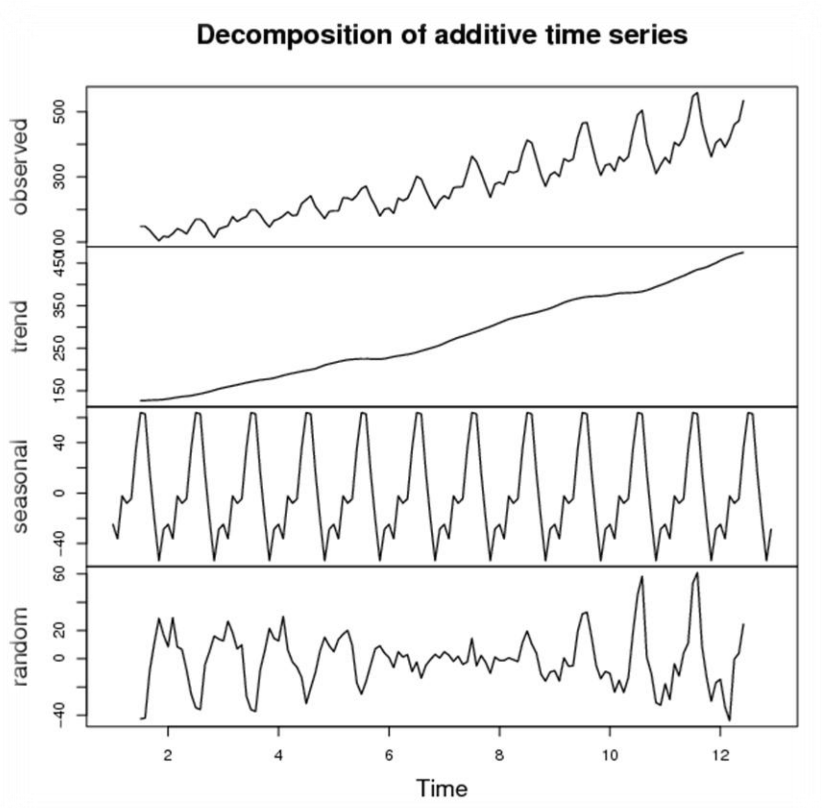
Time series analysis

A time series is a sequence of data points, measured typically at successive points in time spaced at uniform time intervals. Time series *analysis* comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series *forecasting* is the use of a model to predict future values based on previously observed values.

Analysis of time series means to identify the forces or components at work, the net affect of whose interaction is exhibited by the movement of a time series and to isolate, study, analyze and measure them independently by holding other things constant.

There are four major components of time series:

1. Linear Trend
2. Seasonal fluctuation
3. Cyclic variation
4. Irregular fluctuation



Trend-
Trend is a long term movement in a time series. It is the underlying direction (an upward or downward tendency) and rate of change in a time series, when allowance has been made for the other components. Trend is the consistent behavior of the series to move in a specified direction, towards new highs or towards new lows.

Seasonal variations:
These variations in time series are due to the rhythmic forces which operates in a regular and periodic manner over a span of less than an year.
Seasonal variations are recorded due to following two causes:

1. Natural forces- Seasons, Weather conditions, i.e. Natural phenomenon plays an important role in these fluctuations
2. Man made conventions- Fashion, habits, customs, festivals etc. plays important in role in these type of fluctuations.

Cyclic variations:

The oscillatory movements in time series with period of oscillation more than an year are termed as cyclic fluctuations. One complete period id termed as a cycle. The cyclic fluctuations are not necessarily periodic since the length of the cycle as also the intensity of fluctuations may change from one cycle to another.

Irregular movements:

Irregular fluctuations are those which are either wholly unaccountable or are caused by such unforeseen, random, erratic events like wars, floods etc. This category of fluctuations includes all types of variations that are not accounted for a secular trend or seasonal or cyclic variations.

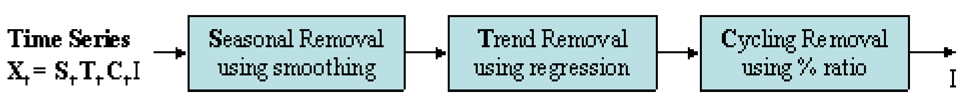
Time series Model

Two models can be regarded as good approximations to the true relationship that exists amongst the four components.

Multiplicative Model

$$Y_t = T_t S_t C_t I_t$$

Where T_t : Secular trend value at time t
S_t : Seasonal variation at time t
C_t: Cyclic fluctuation at time t
I_t: irregular fluctuation at time t



The Three Signals Decomposition and Its Reversal Processes For Forecasting

Additive Model

$$Y_t = T_t + S_t + C_t + I_t$$

Where T_t : Secular trend value at time t
S_t : Seasonal variation at time t
C_t: Cyclic fluctuation at time t
I_t: irregular fluctuation at time t

Methods for measuring trend:

1. Graphical method/Method of free hand curve fitting
2. Method of semi averages
3. Method of moving averages
4. Method of least squares / least square method.
5. Method of curve fitting
   i. A straight line $Y_t = a + bt$
   ii. Second-degree parabola $Y_t = a + bt + ct^2$

iii. Kth degree parabola $Y_t = a_0 + a_1 t + a_2 t^2 + ...a_k t^k$

iv. Exponential curve $Y_t = ab^t$

v. Second degree curve fitted to logarithms $Y_t = ab^t c^{t^2}$

Fitting of these curves are then done as follows:

Fitting Straight line $Y_t = a + bt$

Let curve fit obtained be $\hat{Y}_t = \hat{a} + \hat{b}t$

$$S = \sum_{t=1}^{n} (Y_t - \hat{Y}_t)^2 = \sum (Y_t - \hat{a} - \hat{b}t)^2$$

The normal equation for estimates $\hat{a}$ and $\hat{b}$

$$\frac{\partial S}{\partial \hat{a}} = 0 \Rightarrow \sum_{t=1}^{n} Y_t = n\hat{a} + \hat{b}\sum_{t=1}^{n} t$$

$$\frac{\partial S}{\partial \hat{b}} = 0 \Rightarrow \sum_{t=1}^{n} tY_t = \hat{a}\sum_{t=1}^{n} t + \hat{b}\sum_{t=1}^{n} t^2$$

These equations are then solved for the estimates $\hat{a}$ and $\hat{b}$

Fitting Second Degree Parabola $Y_t = a + bt + ct^2$

Let the curve fit obtained be $\hat{Y}_t = \hat{a} + \hat{b}t + \hat{c}t^2$

The normal equations for estimation for $\hat{a}, \hat{b}, \hat{c}$

$$\sum Y_t = n\hat{a} + \hat{b}\sum t + \hat{c}\sum t^2$$

$$\sum tY_t = \hat{a}\sum t + \hat{b}\sum t^2 + \hat{c}\sum t^3$$

$$\sum t^2 Y_t = \hat{a}\sum t^2 + \hat{b}\sum t^3 + \hat{c}\sum t^4$$

Fitting Kth degree Parabola $Y_t = a_0 + a_1 t + a_2 t^2 + ...a_k t^k$

We can proceed as in the case of 2nd degree parabola 1st degree parabola above to get (k+1) normal equations after minimizing the sum of squares of errors and obtain the estimates of (k+1) parameters of the fit.

Exponential Curve: $Y_t = ab^t$

Taking logarithms of both sides, we have

$$\log Y_t = \log a + t \log b$$

or $U_t = A + Bt$

and now proceed as in (1) to obtain the estimates of A and B which in turn, give us the estimates of 'a' & 'b'.

Second Degree Curve Fitted to the Logarithms : $Y_t = ab^t c^{t^2}$

Taking logarithms of both sides, we have

$$\log Y_t = \log a + t \log b + t^2 \log c$$

or $U_t = A + Bt + Ct^2$

and now we can proceed as in case 2) to obtain the estimates of A, B, C and hence those of a,b and c.

We can use the principle of least squares only when the Number of Parameters is equal to the Number of Variables. In case of Growth Curves, the number of parameters to be estimated is not equal to the number of variables. So, the method of fitting by least squares fails.

Measurement of Seasonal Fluctuations

1. Method of Simple Averages
2. Ratio of Trend Method
3. Ratio of Moving Average Method
4. Link Relative Method

Method of Simple (Arithmetic) Averages:
This is a simple method of isolating seasonal variations. It is based on the assumption that the series contains neither a trend nor cyclical fluctuations, but seasonal & irregular fluctuations.
This method consists of following steps:

- Arrange the data by years and months (or quarters if quarterly data are available)
- Compute the average $\overline{x}_i$ (i = 1,2,3…..12) for the ith month for all the years. This eliminates irregular variations.
- Compute the average $\bar{x}$ of the monthly (quarterly) averages $\overline{x} = \frac{1}{12}\sum_{i=1}^{12}\overline{x}_i$ $\left(\overline{x} = \frac{1}{4}\sum_{i=1}^{4}\overline{x}_i\right)$
- Seasonal indices for different months are obtained by expressing monthly averages as (% age) of $\overline{x}$. Thus, the seasonal index for ith month = $\frac{\overline{x}_i}{\overline{x}}\times 100$

Total of seasonal indices is $12\times 100=1200$ for monthly data & $4\times 100=400$ for quarterly data.

Interpretation of Seasonal Indices

The index value for each month shows how that month's average value relates to the average annual value. Thus, the index for Jan of 142.26 indicates that on the average Jan value will be 42.26% higher than annual average value.
Similarly, the Feb. seasonal index of 79 indicates that on average the Feb value will be 21% less than annual average value.

Clearly, having such a seasonal index is helpful to the manager for purpose of control, since it tells him what fluctuations to expect simply because of seasonal causes. A study of the seasonal patterns is extremely useful to businessperson, producers, sales managers etc. in planning future operations & in formulation of policy decisions regarding purchase, production inventory control, personal requirements, selling & advertisement programs.

In the absence of any knowledge of seasonal variations, a seasonal upswing may be mistaken as indicator of better business conditions whereas a seasonal slump may be interpreted as deteriorating business conditions. Thus, to understand the behavior of time series properly it has to be adjusted for seasonal variations. This is done by isolating them from trend and other components by dividing the time series values by the seasonal variations when multiplicative model ($Y_t = T_t S_t C_t I_t$) is used and subtracting in case of additive model ($Y_t = T_t + S_t + C_t + I_t$).

Method of Moving Averages

Moving average consists of a series of arithmetic means calculated from overlapping groups of successive elements of a time series. Each moving average is based on values covering a fixed time interval, called 'period of moving average' and is shown against the center of the first. The composition of items is adjusted successively by replacing the first observation of the previously averaged group by the next observation below that group. Thus, the moving average for a period k is a series of successive averages of observations at a time starting with first, 2nd, 3rd, to k terms. Thus, the first average is the mean of the first to k terms, the second is the mean of the k terms from second to (k+1)th terms, the third is the mean of the third to (k+2)th term and so on.

Thus, if the time series values are Y_1, Y_2, Y_3 … for different periods, the moving average of period 'k' are given by
1st value moving average = $(Y_1 + Y_2 + Y_3 + \ldots + Y_k) / k$
2nd value moving average = $(Y_2 + Y_3 + Y_4 + \ldots + Y_{k+1}) / k$
3rd value moving average = $(Y_3 + Y_4 + Y_5 + \ldots\ldots + Y_{k+2}) / k$
and so on. The sums in the numerators are called moving totals of order k.

Case 1. *When period is odd*. If the period 'k' of the moving average is odd, the successive values of the moving averages are placed against the middle value of concerned group of items. For example, if k=5, the first moving average value is placed against the middle period, i.e. third value and the second moving average value is placed against the time period four and so on.

Case 2. *When period is even.* If the period 'm' of M.A. is even then there are two middle periods and the M.A. value is placed in between the two middle terms of the time intervals it covers. Obviously, in this case the M.A. value will not coincide with a period
of the given time series, therefore an attempt is made to synchronize them with the original data by taking a two period averages of the moving averages and placing them in between the corresponding periods. This technique is called centering and the corresponding moving average values are called centered moving averages. In particular if the period k=4, the 1st moving average is placed against the middle of 2nd and 3rd items, the 2nd moving average is placed against the middle of 3rd and 4th items and so on.

Smoothing Techniques:

A time series is a sequence of observations, which are ordered in time. Inherent in the collection of data taken over time is some form of random variation. There exist methods for reducing of canceling the effect due to random variation. A widely used technique is "smoothing". This technique, when properly applied, reveals more clearly the underlying trend, seasonal and cyclic components.
Smoothing techniques are used to reduce irregularities (random fluctuations) in time series data. They provide a clearer view of the true underlying behavior of the series. Moving averages rank among the most popular techniques for the preprocessing of time series. They are used to filter random "white noise" from the data, to make the time series smoother or even to emphasize certain informational components contained in the time series.
Exponential smoothing is a very popular scheme to produce a smoothed time series. Whereas in moving averages the past observations are weighted equally, Exponential Smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. Double exponential smoothing is better at handling trends. Triple Exponential Smoothing is better at handling parabola trends.

Exponential smoothing is a widely method used of forecasting based on the time series itself. Unlike regression models, exponential smoothing does not imposed any deterministic model to fit the series other than what is inherent in the time series itself.

Exponential Smoothing

If the focus of interest is forecasting the future rather than reviewing the historical record, the relevant quantities to be estimated are the most recent trend and seasonal terms. These can then be projected forward to derive predictions of future values of the time series. This estimation problem and its solution is the basis of exponential smoothing, an approach to short-term forecasting that is widely used in industry.
There is not a unique forecasting algorithm known as exponential smoothing. Rather exponential smoothing is a general approach to the derivation of forecasting algorithms that has led to the development of several alternative procedures, based to some different assumptions about the characteristics of the time series of interest. The algorithms in popular use are typically justified on grounds of intuitive plausibility and successful practical experience in their application. Exponential smoothing is therefore a somewhat ad-hoc approach to the problem of forecasting a time series based on its own past.

Exponential smoothing algorithm, particularly attractive when forecasts of a very large number of time series, are needed on a regular basis. Specifically, these procedures were developed for and are currently widely used in, routine sales forecasting for inventory control purposes. Typically, short-term forecasts are required, on a monthly basis, for demand for great many mature product lines. In these circumstances, it may not feasible or, given the costs involved, desirable to devote a great deal of time and effort to the tailoring of specific forecasting procedures to the observed properties of each individual sales series. The extra forecast precision and consequent inventory cost savings may fail or compensate for the additional costs incurred. What may be required instead is an expensive algorithm whose application yields adequate short-term forecasts for at least the great majority of series that need to be predicted. In such circumstances, both case of application and a successful track record render exponential smoothing algorithms particularly attractive.

Simple Exponential Smoothing: It calculates the smoothed series as a damping coefficient times the actual series plus 1 minus the damping coefficient times the lagged value of the smoothed series. The extrapolated smoothed series is a constant, equal to the last value of the smoothed series during the period when actual data on the underlying series are available. While the simple Moving Average method is a special case of the ES, the ES is more parsimonious in its data usage.

$$F_{t+1} = \omega D_t + (1 - \omega) F_t$$

where:
D_t is the actual value at time t
F_t is the forecasted value at time t
ω is the weighting factor, which ranges from 0 to 1
t is the current time period.

Notice that the smoothed value becomes the forecast for period t + 1.
A small a provides a detectable and visible smoothing. While a large a provides a fast response to the recent changes in the time series but provides a smaller amount of smoothing. Notice that the exponential smoothing and simple moving average techniques will generate forecasts having the same average age of information if moving average of order n is the integer part of (2-a)/a.
An exponential smoothing over an already smoothed time series is called double-exponential smoothing. In some cases, it might be necessary to extend it even to a triple-exponential smoothing. While simple exponential smoothing requires stationary condition, the double-exponential smoothing can capture linear trends, and triple-exponential smoothing can handle almost all other business time series.

Double Exponential Smoothing: It applies the process described above three to account for linear trend. The extrapolated series has a constant growth rate, equal to the growth of the smoothed series at the end of the data period.

Triple Double Exponential Smoothing: It applies the process described above three to account for nonlinear trend.

Exponentially Weighted Moving Average: Suppose each day's forecast value is based on the previous day's value so that the weight of each observation drops exponentially the further back (k) in time it is. The weight of any individual is
$a(1 - a)^k$, where a is the smoothing constant.

An exponentially weighted moving average with a smoothing constant a, corresponds roughly to a simple moving average of length n, where a and n are related by

$a = 2/(n+1)$ or $n = (2 - a)/a$.

Thus, for example, an exponenentially weighted moving average with a smoothing constant equal to 0.1 would correspond roughly to a 19-day moving average. And a 40-day simple moving average would correspond roughly to an exponentially weighted moving average with a smoothing constant equal to 0.04878.

This approximation is helpful, however, it is harder to update, and may not correspond to an optimal forecast.

Smoothing techniques, such as the Moving Average, Weighted Moving Average, and Exponential Smoothing, are well suited for one-period-ahead forecasting

Holt's Linear Exponential Smoothing Technique: Suppose that the series { y_t } is non-seasonal but does display trend. Now we need to estimate both the current level and the current trend. Here we define the trend T_t at time t as the difference between the current and previous level.

The updating equations express ideas similar to those for exponential smoothing. The equations are:
$L_t = a\ y_t + (1 - a)\ F_t$
for the level and
$T_t = b\ (L_t - L_{t-1}) + (1 - b)\ T_{t-1}$

for the trend. We have two smoothing parameters a and b; both must be positive and less than one. Then the forecasting for k periods into the future is:

$F_{n+k} = L_n + k.\ T_n$

Given that the level and trend remain unchanged, the initial (starting) values are
$T_2 = y_2 – y_1$, $L_2 = y_2$, and $F_3 = L_2 + T_2$

The Holt-Winters' Forecasting Technique: Now in addition to Holt parameters, suppose that the series exhibits multiplicative seasonality and let St be the multiplicative seasonal factor at time t. Suppose also that there are s periods in a year, so s=4 for quarterly data and s=12 for monthly data. St-s is the seasonal factor in the same period last year.
In some time series, seasonal variation is so strong it obscures any trends or cycles, which are very important for the understanding of the process being observed. Winters' smoothing method can remove seasonality and makes long term fluctuations in the series stand out more clearly. A simple way of detecting trend in seasonal data is to take averages over a certain period. If these averages change with time we can say that there is evidence of a trend in the series. The updating equations are:
$L_t = a\ (L_{t-1} + T_{t-1}) + (1 - a)\ y_t / S_{t-s}$
for the level,

$T_t = b\ (L_t - L_{t-1}) + (1 - b)\ T_{t-1}$
for the trend, and
$S_t = g\ S_{t-s} + (1- g)\ y_t / L_t$
for the seasonal factor.
We now have three smoothing parameters a , b, and g all must be positive and less than one.
To obtain starting values, one may use the first a few year data. For example for quarterly data, to estimate the level, one may use a centered 4-point moving average:
$L_{10} = (y_8 + 2y_9 + 2y_{10} + 2y_{11} + y_{12}) / 8$

as the level estimate in period 10. This will extract the seasonal component from a series with 4 measurements over each year.
$T_{10} = L_{10} - L_9$
as the trend estimate for period 10.
$S_7 = (y_7 / L_7 + y_3 / L_3) / 2$
as the seasonal factor in period 7. Similarly,
$S_8 = (y_8 / L_8 + y_4 / L_4) / 2$,

$S_9 = (y_9 / L_9 + y_5 / L_5) / 2$,

$S_{10} = (y_{10} / L_{10} + y_6 / L_6) / 2$

For Monthly Data, the correspondingly we use a centered 12-point moving average:

$L_{30} = (y_{24} + 2y_{25} + 2y_{26} + ... + 2y_{35} + y_{36}) / 24$
as the level estimate in period 30.
$T_{30} = L_{30} - L_{29}$
as the trend estimate for period 30.
$S_{19} = (y_{19} / L_{19} + y_7 / L_7) / 2$
as the estimate of the seasonal factor in period 19, and so on, up to 30:
$S_{30} = (y_{30} / L_{30} + y_{18} / L_{18}) / 2$
Then the forecasting k periods into the future is:
$F_{n+k} = (L_n + k. T_n) S_{t+k-s}$, for k = 1, 2, ...,s

Measuring Accuracy of Forecast:

A forecast is never completely accurate; forecasts will always deviate from the actual demand. The objective of forecasting is that it be as slight as possible. There are many measures of forecast error, the more popular ones are; mean absolute deviation (MAD), mean absolute percent deviation (MAPD), cumulative error, and average error or bias (E).

MEAN ABSOLUTE DEVIATION (MAD)

· Most popular and simplest to use measure of forecasting
· MAD is and average of the difference between the forecast and the actual demand
· Formula: $MAD= \frac{(Sum\ |D_t - F_t|)}{n}$

Where: t = the period number
D_t = the demand in period t
F_t = the forecast for period t
n = the total number of periods
| | = the absolute value

· The smaller/lower value of MAD, the more accurate the forecast
· One benefit of MAD is to compare the accuracy of several different forecasting techiniques.

MEAN ABSOLUTE PERCENT DEVIATION (MAPD)

· Measures the absolute error as a percentage of demand rather than per period.
· Resulting in elimination of the problem fo interpreting the measure of accuracy relative to the magnitude of the demand and forecast values, as MAD does.
· Formula: $MAPD= \frac{(Sum\ |D_t - F_t|)}{Sum(D_t)}$

CUMULATIVE ERROR

· Formula: $E= Sum(e_t)$
· A large postive value indicates the forecast is probably consistently lower than the actual demand, or is biased low.
· A large negative value implies the forecast is consistently higher than actual demand or is biased high.
· The cumulative error for exponential smoothing forecast is simply the sum of the values in the error column.

AVERAGE ERROR

· A measure closely related to cumulative error is the average error or bias. It is computed by averaging the cumulative error over the number of time periods.
· Formula: $E= \frac{Sum\ (e_t)}{n}$
· A positive value indicates low bias and a negative value indicates a high bias. A value close to zero implies a lack of bias.

Coefficient of determination:

In statistics, the **coefficient of determination**, denoted $\boldsymbol{R^2}$ and pronounced **R squared**, indicates how well data points fit a statistical model – sometimes simply a line or curve.

$$R^2 = 1-(Var_{err} / Var_{total})$$

Procurement

Procurement is the act of obtaining or buying of goods and services.
The process includes preparation and processing of a demand as well as the end receipt and approval of payment. Manufacturers often rely on different types of long term contracts with established suppliers to procure goods often involving delivery lead times. Commodity markets as well as online markets provide additional procurement flexibility; manufacturers can procure through their conventional channels or interact directly with the market either through spot or forward transactions

Procurement and inventory management models in the operations management and supply chain management literature usually assume constant or known procurement prices while modeling in detail transaction costs, storage costs and costs associated with fulfilling a stochastic demand. In this research, we explore how exogenously determined random shocks in procurement costs affect operating decisions of a firm. In particular, we explore in detail the procurement process of commodities whose prices are subject to random shocks due to demand and supply fluctuations. Commodity prices exhibit volatility and substantial cyclical behavior that exacerbates the complexity of procurement for the commodity users.

In this study we are suggesting the procurement policy for the management of raw material inventory for the manufacturing of electric goods.

The basic assumptions of our model are:

1. Demand is different in each period.
2. Procurement is done at the beginning of period and demand is met instantaneously throughout the period.
3. Shortages are not allowed.

Notations:

C_n=Total cost up to and including the n^{th} period.
r_i = requirement of the i^{th} period
A = Ordering Cost
I= Inventory Carrying Cost
C= Cost per unit

The total cost for the n-periods is given by

C_n (j) = C_{j-1} + A + C (r_j + r_{j-1} +………+ r_n) + (I*C) (r_j /2 + r_{j+1}/2 +……+ r_n/2) + (I*C) (r_{j+1}/2 + r_{j+2}/2 +……+ r_n/2) +…….+(I*C) (r_n/2)

= C_{j-1} + A + C (r_j + ………+ r_n) + (I*C) (r_j /2 + (r_{j+1})3/2 +……+ (r_n) (n-j+1)/2)

Our objective is to minimize the cost
Thus we have
Min C n (j) = Min {Cj-1 + A + C(rj + ………+ rn) + (I*C) (rj /2 + (rj+1)3/2 +…….+ (rn)(nj+1)/2) }

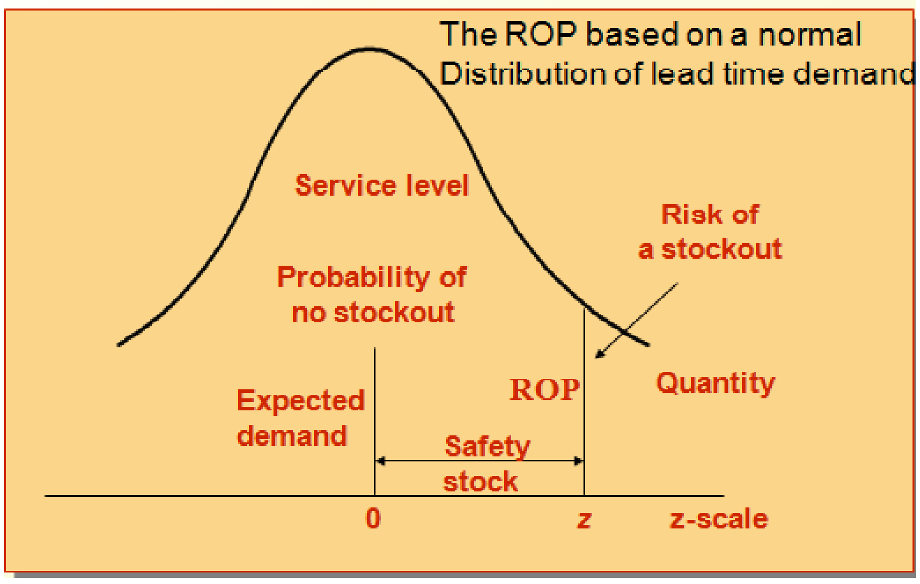
Reorder point , Safety Stock and Service level

- *Reorder Point* - When the quantity on hand of an item drops to this amount, the item is reordered
- *Safety Stock/Buffer Stock* - Stock that is held in excess of expected demand due to variable demand rate and/or lead time.
- *Service Level* - Probability that demand will not exceed supply during lead time.

Determinants of Reorder point (ROP):

- The rate of demand (based on a forecast)
- The lead time
- Demand and/or lead time variability
- Stockout risk (safety stock)

ROP = Expected demand during lead time + safety stocks



An estimate of expected demand during lead time and its standard deviation are available

$$ROP = \begin{matrix}\text{Expected demand}\\ \text{during lead time}\end{matrix} + z\sigma_{dLT}$$

Reorder point when the demand is variable and lead time is constant

$\bar{d}$ = Average daily or weekly demand

σ_d = Standard deviation of demand per day or week

LT = Lead time in days or weeks

Let d_i=daily/weekly demand

d_i's are iid random variables

demand during lead time = D=$\sum_{i=1}^{LT} d_i$

expected demand during lead time =E(D)= $E(\sum_{i=1}^{LT} d_i) = E(\sum_{i=1}^{LT} d) = E(dLT) = \bar{d}LT$

Variance of demand during lead time = $\sum_{i=1}^{LT} \sigma_{di}^2 = \sum_{i=1}^{LT} \sigma_d^2 = \sigma_d^2 LT$

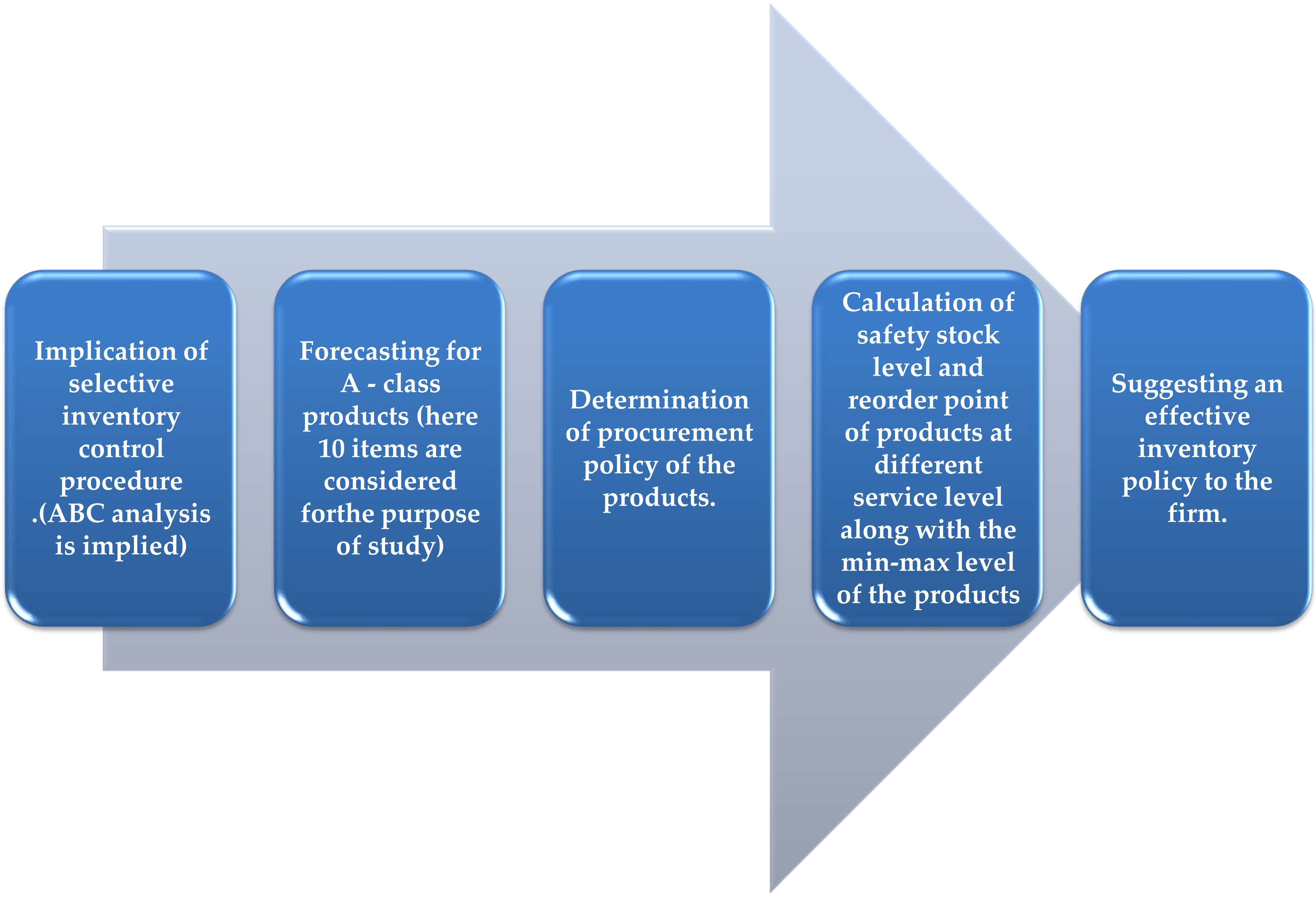
Standard deviation of demand during lead time = $= \sigma_d \sqrt{LT}$

$$ROP = \bar{d} \times LT + z\sqrt{LT}\sigma_d$$

Objective of study

"To determine the procurement policy for raw materials used in the manufacturing of electrical goods in C & S electric ltd. "

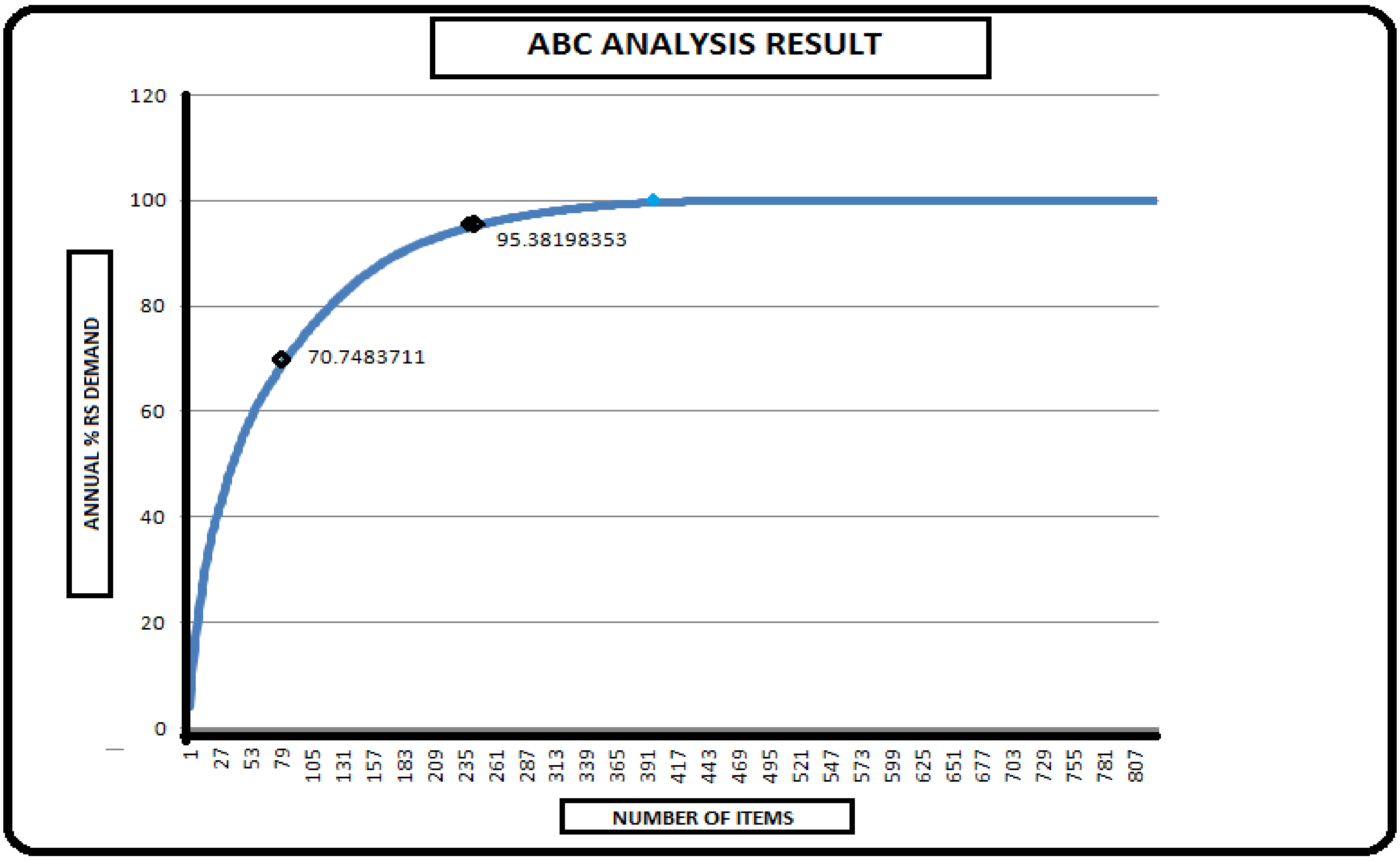
The steps carried out for the study are:



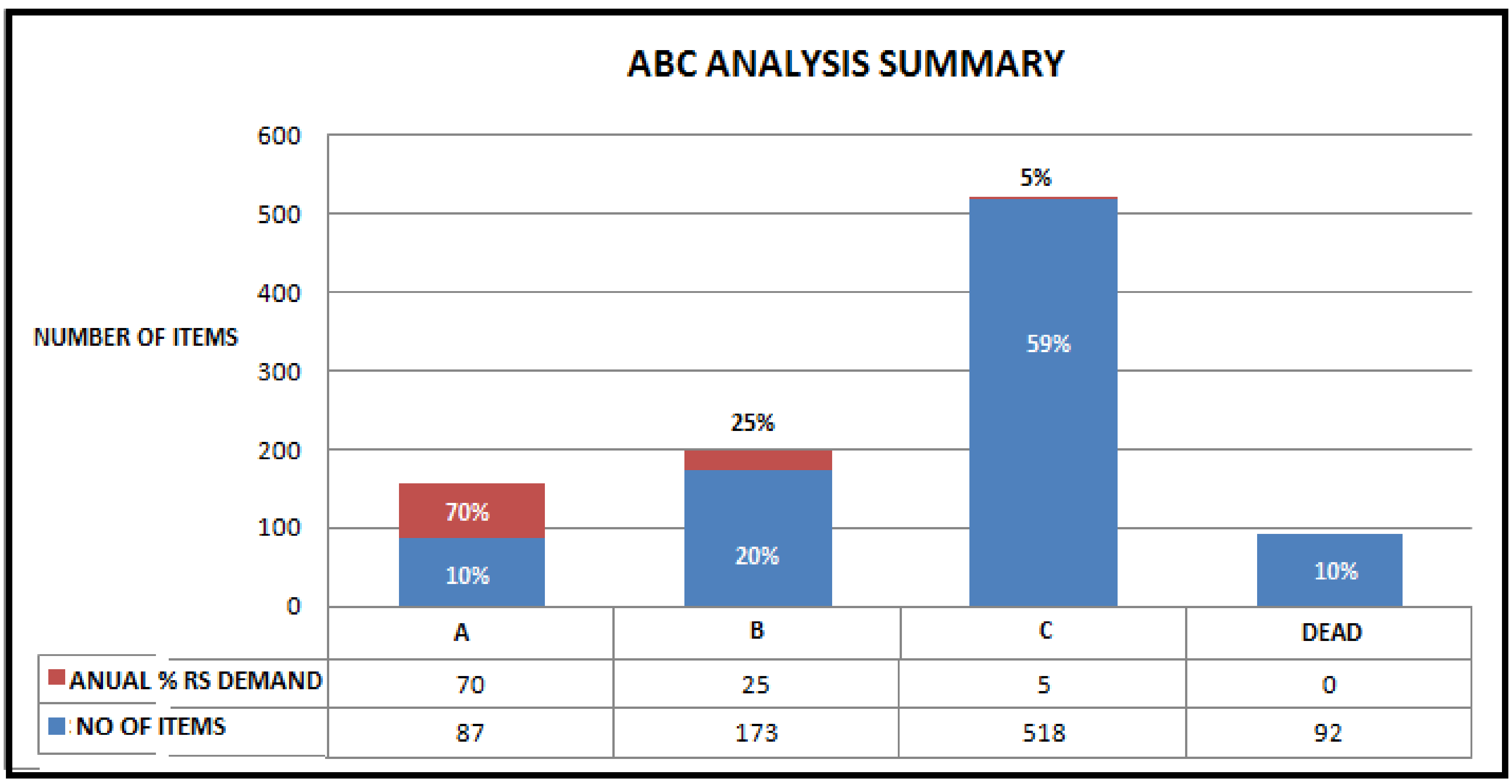
- **Implication of selective inventory control procedure .(ABC analysis is implied)**

  On the basis of the method specified in the literature review in the section of selective inventory control the ABC analysis is implied on the inventory of 807 items of normal and extracare category provided by the company the following results of abc analysis is obtained--

  - 1. A class item--- 80 (rupee usage 70% of the total.)
  - 2. B class item --- 173 (rupee usage 25% of the total)
  - 3. C class item --- 518(rupee usage 5% of the total)
  - 4.D class item----92(rupee usage 0% of total or DEAD PRODECT)
- (This classification is generated on the basis of the inflexion points obtained in the below graph plotted corresponding to the cumulative average value % on vertical axis and no. of items on horizontal axis.)Total inventory cost-- -10355245263 in Rupee
- ABC analysis is applied on the given data of 807 SKU's movement on monthly basis.



Here is the summary of the abc analysis which represents clear picture of the movement and profit from items.



A CATEGORY RANKING OF SKU'S BASED ON ABC ANALYSIS								
RANK	SKU	% YEARLY DEMAND	RANK	SKU	% YEARLY DEMAND	RANK	SKU	% YEARLY DEMAND
1	04020003NP	3.932005806	21	02000211SW	0.915898731	41	02001150RP	0.634781681
2	02000199TU	3.30637654	22	02001043NT	0.867727878	42	04010008NR	0.613365965
3	02000221RU	2.99955387	23	02001126NR	0.814941586	43	4020026	0.608899243
4	04020001NAS	2.342896704	24	4030084	0.784399577	44	04030073NP	0.606246384
5	02000330QW	2.307571418	25	02000979TS	0.783880999	45	02000328NT	0.574313003
6	04020021NP	2.2661611	26	04030143C	0.782617871	46	02000968SV	0.574212725
7	04010030NP	1.896884091	27	02000205QT	0.769158025	47	02501673SVLB	0.551317893
8	02001012TV	1.702570586	28	02001156PP	0.758089239	48	02001093VD	0.521864607
9	04030145C	1.673837708	29	4030085	0.7572346	49	04010029NP	0.51920354
10	04030142C	1.662761196	30	02001132NS	0.752453448	50	04052001NP	0.514465845
11	02000213RV	1.54230939	31	04030009P	0.751470371	51	02000324NU	0.49658621
12	02000261SV	1.396128323	32	04030011P	0.744234231	52	02000248NR	0.48937487
13	02000949VD	1.315116316	33	04010010N	0.73531141	53	02000972RU	0.488239522
14	02000322TY	1.299717839	34	02000944SV	0.718175013	54	02000967SV	0.478947381
15	02000984QV	1.273137397	35	02000328NS	0.713284506	55	02001107NP	0.474642548
16	4020019	1.159474227	36	2250055	0.672960883	56	4030034	0.460147093
17	02000193QU	1.122460135	37	02001154PP	0.66925986	57	4020016	0.426743731
18	4030157	1.115702014	38	4030161	0.667140162	58	02000234QW	0.419905071
19	4030160	1.109447406	39	02000277NV	0.662591742	59	02250039NP	0.407840847
20	2250003	1.082055974	40	02331017OQ	0.645794458	60	02331008PQ	0.40220776

PRODUCT RANKING BASED ON THE DEMAND OF THEM.

RANKING OF SKU'S BASED ON FSN ANALYSIS					
RANK	SKU	RANK	SKU	RANK	SKU
1	04020003NP	21	4030160	41	02250039NP
2	04020001NAS	22	04020021NP	42	04010027NP
3	02000322TY	23	02000261SV	43	02000979TS
4	04010010N	24	02000193QU	44	02000213RV
5	04030145C	25	4020016	45	02000944SV
6	04030142C	26	4020026	46	4030093
7	4030084	27	4020006	47	02000949VD
8	4030085	28	02001156PP	48	02001107NP
9	02001154PP	29	4030161	49	4030079
10	04010011N	30	4020024	50	02331017OQ
11	02000199TU	31	02001012TV	51	04030016C
12	04030143C	32	02000205QT	52	02000968SV
13	02000330QW	33	4030171	53	4030078
14	04030009P	34	4030094	54	02501673SVLB
15	02000221RU	35	4020019	55	2331082
16	02001164PP	36	04050001NP	56	02000248NR
17	04030011P	37	02001152RP	57	4030170
18	02000321UZ	38	04030146C	58	02000202SQ
19	04020001NP	39	4030157	59	02000967SV
20	02001150RP	40	02001153RP	60	02000984QV

FORECASTING

Forecasting of 7 items are done using IBM-SPSS 20

The steps involving in this procedure are as follows:

Step 1: To define a time series in the Data Editor, click the **Variable View** tab and enter a variable name in any blank row.

Step 2: Transformation of data in time series is done using define date procedure. The **Define Dates** procedure (on the Data menu) generates date variables used to establish periodicity and to distinguish between historical, validation, and forecasting periods.

Step 3: From the menus choose:

Analyze > **Forecasting** > **Create Models...**

Step 4: On the Variables tab, select one or more dependent variables to be modeled.

Step 5: From the Method drop-down box, select a modeling method. For automatic modeling, leave the default method of **Expert Modeler**. This will invoke the Expert Modeler to determine the best-fitting model for each of the dependent variables.

Step 6: To produce forecasts:

Click the **Options** tab. Specify the forecast period. This will produce a chart that includes forecasts and observed values.

Remark

Expert Modeler. The Expert Modeler automatically finds the best-fitting model for each dependent series. If independent (predictor) variables are specified, the Expert Modeler selects, for inclusion in ARIMA models, those that have a statistically significant relationship with the dependent series. Model variables are transformed where appropriate using differencing and/or a square root or natural log transformation.
By default, the Expert Modeler considers both exponential smoothing and ARIMA models. You can, however, limit the Expert Modeler to only search for ARIMA models or to only search for exponential smoothing models. You can also specify automatic detection of outliers.

The forecasting methodologies implied on the products are shown as follows:

FORECASTING OF THE MATERIAL 04020003NP

Time Series Modeler

Model Description

			Model Type
Model ID	demand	Model_1	Winters' Additive

Model Summary

Model Fit

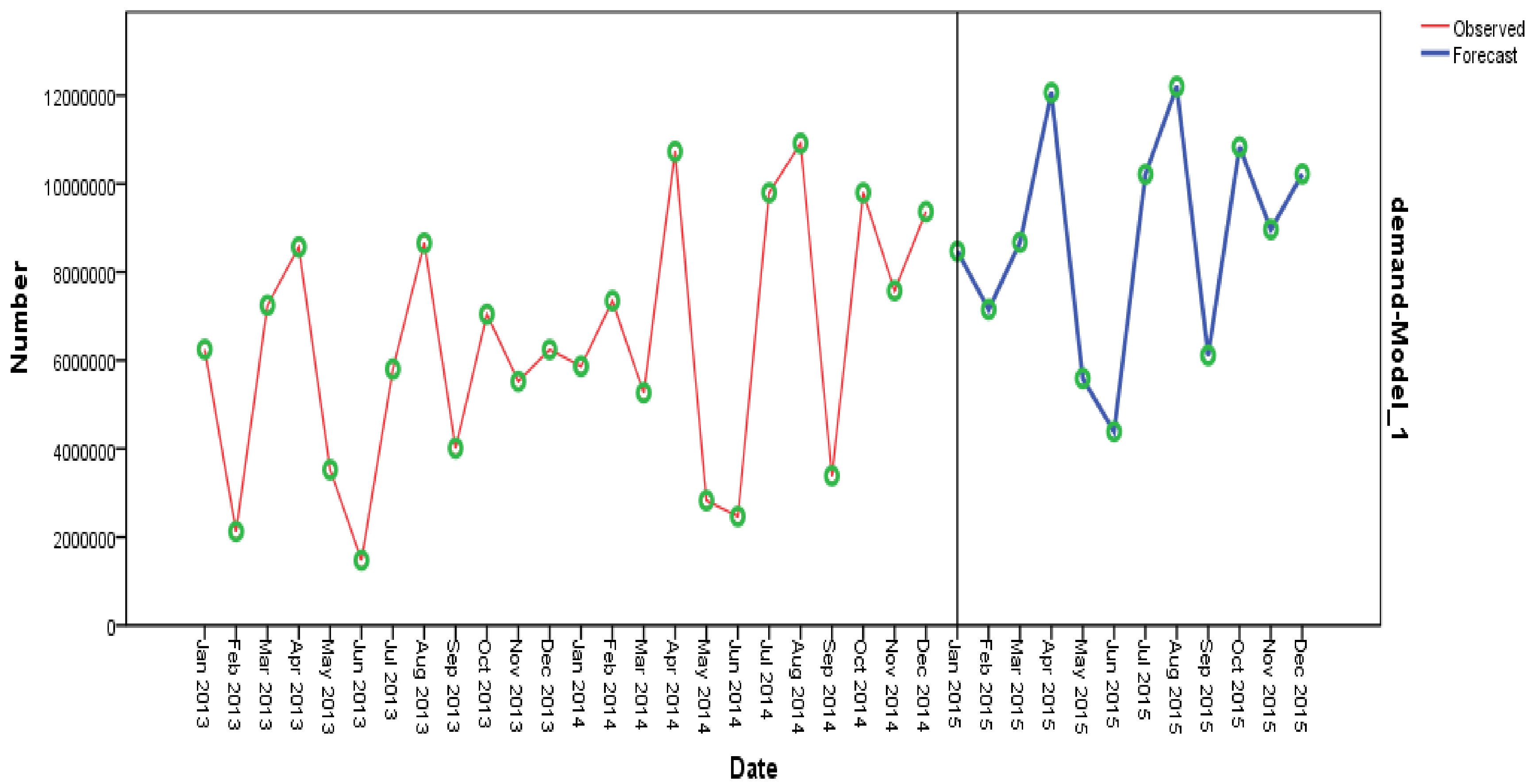
Fit Statistic	Mean	Minimum	Maximum	Percentile						
				5	10	25	50	75	90	95
Stationary R-squared	.911	.911	.911	.911	.911	.911	.911	.911	.911	.911
R-squared	.847	.847	.847	.847	.847	.847	.847	.847	.847	.847
RMSE	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434	1148955.434
MAE	915741.815	915741.815	915741.815	915741.815	915741.815	915741.815	915741.815	915741.815	915741.815	915741.815
MaxAE	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534	2083428.534

Model Statistics

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.911	1148955.434	18.817	915741.815	97.998	2083428.534	35.758	15	.002	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	8474051	7153435	8673133	12065669	5591288	4386954	10216504	12202382	6115558	10837316	8966598	10222753
	UCL	10863435	9551917	11080679	14482246	8016862	6821491	12659972	14654748	8576790	13307381	11445466	12710393
	LCL	6084667	4754952	6265586	9649092	3165715	1952417	7773036	9750016	3654326	8367250	6487730	7735113



FORECASTING OF THE MATERIAL 02000199TU

Time Series Modeler

Model Description

		Model Type
Model ID	demand Model_1	Winters' Additive

Model Summary

Model Fit

Fit Statistic	Mean	Minimum	Maximum	Percentile						
				5	10	25	50	75	90	95
Stationary R-squared	.710	.710	.710	.710	.710	.710	.710	.710	.710	.710
R-squared	.834	.834	.834	.834	.834	.834	.834	.834	.834	.834
RMSE	121798.309	121798.309	121798.309	121798.309	121798.309	121798.309	121798.309	121798.309	121798.309	121798.309
MAE	95264.403	95264.403	95264.403	95264.403	95264.403	95264.403	95264.403	95264.403	95264.403	95264.403
MaxAE	237001.694	237001.694	237001.694	237001.694	237001.694	237001.694	237001.694	237001.694	237001.694	237001.694

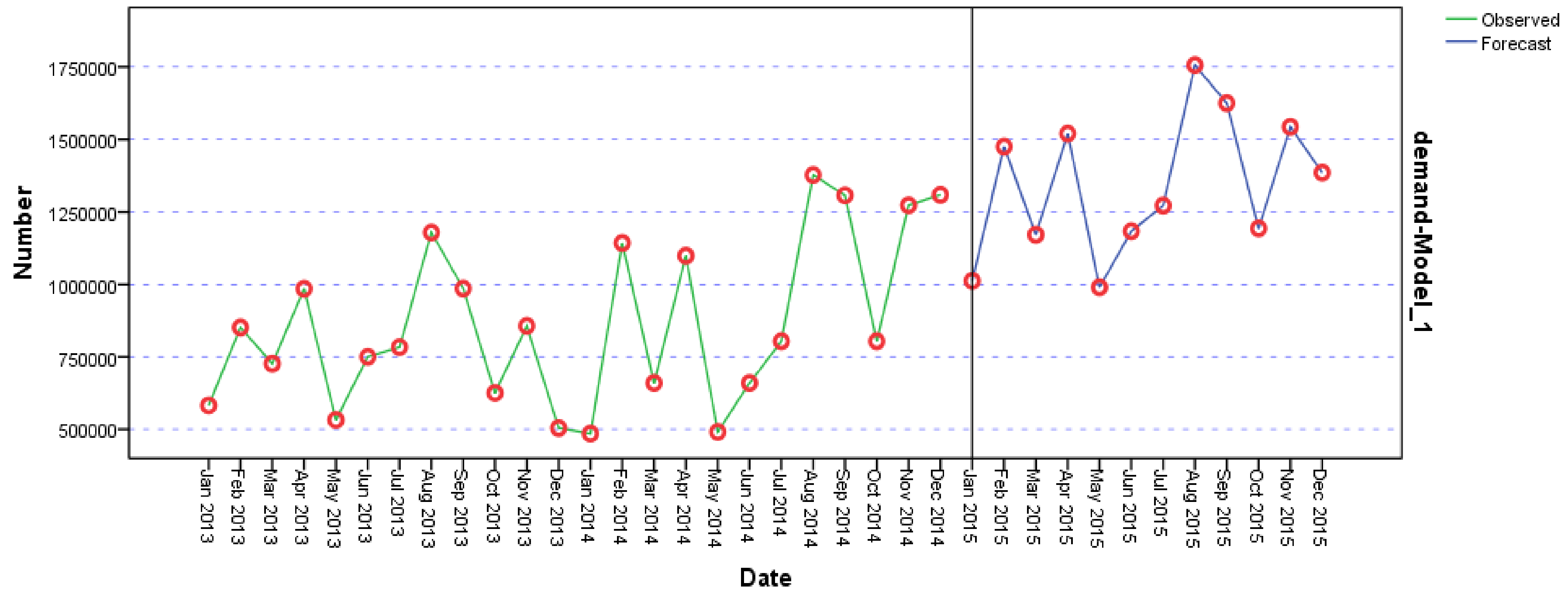
Model Statistics

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	

demand-Model_1	0	.710	121798.309	11.664	95264.403	46.920	237001.694	19.115	15	.209	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	1012163	1475428	1171510	1520365	990238	1183607	1272120	1756541	1625076	1193041	1543478	1385403
	UCL	1265456	1770787	1503652	1885604	1385817	1607360	1722288	2231659	2123899	1714493	2086619	1949400
	LCL	758869	1180069	839369	1155126	594660	759855	821952	1281423	1126252	671588	1000337	821406



FORECASTING OF THE MATERIAL 02000221RU

Time Series Modeler

Model Description

			Model Type
Model ID	demand	Model_1	Winters' Additive

Model Summary

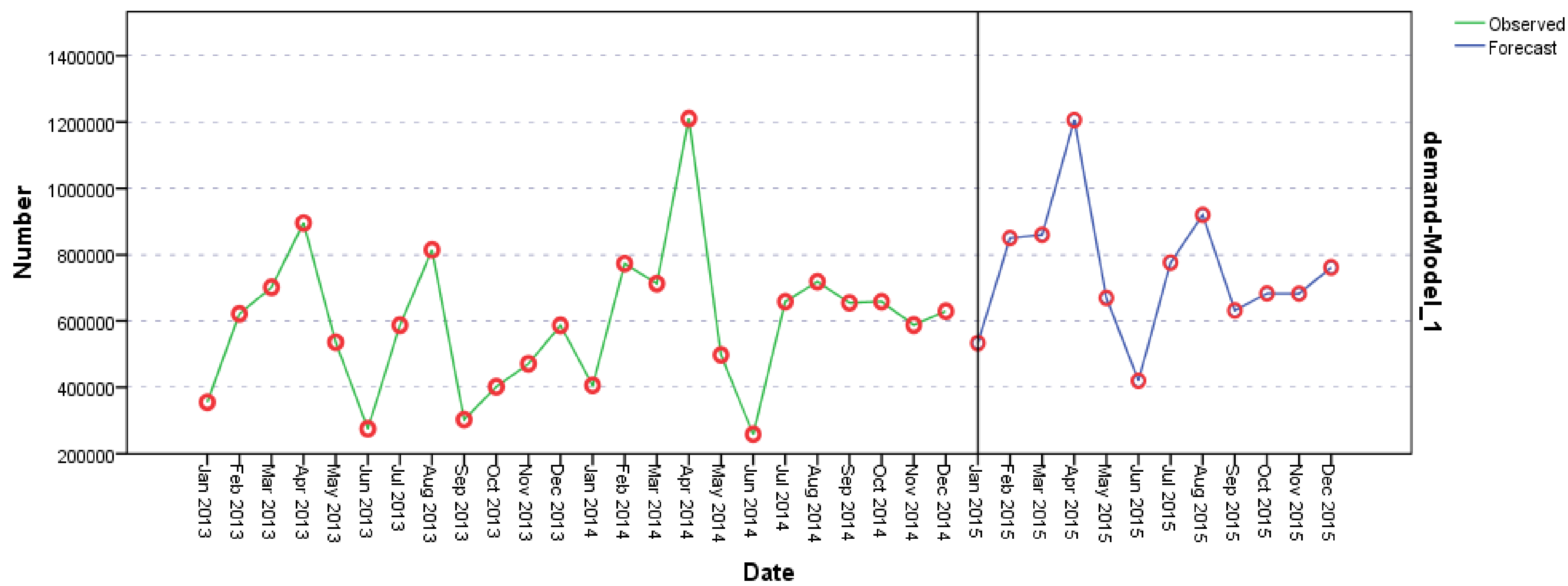
Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.883	.	.883	.883	.883	.883	.883	.883	.883	.883	.883
R-squared	.885	.	.885	.885	.885	.885	.885	.885	.885	.885	.885
RMSE	76360.865	.	76360.865	76360.865	76360.865	76360.865	76360.865	76360.865	76360.865	76360.865	76360.865
MAPE	11.204	.	11.204	11.204	11.204	11.204	11.204	11.204	11.204	11.204	11.204
MaxAPE	46.006	.	46.006	46.006	46.006	46.006	46.006	46.006	46.006	46.006	46.006
MAE	58696.793	.	58696.793	58696.793	58696.793	58696.793	58696.793	58696.793	58696.793	58696.793	58696.793
MaxAE	143071.269	.	143071.269	143071.269	143071.269	143071.269	143071.269	143071.269	143071.269	143071.269	143071.269

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.883	76360.865	11.204	58696.793	46.006	143071.269	25.247	15	.047	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	533475	850460	860222	1206329	669828	419616	776049	919905	631699	683093	682573	761358
	UCL	692276	1009991	1020478	1367309	831528	582032	939178	1083744	796246	848344	848525	928008
	LCL	374674	690930	699965	1045349	508129	257200	612919	756066	467153	517843	516621	594708



FORECASTING OF THE MATERIAL 02000330QW

Model Description

			Model Type
Model ID	demand	Model_1	Winters' Additive

Model Summary

Model Fit

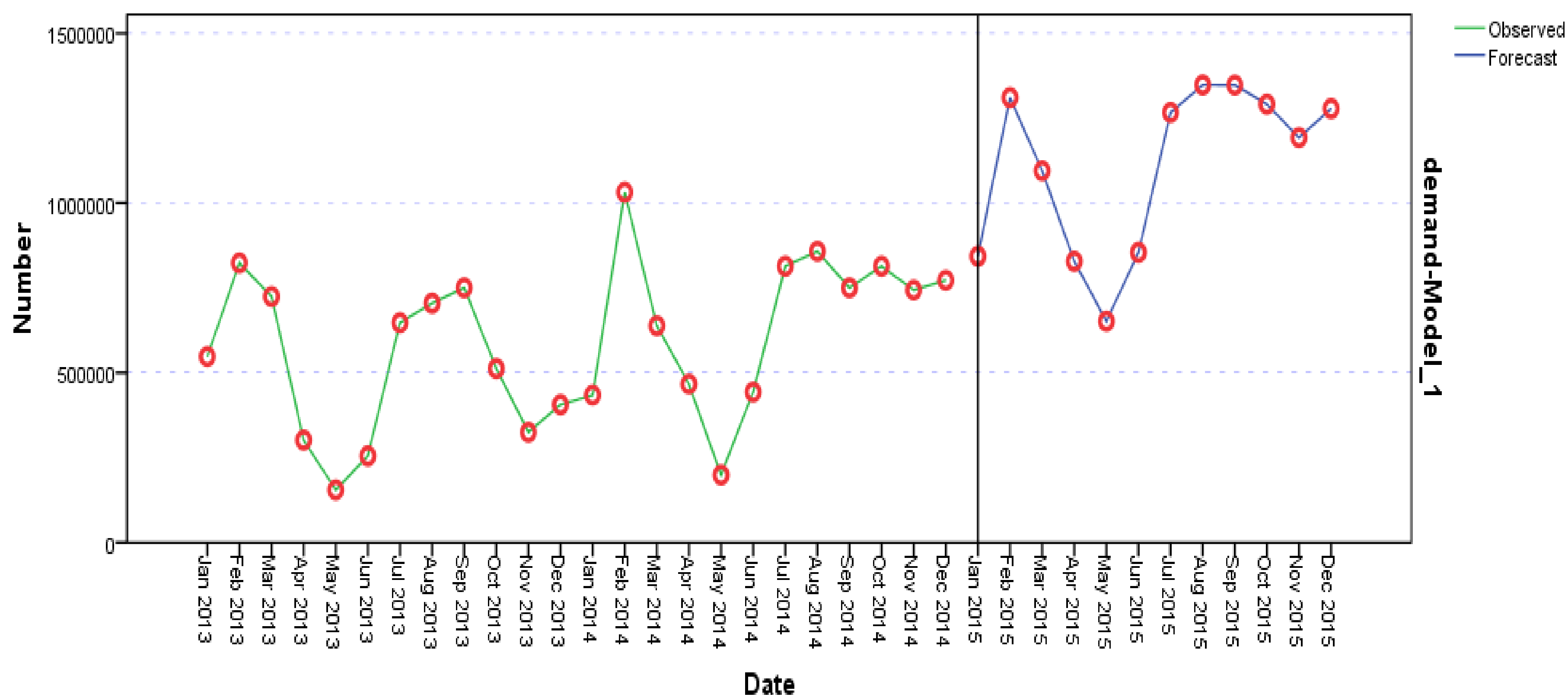
Fit Statistic	Mean	Minimum	Maximum	Percentile						
				5	10	25	50	75	90	95
Stationary R-squared	.826	.826	.826	.826	.826	.826	.826	.826	.826	.826
R-squared	.899	.899	.899	.899	.899	.899	.899	.899	.899	.899
RMSE	78304.139	78304.139	78304.139	78304.139	78304.139	78304.139	78304.139	78304.139	78304.139	78304.139
MAPE	11.774	11.774	11.774	11.774	11.774	11.774	11.774	11.774	11.774	11.774
MaxAPE	37.001	37.001	37.001	37.001	37.001	37.001	37.001	37.001	37.001	37.001
MAE	60596.792	60596.792	60596.792	60596.792	60596.792	60596.792	60596.792	60596.792	60596.792	60596.792
MaxAE	154724.636	154724.636	154724.636	154724.636	154724.636	154724.636	154724.636	154724.636	154724.636	154724.636
Normalized BIC	22.934	22.934	22.934	22.934	22.934	22.934	22.934	22.934	22.934	22.934

Model Statistics

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.826	78304.139	11.774	60596.792	37.001	154724.636	24.445	15	.058	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	843230	1310751	1095251	828345	651714	854541	1266933	1347985	1347798	1291191	1192773	1278455
	UCL	1006073	1480653	1277622	1029167	876909	1109576	1556683	1676744	1719363	1708951	1659791	1797532
	LCL	680388	1140850	912881	627523	426519	599506	977184	1019226	976234	873431	725755	759377



FORECASTING OF THE MATERIAL 04020001NAS

Model Description

		Model Type
Model ID	demand Model_1	Winters' Additive

Model Summary

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95

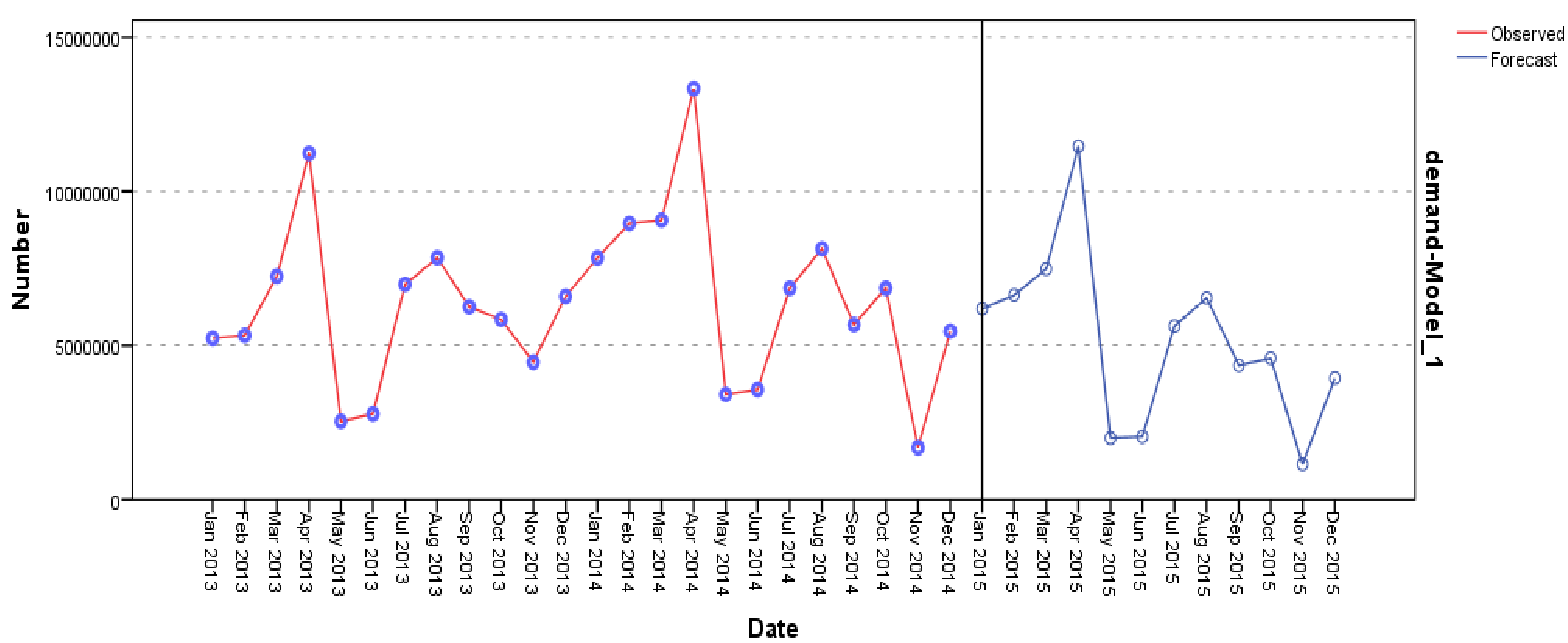
Stationary R-squared	.808	.	.808	.808	.808	.808	.808	.808	.808	.808	.808
R-squared	.951	.	.951	.951	.951	.951	.951	.951	.951	.951	.951
RMSE	626528.383	.	626528.383	626528.383	626528.383	626528.383	626528.383	626528.383	626528.383	626528.383	626528.383
MAPE	9.799	.	9.799	9.799	9.799	9.799	9.799	9.799	9.799	9.799	9.799
MaxAPE	48.464	.	48.464	48.464	48.464	48.464	48.464	48.464	48.464	48.464	48.464
MAE	475490.400	.	475490.400	475490.400	475490.400	475490.400	475490.400	475490.400	475490.400	475490.400	475490.400
MaxAE	1310569.048	.	1310569.048	1310569.048	1310569.048	1310569.048	1310569.048	1310569.048	1310569.048	1310569.048	1310569.048
Normalized BIC	27.093	.	27.093	27.093	27.093	27.093	27.093	27.093	27.093	27.093	27.093

Model Statistics

Model	Number of Predictors	Model Fit statistics	Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	
demand-Model_1	0	.808	25.277	15	.046	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	6192342	6636107	7491289	11463006	1998560	2043061	5630212	6543044	4352853	4587356	1149543	3942346
	UCL	7495279	8057391	9131247	13420365	4358812	4877394	8998385	10496471	8936936	9843080	7114560	10651709
	LCL	4889405	5214822	5851331	9505648	-361692	-791273	2262039	2589616	-231230	-668369	-4815474	-2767018



FORECASTING OF THE MATERIAL 02000213RV

Model Description

			Model Type
Model ID	demand	Model_1	Simple Seasonal

Model Summary

Model Fit

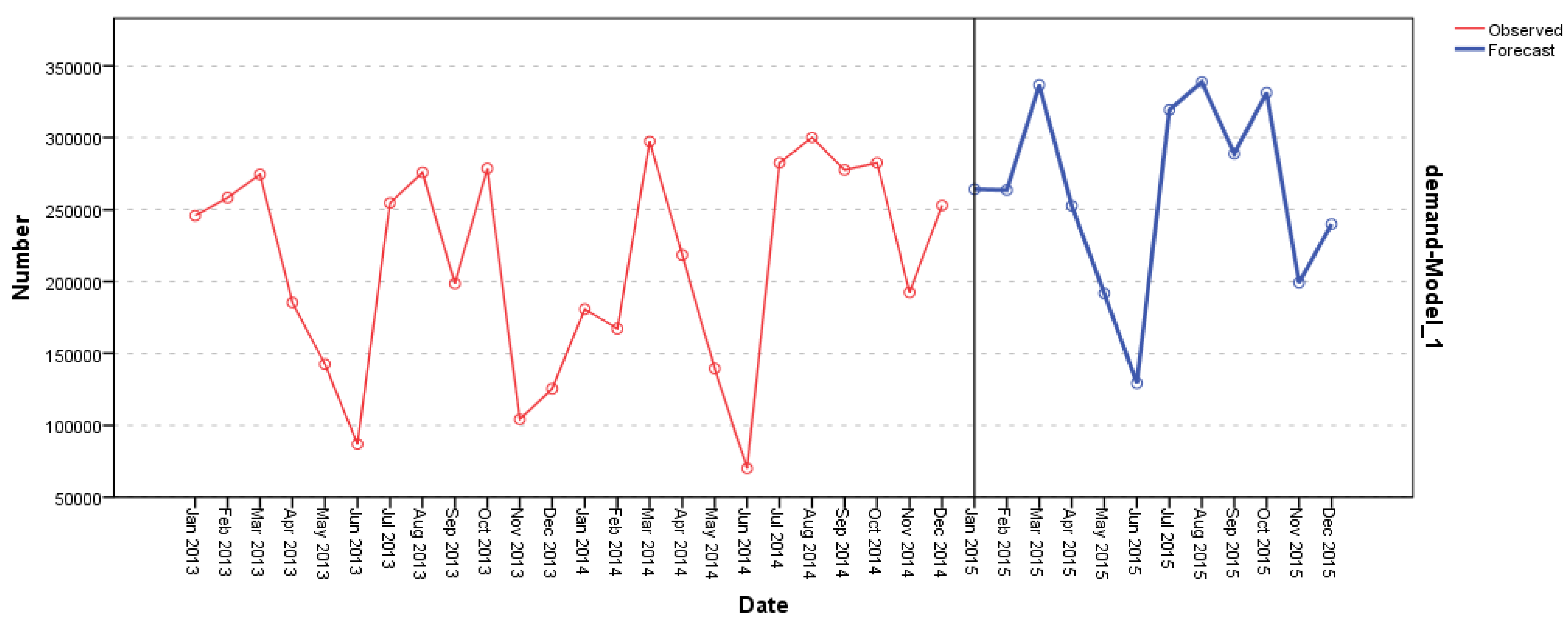
Fit Statistic	Mean	SE	Minimum	Maximum	Percentile 5	10	25	50	75	90	95
Stationary R-squared	.748	.	.748	.748	.748	.748	.748	.748	.748	.748	.748
R-squared	.866	.	.866	.866	.866	.866	.866	.866	.866	.866	.866
RMSE	26834.739	.	26834.739	26834.739	26834.739	26834.739	26834.739	26834.739	26834.739	26834.739	26834.739
MAPE	11.144	.	11.144	11.144	11.144	11.144	11.144	11.144	11.144	11.144	11.144
MaxAPE	30.553	.	30.553	30.553	30.553	30.553	30.553	30.553	30.553	30.553	30.553
MAE	21785.076	.	21785.076	21785.076	21785.076	21785.076	21785.076	21785.076	21785.076	21785.076	21785.076
MaxAE	54732.885	.	54732.885	54732.885	54732.885	54732.885	54732.885	54732.885	54732.885	54732.885	54732.885
Normalized BIC	20.660	.	20.660	20.660	20.660	20.660	20.660	20.660	20.660	20.660	20.660

Model Statistics

Model	Number of Predictors	Model Fit statistics: Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Ljung-Box Q(18): Statistics	DF	Sig.	Number of Outliers
demand-Model_1	0	.748	26834.739	11.144	21785.076	30.553	54732.885	20.756	16	.188	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	264215	263682	336775	252770	191811	129310	319492	338835	288921	331412	199201	240064
	UCL	319867	328582	409761	333032	278741	222433	418420	443246	398541	446005	318560	364005
	LCL	208563	198781	263789	172509	104881	36188	220564	234424	179301	216819	79843	116123



FORECASTING OF THE MATERIAL 04030142C

Model Description

	Model Type
Model ID demand Model_1	Winters' Additive

Model Summary

Model Fit

Fit Statistic	Mean	Minimum	Maximum	Percentile 5	10	25	50	75	90	95

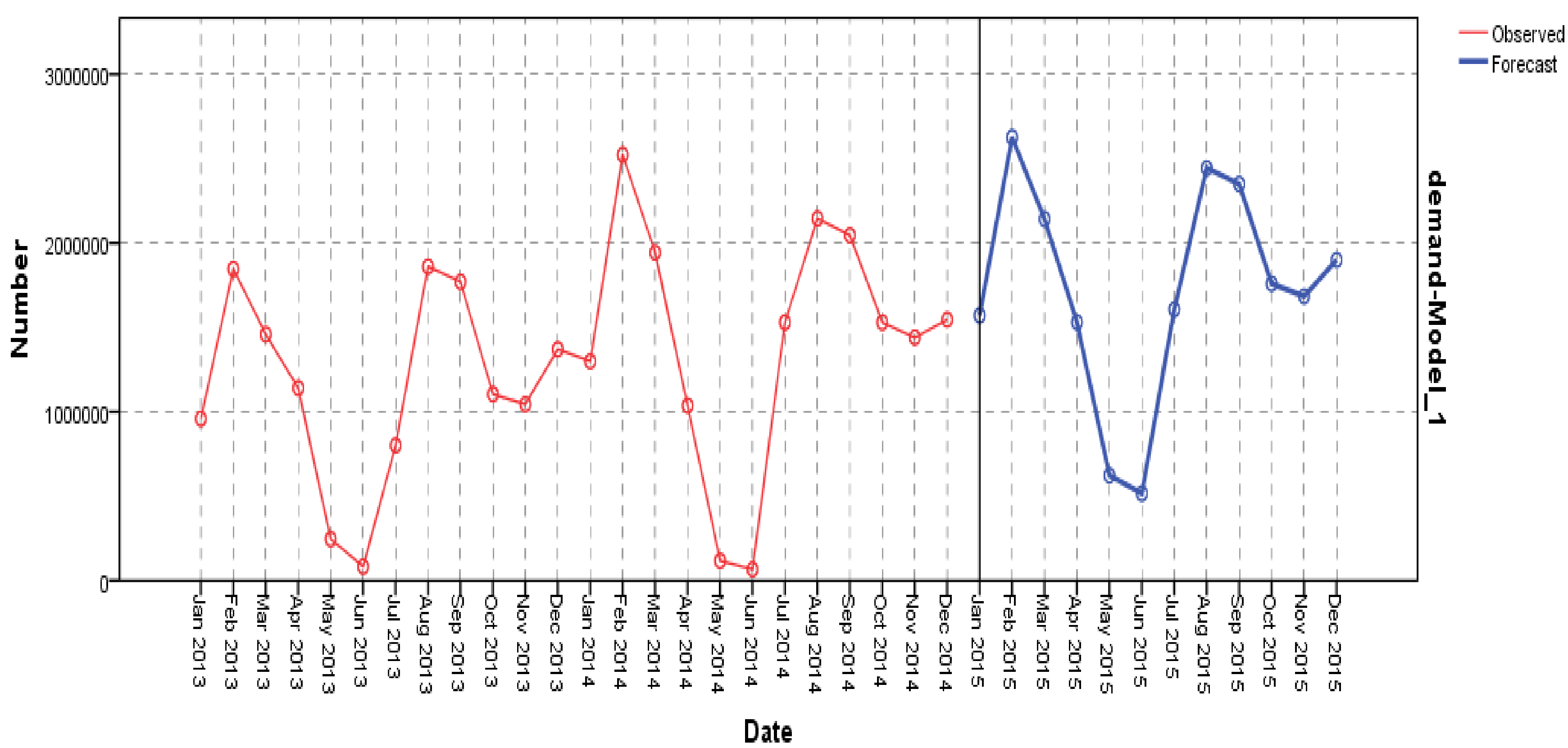
Stationary R-squared	.826	.826	.826	.826	.826	.826	.826	.826	.826	.826
R-squared	.955	.955	.955	.955	.955	.955	.955	.955	.955	.955
RMSE	148620.803	148620.803	148620.803	148620.803	148620.803	148620.803	148620.803	148620.803	148620.803	148620.803
MAPE	33.797	33.797	33.797	33.797	33.797	33.797	33.797	33.797	33.797	33.797
MaxAPE	213.658	213.658	213.658	213.658	213.658	213.658	213.658	213.658	213.658	213.658
MAE	108690.333	108690.333	108690.333	108690.333	108690.333	108690.333	108690.333	108690.333	108690.333	108690.333
MaxAE	246107.089	246107.089	246107.089	246107.089	246107.089	246107.089	246107.089	246107.089	246107.089	246107.089
Normalized BIC	24.216	24.216	24.216	24.216	24.216	24.216	24.216	24.216	24.216	24.216

Model Statistics

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.826	148620.803	33.797	108690.333	213.658	246107.089	32.844	15	.005	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	1570475	2626034	2141743	1530048	622919	515692	1606468	2444123	2349473	1758187	1683692	1899328
	UCL	1879548	2936477	2453549	1843211	937433	831551	1923667	2762657	2669335	2079372	2006195	2223143
	LCL	1261401	2315591	1829938	1216886	308405	199832	1289268	2125590	2029611	1437002	1361190	1575512



FORECASTING OF THE MATERIAL 02001012TV

Time Series Modeler

Model Description

			Model Type
Model ID	demand	Model_1	Winters' Additive

Model Summary

Model Fit

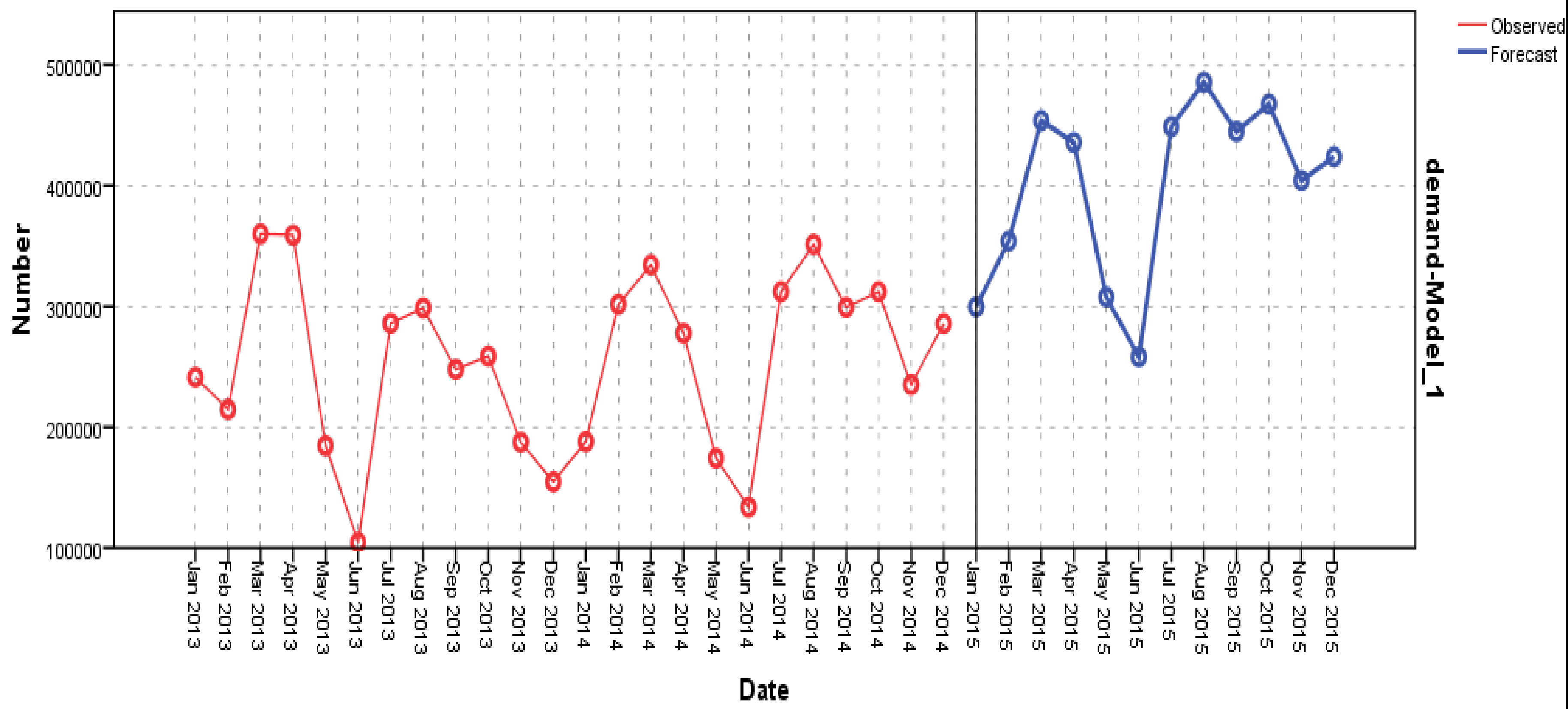
Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.798	.	.798	.798	.798	.798	.798	.798	.798	.798	.798
R-squared	.855	.	.855	.855	.855	.855	.855	.855	.855	.855	.855
RMSE	29087.744	.	29087.744	29087.744	29087.744	29087.744	29087.744	29087.744	29087.744	29087.744	29087.744
MAPE	8.081	.	8.081	8.081	8.081	8.081	8.081	8.081	8.081	8.081	8.081
MaxAPE	30.649	.	30.649	30.649	30.649	30.649	30.649	30.649	30.649	30.649	30.649
MAE	18908.936	.	18908.936	18908.936	18908.936	18908.936	18908.936	18908.936	18908.936	18908.936	18908.936
MaxAE	76367.605	.	76367.605	76367.605	76367.605	76367.605	76367.605	76367.605	76367.605	76367.605	76367.605
Normalized BIC	20.953	.	20.953	20.953	20.953	20.953	20.953	20.953	20.953	20.953	20.953

Model Statistics

Model	Number of Predictors	Model Fit statistics						Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.798	29087.744	8.081	18908.936	30.649	76367.605	33.810	15	.004	0

Forecast

Model		Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
demand-Model_1	Forecast	299708	354048	453815	435803	307777	258047	448802	485511	444783	467470	404146	423820
	UCL	360199	417479	522580	512521	394992	358059	563626	616906	594296	636481	593901	635464
	LCL	239217	290616	385050	359084	220561	158036	333978	354116	295270	298460	214391	212176



FORECASTING OF THE MATERIAL 02000322TY

Model Description

			Model Type
Model ID	demand	Model_1	Winters' Additive

Model Summary

Model Fit

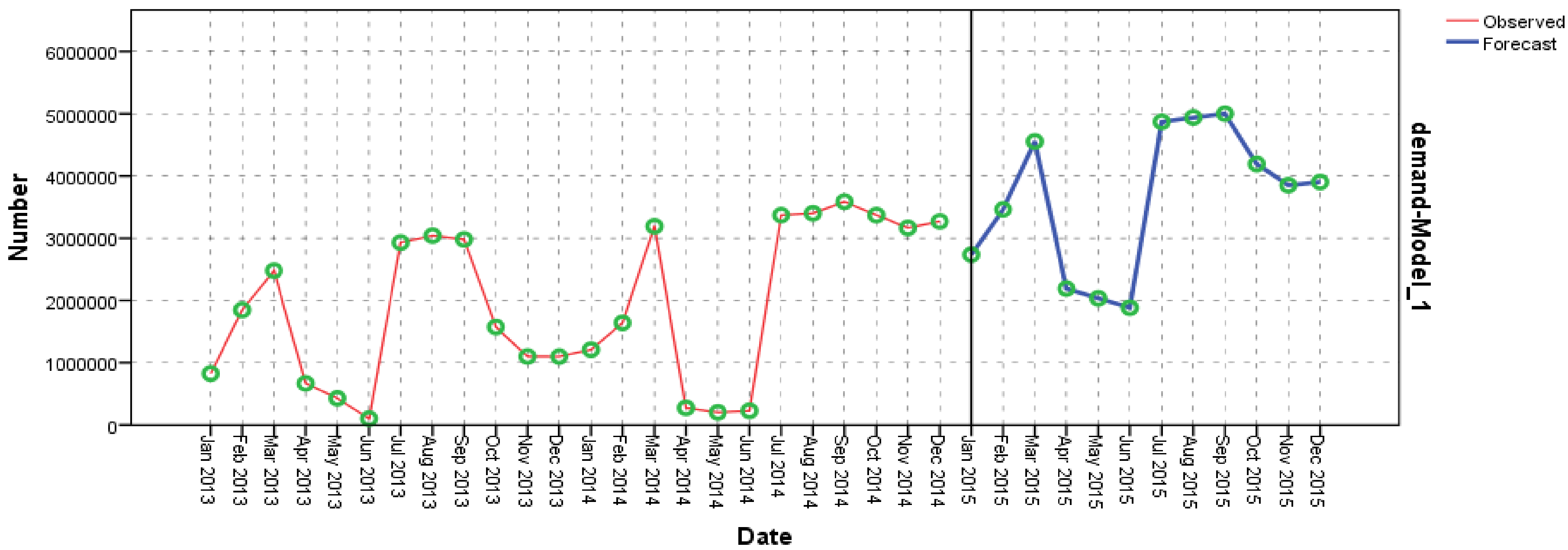
Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.753	.	.753	.753	.753	.753	.753	.753	.753	.753	.753
R-squared	.936	.	.936	.936	.936	.936	.936	.936	.936	.936	.936
RMSE	334581.979	.	334581.979	334581.979	334581.979	334581.979	334581.979	334581.979	334581.979	334581.979	334581.979
MAPE	30.245	.	30.245	30.245	30.245	30.245	30.245	30.245	30.245	30.245	30.245
MaxAPE	170.113	.	170.113	170.113	170.113	170.113	170.113	170.113	170.113	170.113	170.113
MAE	243452.993	.	243452.993	243452.993	243452.993	243452.993	243452.993	243452.993	243452.993	243452.993	243452.993
MaxAE	620111.368	.	620111.368	620111.368	620111.368	620111.368	620111.368	620111.368	620111.368	620111.368	620111.368
Normalized BIC	25.839	.	25.839	25.839	25.839	25.839	25.839	25.839	25.839	25.839	25.839

Model Statistics

Model	Number of Predictors	Model Fit statistics					Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.753	334581.979	243452.993	170.113	620111.368	18.586	15	.233	0

Forecast

Model		Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015
DEMAND-Model_1	Forecast	2072354	3164015	800154	644294	493811	3479410	3548883	3611662	2801067	2461296	2512596
	UCL	3150505	4325234	2038882	1955960	1874567	4925960	5058362	5181549	4429122	4145512	4251159
	LCL	994203	2002796	-438575	-667372	-886945	2032861	2039405	2041775	1173011	777080	774033



FORECASTING OF THE MATERIAL 4030157

Model Description

	Model Type
Model ID demand Model_1	Simple Seasonal

Model Summary

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.855	.	.855	.855	.855	.855	.855	.855	.855	.855	.855
R-squared	.873	.	.873	.873	.873	.873	.873	.873	.873	.873	.873
RMSE	54192.476	.	54192.476	54192.476	54192.476	54192.476	54192.476	54192.476	54192.476	54192.476	54192.476
MAPE	115.739	.	115.739	115.739	115.739	115.739	115.739	115.739	115.739	115.739	115.739
MaxAPE	2014.121	.	2014.121	2014.121	2014.121	2014.121	2014.121	2014.121	2014.121	2014.121	2014.121
MAE	29573.269	.	29573.269	29573.269	29573.269	29573.269	29573.269	29573.269	29573.269	29573.269	29573.269
MaxAE	167172.002	.	167172.002	167172.002	167172.002	167172.002	167172.002	167172.002	167172.002	167172.002	167172.002
Normalized BIC	22.058	.	22.058	22.058	22.058	22.058	22.058	22.058	22.058	22.058	22.058

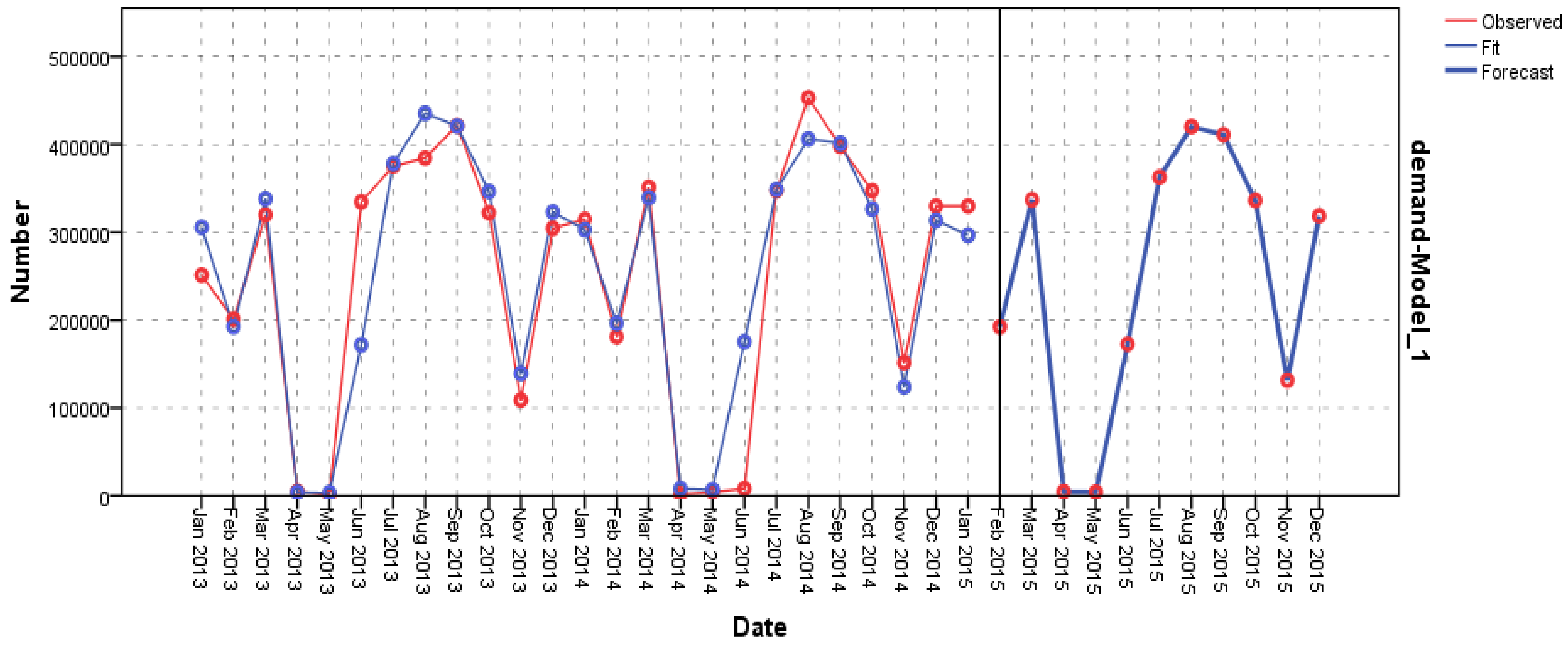
Model Statistics

Model	Number of Predictors	Model Fit statistics							Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	R-squared	RMSE	MAPE	MAE	MaxAPE	MaxAE	Statistics	DF	Sig.	
demand-Model_1	0	.855	.873	54192.476	115.739	29573.269	2014.121	167172.002	18.392	16	.301	0

Forecast

Model	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015	Dec 2015

	Forecast	192531	337106	4658	4183	172794	362900	420343	411073	336383	131641	318649
demand-Model_1	UCL	304637	449769	117876	117954	287114	477768	535756	527028	452877	248672	436214
	LCL	80425	224442	-108561	-109588	58473	248032	304930	295118	219889	14610	201084



Procurement model:

Under the assumptions mentioned in the literature in order to determine the procurement policy we imply the model at each product considering it as different period problems. The formulae used for different period problems are as follows—

<u>Let us consider it as one period problem:</u>

Let $C0(0) = 0$

<u>Let Us Consider it as a first period problem</u>

$C1(1) = C0+A+c(r1)+Ic((r1)/2)$

<u>Let Us Consider it as a Second period problem</u>

$C2(1) = C0+A+c(r1+r2)+Ic((r1)/2+r2)$

$C2(2) = C1+A+c(r2)+Ic((r2)/2)$

$C2 = \min\{ C2(1), C2(2) \}$

<u>Let Us Consider it as a Third period problem</u>

$C3(1) = C0+A+c(r1+r2+r3)+Ic((r1)/2+r2+(r3*3)/2)$

$C3(2) = C1+A+c(r2+r3)+Ic((r2)/2+r3)$

$C3(3) = C2+A+c(r3)+Ic((r3)/2)$

$C3=\min\{ C3(1),C3(2),C3(3) \}$

<u>Let Us Consider it as a Fourth period problem</u>

$C4(1) = C0+A+c(r1+r2+r3+r4)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)$

$C4(2) = C1+A+c(r2+r3+r4)+Ic((r2)/2+r3+(r4*3)/2)$

$C4(3) = C2+A+c(r3+r4)+Ic((r3)/2+r4)$

$C4(4) = C3+A+c(r4)+Ic((r4)/2)$

$C4=\min\{ C4(1),C4(2),C4(3),C4(4) \}$

<u>Let Us Consider it as a Fifth period problem</u>

$C5(1) = C0+A+c(r1+r2+r3+r4+r5)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2)$

$C5(2) = C1+A+c(r2+r3+r4+r5)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2)$

$C5(3) = C2+A+c(r3+r4+r5)+Ic((r3)/2+r4+(r5*3)/2)$

$C5(4) = C3+A+c(r4+r5)+Ic((r4)/2+r5)$

$C5(5) = C4+A+c(r5)+Ic((r5)/2)$

$C5=\min\{ C5(1),C5(2),C5(3),C5(4),C5(5) \}$

<u>Let Us Consider it as a Six period problem</u>

C6(1) = C0+A+c(r1+r2+r3+r4+r5+r6)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2)

C6(2) = C1+A+c(r2+r3+r4+r5+r6)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2)

C6(3) = C2+A+c(r3+r4+r5+r6)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2)

C6(4) = C3+A+c(r4+r5+r6)+Ic((r4)/2+r5+(r6*3)/2)

C6(5) = C4+A+c(r5+r6)+Ic((r5)/2+r6)

C6(6) = C5+A+c(r6)+Ic((r6)/2)

C6=min{ C6(1),C6(2),C6(3),C6(4),C6(5),C6(6) }

<u>Let Us Consider it as a Seventh period problem</u>

C7(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2)

C7(2) = C1+A+c(r2+r3+r4+r5+r6+r7)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2)

C7(3) = C2+A+c(r3+r4+r5+r6+r7)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2)

C7(4) = C3+A+c(r4+r5+r6+r7)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2)

C7(5) = C4+A+c(r5+r6+r7)+Ic((r5)/2+r6+(r7*3)/2)

C7(6) = C5+A+c(r6+r7)+Ic((r6)/2+r7)

C7(7) = C6+A+c(r7)+Ic((r7)/2)

C7= min{ C7(1),C7(2),C7(3),C7(4),C7(5),C7(6),C7(7) }

<u>Let Us Consider it as a Eighth period problem</u>

C8(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7+r8)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2+(r8*8)/2)

C8(2)=C1+A+c(r2+r3+r4+r5+r6+r7+r8)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2+(r8*7)/2)

C8(3) = C2+A+c(r3+r4+r5+r6+r7+r8)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2+(r8*6)/2)

C8(4) = C3+A+c(r4+r5+r6+r7+r8)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2+(r8*5)/2)

C8(5) = C4+A+c(r5+r6+r7+r8)+Ic((r5)/2+r6+(r7*3)/2+(r8*4)/2)

C8(6) = C5+A+c(r6+r7+r8)+Ic((r6)/2+r7+(r8*3)/2)

C8(7) = C6+A+c(r7+r8)+Ic((r7)/2+r8)

C8(8) = C7+A+c(r8)+Ic((r8)/2)

C8= min{ C8(1),C8(2),C8(3),C8(4),C8(5),C8(6),C8(7),C8(8) }

<u>Let Us Consider it as a Ninth period problem</u>

C9(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7+r8+r9)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2+(r8*8)/2+(r9*9)/2)

C9(2)=C1+A+c(r2+r3+r4+r5+r6+r7+r8+r9)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2+(r8*7)/2+(r9*8)/2)

C9(3)=C2+A+c(r3+r4+r5+r6+r7+r8+r9)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2+(r8*6)/2+ (r9*7)/2)

C9(4) = C3+A+c(r4+r5+r6+r7+r8+r9)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2+(r8*5)/2+(r9*6)/2)

C9(5) = C4+A+c(r5+r6+r7+r8+r9)+Ic((r5)/2+r6+(r7*3)/2+(r8*4)/2+(r9*5)/2)

C9(6) = C5+A+c(r6+r7+r8+r9)+Ic((r6)/2+r7+(r8*3)/2+(r9*4)/2)

C9(7) = C6+A+c(r7+r8+r9)+Ic((r7)/2+r8+(r9*3)/2)

C9(8) = C7+A+c(r8+r9)+Ic((r8)/2+r9)

C9(9) = C8+A+c(r9)+Ic(r9/2)

C9= min{ C9(1),C9(2),C9(3),C9(4),C9(5),C9(6),C9(7),C9(8),C9(9) }

<u>Let Us Consider it as a Tenth period problem</u>

C10(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7+r8+r9+r10)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2+(r8*8)/2+(r9*9)/2+(r10*10)/2)

C10(2)=C1+A+c(r2+r3+r4+r5+r6+r7+r8+r9+r10)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2+(r8*7)/2+(r9*8)/2+(r10*9)/2)

C10(3)=C2+A+c(r3+r4+r5+r6+r7+r8+r9+r10)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2+(r8*6)/2+(r9*7)/2+(r10*8)/2)

C10(4)=C3+A+c(r4+r5+r6+r7+r8+r9+r10)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2+(r8*5)/2+(r9*6)/2+(r10*7)/2)

C10(5)=C4+A+c(r5+r6+r7+r8+r9+r10)+Ic((r5)/2+r6+(r7*3)/2+(r8*4)/2+(r9*5)/2+(r10*6)/2)

C10(6) = C5+A+c(r6+r7+r8+r9+r10)+Ic((r6)/2+r7+(r8*3)/2+(r9*4)/2+(r10*5)/2)

C10(7) = C6+A+c(r7+r8+r9+r10)+Ic((r7)/2+r8+(r9*3)/2+(r10*4)/2)

C10(8) = C7+A+c(r8+r9+r10)+Ic((r8)/2+r9+(r10*3)/2)

C10(9) = C8+A+c(r9+r10)+Ic(r9/2+r10)

C10(10) = C9+A+c(r10)+Ic(r10/2)

C10= min{ C10(1),C10(2),C10(3),C10(4),C10(5),C10(6),C10(7),C10(8),C10(9),C10(10) }

<u>Let Us Consider it as a Eleventh period problem</u>

C11(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7+r8+r9+r10+r11)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2+(r8*8)/2+(r9*9)/2+(r10*10)/2+(r11*11)/2)

C11(2)=C1+A+c(r2+r3+r4+r5+r6+r7+r8+r9+r10+r11)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2+(r8*7)/2+(r9*8)/2+(r10*9)/2+(r11*10)/2)

C11(3)=C2+A+c(r3+r4+r5+r6+r7+r8+r9+r10+r11)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2+(r8*6)/2+(r9*7)/2+(r10*8)/2+(r11*9)/2)

C11(4)=C3+A+c(r4+r5+r6+r7+r8+r9+r10+r11)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2+(r8*5)/2+(r9*6)/2+(r10*7)/2+(r11*8)/2)

C11(5)=C4+A+c(r5+r6+r7+r8+r9+r10+r11)+Ic((r5)/2+r6+(r7*3)/2+(r8*4)/2+(r9*5)/2+(r10*6)/2+(r11*7)/2)

C11(6)=C5+A+c(r6+r7+r8+r9+r10+r11)+Ic((r6)/2+r7+(r8*3)/2+(r9*4)/2+(r10*5)/2+(r11*6)/2)

C11(7) = C6+A+c(r7+r8+r9+r10+r11)+Ic((r7)/2+r8+(r9*3)/2+(r10*4)/2+(r11*5)/2)

C11(8) = C7+A+c(r8+r9+r10+r11)+Ic((r8)/2+r9+(r10*3)/2+(r11*4)/2

C11(9) = C8+A+c(r9+r10+r11)+Ic(r9/2+r10+(r11*3)/2)

C11(10) = C9+A+c(r10+r11)+Ic(r10/2+r11)

C11(11) = C10+A+c(r11)+Ic(r11/2)

C11= min{C11(1),C11(2),C11(3),C11(4),C11(5),C11(6),C11(7),C11(8),C11(9),C11(10),c11(11)}

<u>Let Us Consider it as a Twelth period problem</u>

C12(1)=C0+A+c(r1+r2+r3+r4+r5+r6+r7+r8+r9+r10+r11+r12)+Ic((r1)/2+r2+(r3*3)/2+(r4*4)/2+(r5*5)/2+(r6*6)/2+(r7*7)/2+(r8*8)/2+(r9*9)/2+(r10*10)/2+(r11*11)/2+(r12*12) /2)

C12(2)=C1+A+c(r2+r3+r4+r5+r6+r7+r8+r9+r10+r11+r12)+Ic((r2)/2+r3+(r4*3)/2+(r5*4)/2+(r6*5)/2+(r7*6)/2+(r8*7)/2+(r9*8)/2+(r10*9)/2+(r11*10)/2+(r12*11)/2)

C12(3)=C2+A+c(r3+r4+r5+r6+r7+r8+r9+r10+r11+r12)+Ic((r3)/2+r4+(r5*3)/2+(r6*4)/2+(r7*5)/2+(r8*6)/2+(r9*7)/2+(r10*8)/2+(r11*9)/2+(r12*10)/2)

C12(4)=C3+A+c(r4+r5+r6+r7+r8+r9+r10+r11+r12)+Ic((r4)/2+r5+(r6*3)/2+(r7*4)/2+(r8*5)/2+(r9*6)/2+(r10*7)/2+(r11*8)/2+(r12*9)/2)

C12(5)=C4+A+c(r5+r6+r7+r8+r9+r10+r11+r12)+Ic((r5)/2+r6+(r7*3)/2+(r8*4)/2+(r9*5)/2+(r10*6)/2+(r11*7)/2+(r12*8)/2)

C12(6)=C5+A+c(r6+r7+r8+r9+r10+r11+r12)+Ic((r6)/2+r7+(r8*3)/2+(r9*4)/2+(r10*5)/2+(r11*6)/2+(r112*7/2)

C12(7)=C6+A+c(r7+r8+r9+r10+r11+r12)+Ic((r7)/2+r8+(r9*3)/2+(r10*4)/2+(r11*5)/2+(r12*6)/2)

C12(8) = C7+A+c(r8+r9+r10+r11+r12)+Ic((r8)/2+r9+(r10*3)/2+(r11*4)/2+(r12*5)/2)

C12(9) = C8+A+c(r9+r10+r11+r12)+Ic(r9/2+r10+(r11*3)/2+(r12*4)/2)

C12(10) = C9+A+c(r10+r11+r12)+Ic(r10/2+r11+(r12*3)/2)

C12(11) = C10+A+c(r11+r12)+Ic(r11/2+r12)

C12(12) = C11+A+c(r12)+Ic(r12/2)

C12=min{C12(1),C12(2),C12(3),C12(4),C12(5),C12(6),C12(7),C12(8),C12(9),C12(10),C12(11) ,C12(12) }

PROCUREMENT FOR TOP 10 PRODUCTS

Cost in GRN Process
Average salary of an quality engineer: 20000 /- months

Work hours: 10 hours per day
Total work days per month: 26
Total work hours: 26*5=130
Per hour cost of quality engineer: 20000/260=76.92

5 hours of testing: 76.92*5=384.6
Two Engineers: 769.2
Overhead ordering expenses
(includes paper work cost communication charge , human resource)
: 200
Total ordering cost per order: 969.2

Inventory carring Charge(I) =20%per year

=0.20 per year

=0.20/12 per Month

=0.0166666 Per Month

Unit Cost (c) = 5per Unit

Inventory Carring Cost(Ic) = I*c

= 0.016666*5

= .083333Per Mont

	04020003NP		02000199TU		02000221RU		02000330QW	
UNIT COST	5		30		40		30	
I	.0083333(20%)		(15%)0.0125		.016666		.00833333	

IC	.0415		.375		.6666		.099999	
ORDERING COST	969.2		969.2		969.2		969.2	
January	8474051	r1	1012163	r1	843230	r1	6192342	r1
February	7153435	r2	1475428	r2	1310751	r2	6636107	r2
march	8673133	r3	1171510	r3	1095251	r3	7491289	r3
April	12065669	r4	1520365	r4	828345	r4	11463006	r4
may	5591288	r5	990238	r5	651714	r5	1998560	r5
June	4386954	r6	1183607	r6	854541	r6	2043061	r6
July	10216504	r7	1272120	r7	1266933	r7	5630212	r7
august	12202382	r8	1756541	r8	1347985	r8	6543044	r8
September	6115558	r9	1625076	r9	1347798	r9	4352853	r9
October	10837316	r10	1193041	r10	1291191	r10	4587356	r10
November	8966598	r11	1543478	r11	1192773	r11	1149543	r11
December	10222753	r12	1385403	r12	1278455	r12	3942346	r12
c(0)	0		0		0		0	
c(1)	42723326.38		30617920.78		21516818.69		25507699.37	
c2(1)	79086597.12	min	75618445.27	min	56102169.34	Min	65485578.65	Min
c2(2)	78788549.3	78788549.3	75249603.17	75249603.17	55818694.81	55818694.81	65157904.31	65157904.31
c3(1)	142019300.9	min	113258753.8	min	92084891.69	Min	100641386.9	Min
c3(2)	122876946.5		110980634.7		90801033.21		98563037.91	
c3(3)	122515580.4	122515580.4	110687769.1	110687769.1	90514304.81	90514304.81	98289236.41	98289236.41
c4(1)	187886434.2	min	160293901	min	142841145.6	Min	125671487.8	Min
c4(2)	184713439.8		157731812.9		140260474		124034621.8	
c4(3)	194909594.4		157819084.1		139973793.8		123967931.4	
c4(4)	183346641.6	183346641.6	156678795.3	156678795.3	139169559.2	139169559.2	123346664.7	123346664.7
c5(1)	214996814.9	min	189718484.8	min	169142226.6	Min	145209205.8	min
c5(2)	213601723.8		188429151.3		167946662.2		144237729.7	
c5(3)	212504680.7		187508660		167034573.2		143593928.3	
c5(4)	211769003.6		186881034.5		166409213.3		143223928.6	
c5(5)	211536042.7	211536042.7	186633485.1	186633485.1	166185947.1	166185947.1	143061007	143061007
c6(1)	238028279.5	min	227002034.3	min	186766065	Min	172127196.1	min
c6(2)	236450406		225416810.8		185430634.3		170942093.3	
c6(3)	235170580.4		224200429.7		184378678.8		170084665.1	
c6(4)	234252120.9		223276914.2		183613452.5		169501038.8	
c6(5)	233836377.5		222733474.9		183250319.9		169124490.4	
c6(6)	233653595.1	233653595.1	222437585.1	222437585.1	183110454.3	183110454.3	168910864	168910864
c7(1)	292090494	min	267391755.2	min	219618733.6	Min	212352230.1	min
c7(2)	290086949.9		265488514.5		218024630.2		210850406.7	
c7(3)	288381453.6		263954116		216714002.1		209676258	
c7(4)	287037323.5		262712583.4		215690103.2		208775911.1	
c7(5)	286195909.4		261851126.7		215068297.8		208082642.1	
c7(6)	285587456.4		261237219.7		214669759.6		207552295.1	
c7(7)	285161785.8	285161785.8	260919202.5	260919202.5	214411087.7	214411087.7	207235574.8	207235574.8
c8(1)	357169701.9	min	323600926.7	min	258867915.5	Min	255487642.3	min
c8(2)	354657745.6		321258568.3		256967189.3		253648836.1	

c8(3)	352443837.1		319285052.2		255349938.5		252137704.6	
c8(4)	350591294.7		317604401.8		254019416.8		250900374.9	
c8(5)	349241468.4		316303827.5		253090988.8		249870123.2	
c8(6)	348124603.2		315250802.7		252385827.8		249002793.4	
c8(7)	347190520.3		314493667.9		251820533.2		248349090.4	
c8(8)	346682108.1	346682108.1	314054550.4	314054550.4	251513911.3	251513911.3	248012107.9	248012107.9
c9(1)	390040734.4	min	376009481.5	min	286030896.7	Min	298954006.5	min
c9(2)	387273973.4		373260870.3		283919612.6		296778264.3	
c9(3)	384805260.2		370881101.4		282091803.8		294930196.8	
c9(4)	382697913.1		368794198.3		280550724.3		293355931.1	
c9(5)	381093282.1		367087371.2		279411738.3		291988743.3	
c9(6)	379721612.1		365628093.7		278496019.4		290784477.5	
c9(7)	378532724.5		364464706.2		277720166.9		289793838.4	
c9(8)	378757597.6		363619335.9		277202987.1		289119920	
c9(9)	377514702.9	377514702.9	363213083.3	363213083.3	276992430	276992430	288782984.2	288782984.2
c10(1)	448742682.2	min	414783194.6	min	315631502.3	Min	340917584.9	min
c10(2)	445524384.3		411736335.2		313292529.6		338419057.9	
c10(3)	441107839.8		407938579.7		312061835		335613684.4	
c10(4)	440045250.5		406673166.5		309468264.2		334351154.9	
c10(5)	437989082.7		404668091.1		308101589.7		332661182.3	
c10(6)	436165875.9		402910565.3		306958182.2		331134131.7	
c10(7)	434525451.6		401448929.4		305954641.2		329820707.8	
c10(8)	433310697.9		400305310.8		305209772.8		328824004.5	
c10(9)	432604356.4		399600809.9		304771527.1		328164283.9	
c10(10)	371395714.4	371395714.4	399302561.7	399302561.7	304543839.3	304543839.3	327841499.4	327841499.4
c11(1)	497685198.5	min	465331929.4	min	345437089.8	min	379980769.4	min
c11(2)	494093307.4		461899215.8		342870602		377184061.1	
c11(3)	489208240.5		457146032.1		340652959.8		373510932.1	
c11(4)	487866986.9		456064339		338591306.1		372519795.5	
c11(5)	485437225.8		453673409.6		336997116.3		370531641.6	
c11(6)	483240425.7		451530029.7		335626193.6		368706409.6	
c11(7)	481226408.1		449682539.8		334395137.3		367094804.4	
c11(8)	479638061.1		448153067.1		333422753.7		365799919.8	
c11(9)	478558126.4		447062712.1		332756992.8		364842017.9	
c11(10)	416975891		446378609.9		332301789.8		364221052	
c11(11)	416602297.8	416602297.8	445992756	445992756	332074275.4	332074275.4	363922871	363922871
c12(1)	553910135.6	min	511050062.1	min	378936720	min	422169631	min
c12(2)	549892313.4		507271011.7		376116456.3		419053321.7	
c12(3)	544388906.1		501017034.3		372105762.5		413906134.9	
c12(4)	542814130.9		500743461.1		371329608.7		413749854.2	
c12(5)	539958438.8		498006194.7		369481643.1		411442099.3	
c12(6)	537335707.8		495516478		367856944.5		409297266.4	
c12(7)	534895759.1		493322651.1		366372112.4		407366060.2	
c12(8)	532881481.1		491446841.6		365145952.9		405751574.6	
c12(9)	531375615.4		490010149.7		364226416.2		404474071.7	
c12(10)	469367449		488979710.6		363517437.3		403533504.9	
c12(11)	468567924.8		488247519.8		363036147.1		402915722.9	
c12(12)	422935410.5	422935410.5	441210988.8	441210988.8	335251936	335251936	366514750.6	366514750.6

	04020001NAS		02000213RV		04030142C		02001012TV	
UNIT COST	3		60		10		55	
I	.025		.020833		.008333		.020833	
IC	.075		1.6998		.08333		1.45815	
ORDERING COST	969.2		969.2		969.2		969.2	
January	6192342	r1	264215	r1	299708	r1	299708	r1
February	6636107	r2	263682	r2	354048	r2	354048	r2
march	7491289	r3	336775	r3	453815	r3	453815	r3
April	11463006	r4	252770	r4	435803	r4	435803	r4
may	1998560	r5	191811	r5	307777	r5	307777	r5
June	2043061	r6	129310	r6	258047	r6	258047	r6
July	5630212	r7	319492	r7	448802	r7	448802	r7
august	6543044	r8	338835	r8	485511	r8	485511	r8
September	4352853	r9	288921	r9	444783	r9	444783	r9
October	4587356	r10	331412	r10	467470	r10	467470	r10
November	1149543	r11	199201	r11	404146	r11	404146	r11
December	3942346	r12	240064	r12	423820	r12	423820	r12
c(0)	0		0		0		0	
c(1)	18654430		16018008.07		16359088.51		16586965.18	
c2(1)	38728653.01	min	32168477.84	min	44807702.64	min	36303013.18	min
c2(2)	38645702.03	38645702.03	32003703.08	32003703.08	43713565.67	43713565.67	36181309.73	36181309.73
c3(1)	78909658.5	min	52814272.57	min	69875507.01	min	62054200.68	min
c3(2)	61306850.51		52631104.47		66915710.12		61453132.54	
c3(3)	61213209.8	61213209.8	52420653.89	52420653.89	66023353	66023353	61297134.18	61297134.18
c4(1)	97018756.24	min	69436177.71	min	89302640.3	min	86898458.14	min
c4(2)	96125729.51		68271172.39		84128673.61		85871719.38	
c4(3)	107065233.8		67839623.89		82853881		85702102.18	
c4(4)	95745514.83	95745514.83	67744809.99	67744809.99	81961327.6	81961327.6	85416107.01	85416107.01
c5(1)	102566197.7	min	80912327.29	min	94279548.31	min	103755955.7	min
c5(2)	102221337.1		80259283.16		91396020.42		103222647.8	
c5(3)	101959427.5		79771013.92		89606629.6		102811043.8	
c5(4)	101791158.6		79493195.37		88709596		102555438.7	
c5(5)	101766176.8	101766176.8	79373332.8	79373332.8	88450056.9	88450056.9	102449640.9	102449640.9
c6(1)	108848609.7	min	89155762.21	min	100725646.7	min	118480762.7	min
c6(2)	108478210.9		88421912.26		97627255.78		117858751	
c6(3)	108190763.1		87852837.2		95623001.89		117358443.4	
c6(4)	107996956.1		87494212.83		94511105.21		117014134.7	
c6(5)	107946436.1		87293544.44		94036703.04		116819633.2	
c6(6)	107920898	107920898	87212738.74	87212738.74	93821840.07	93821840.07	116730930.1	116730930.1
c7(1)	126231887.3	min	109722836.1	min	121475671	min	144244802.5	min
c7(2)	125791111.1		108789335.6		117707945.1		143468515.2	
c7(3)	125433286		108020610		115034356.3		142813931.8	
c7(4)	125169101.6		107462335		113253124.8		142315347.4	
c7(5)	125048204.2		107062016.1		112109387.7		141966570.3	
c7(6)	124952288.7		106781559.8		111225189.9		141723591.5	
c7(7)	124881911.3	124881911.3	106581909.4	106581909.4	110555855.1	110555855.1	141569316.4	141569316.4

c8(1)	146515321.1	min	131746840	min	154063651.8	min	172283062.7	min
c8(2)	145992757.2		130601601.5		149277582.1		171339881	
c8(3)	145553144.3		129621137.9		145585649.4		170518403.3	
c8(4)	145207172.2		128851125		142786074		169852924.5	
c8(5)	145004487.1		128239068.1		140623993.1		169337252.9	
c8(6)	144826783.9		127746873.8		138721451.4		168927379.7	
c8(7)	144674618.8		127335485.4		137033772.8		168606210.2	
c8(8)	144592831.1	144592831.1	127123747.5	127123747.5	136015429	136015429	168439316.3	168439316.3
c9(1)	160063574.1	min	150707020.6	min	186368553.1	min	198122175.1	min
c9(2)	159486599.7		149381235.4		180603575.5		197026099.3	
c9(3)	158992576.4		148220225		175932734.9		196051727.4	
c9(4)	158592193.9		147269665.4		172154251.6		195233354.4	
c9(5)	158335098.3		146477061.7		169013262.7		194564788.7	
c9(6)	158102984.6		145804320.7		166131813.1		194002021.3	
c9(7)	157896409.1		145212385.6		163465226.5		193527957.6	
c9(8)	157760211		144820101		161467974.9		193208169.6	
c9(9)	157705800.6	157705800.6	144639554.4	144639554.4	160489067	160489067	193055276	193055276
c10(1)	174399059.3	min	172662734.2	min	211275909.2	min	225439953.3	min
c10(2)	173764743.2		171129849.6		204778383		224183184.6	
c10(3)	172918709.7		172807473.1		195396023.4		224348498.3	
c10(4)	172755653.9		168604080.9		194863961.9		222069054.1	
c10(5)	172441216.6		167604377.9		190990424.4		221239795.6	
c10(6)	172151761.2		166724537.5		187376426.2		220516335.4	
c10(7)	171887844		165925503		183977291		219881578.9	
c10(8)	171694304.2		165326119.1		181247490.7		219401098.1	
c10(9)	171582552		164938473.1		179536034.3		219087511.6	
c10(10)	171525210.3	171525210.3	164731373.9	164731373.9	178803485.7	178803485.7	218926819.4	218926819.4
c11(1)	178005749.8	min	185984081.9	min	235829442.2	min	249196160.3	min
c11(2)	177357064.5		184326716.6		228630405.7		247800466.4	
c11(3)	176468182.1		184456094.8		217597245.5		247043659.1	
c11(4)	176319236.8		181551986.5		217312964		245408485.6	
c11(5)	175990430.2		180427802.8		212737916.3		244440301.9	
c11(6)	175686605.6		179423481.8		208422407.8		243577916.5	
c11(7)	175408319.2		178499966.6		204321762.3		242804234.8	
c11(8)	175200410.1		177776101.9		200890451.8		242184828.8	
c11(9)	175074288.7		177263975.2		198477485.1		241732317.2	
c11(10)	175002577.8		176932395.3		197043426.3		241432699.8	
c11(11)	174988208.6	174988208.6	176807914.7	176807914.7	196341916.1	196341916.1	241293775.1	241293775.1
c12(1)	190424137.3	min	202188113.9	min	264318982.4	min	274254517.8	min
c12(2)	189726172.9		200380732.6		256328590.8		272713135.8	
c12(3)	188730286.4		197474299.1		242579980.9		270223198.7	
c12(4)	188589786.9		197305970.5		243428439.1		270029778.7	
c12(5)	188211701.3		196031770.8		238062036.4		268915906.9	
c12(6)	187858597.5		194877433.7		232955172.9		267907833.4	
c12(7)	187531031.9		193803902.5		228063172.4		266988463.6	
c12(8)	187273843.7		192930021.9		223840506.8		266223369.4	
c12(9)	187098443.2		192267879.2		220636185.1		265625169.7	
c12(10)	186977453.2		191786283.2		218410771.3		265179864.1	
c12(11)	186913804.8		191511786.7		216917906.1		264895251.4	
c12(12)	183401527.5	183401527.5	179285230	179285230	198588120.9	198588120.9	242382608.1	242382608.1

	04020001NAS			02000213RV	
UNIT COST	3		UNIT COST	60	
I	.00833		CARRYING COST	.0166	
IC	.02499			.996	
ORDERING COST	969.2		ORDERING COST	969.2	
January	2072354	r1	January	292531	r1
February	3164015	r2	February	192531	r2
march	800154	r3	march	337106	r3
April	644294	r4	April	4658	r4
may	493811	r5	may	4183	r5
June	3479410	r6	June	172794	r6
July	3548883	r7	July	362900	r7
august	3611662	r8	august	420343	r8
September	2801067	r9	September	411073	r9
October	2461296	r10	October	336383	r10
November	2512596	r11	November	131641	r11
December	423820	r12	December	318649	r12
c(0)	0		c(0)	0	
c(1)	10793337.75		c(1)	11798360.69	
c2(1)	27931224.99	min	c2(1)	19627441.28	min
c2(2)	27272318.89	27272318.89	c2(2)	19563521.38	19563521.38
c3(1)	34978428.75	min	c3(1)	33682030.69	min
c3(2)	31606353.04		c3(2)	33271599.77	
c3(3)	31439720.99	31439720.99	c3(3)	33159680.98	33159680.98
c4(1)	36726755.01	min	c4(1)	33646130.5	min
c4(2)	35230345.71		c4(2)	33462559.14	
c4(3)	35305484.99		c4(3)	33350658.98	
c4(4)	34795365.24	34795365.24	c4(4)	33347547.83	33347547.83
c5(1)	39173293.81	min	c5(1)	33814208.46	min
c5(2)	38110745.27		c5(2)	33635434.16	
c5(3)	37707102.86		c5(3)	33520580.16	
c5(4)	37470092.52		c5(4)	33517645.34	
c5(5)	37367256.41	37367256.41	c5(5)	33516256.99	33516256.99
c6(1)	60917866.61	min	c6(1)	41070174.1	min
c6(2)	59130730.94		c6(2)	40834032.2	
c6(3)	58002501.39		c6(3)	40661810.59	
c6(4)	57040903.92		c6(4)	40601508.17	
c6(5)	56213480.67		c6(5)	40542752.2	
c6(6)	55488893.56	55488893.56	c6(6)	40485385	40485385
c7(1)	83835665.8	min	c7(1)	56429553.7	min
c7(2)	125791111.1		c7(2)	56072929	
c7(3)	125433286		c7(3)	55780224.59	
c7(4)	125169101.6		c7(4)	55599439.37	
c7(5)	125048204.2		c7(5)	55420200.6	
c7(6)	124952288.7		c7(6)	55242350.6	
c7(7)	124881911.3	124881911.3	c7(7)	55121868.2	55121868.2
c8(1)	146515321.1	min	c8(1)	74359704.71	min
c8(2)	145992757.2		c8(2)	73863526.13	

c8(3)	145553144.3		c8(3)	73431267.84	
c8(4)	145207172.2		c8(4)	73110928.75	
c8(5)	145004487.1		c8(5)	72792136.11	
c8(6)	144826783.9		c8(6)	72474732.22	
c8(7)	144674618.8		c8(7)	72214695.95	
c8(8)	144592831.1	144592831.1	c8(8)	72075142.47	72075142.47
c9(1)	160063574.1	min	c9(1)	92030910.84	min
c9(2)	159486599.7		c9(2)	91398256.02	
c9(3)	158992576.4		c9(3)	90829521.5	
c9(4)	158592193.9		c9(4)	90372706.16	
c9(5)	158335098.3		c9(5)	89917437.29	
c9(6)	158102984.6		c9(6)	89463557.17	
c9(7)	157896409.1		c9(7)	89067044.66	
c9(8)	157760211		c9(8)	88791014.94	
c9(9)	157705800.6	157705800.6	c9(9)	88654539.11	88654539.11
c10(1)	174399059.3	min	c10(1)	106603022.4	min
c10(2)	173764743.2		c10(2)	105858688.4	
c10(3)	172918709.7		c10(3)	106512545.9	
c10(4)	172755653.9		c10(4)	104609780.3	
c10(5)	172441216.6		c10(5)	104042832.2	
c10(6)	172151761.2		c10(6)	103477272.9	
c10(7)	171887844		c10(7)	102969081.3	
c10(8)	171694304.2		c10(8)	102581372.4	
c10(9)	171582552		c10(9)	102333217.4	
c10(10)	171525210.3	171525210.3	c10(10)	102221538.7	102221538.7
c11(1)	178005749.8	min	c11(1)	112349415.3	min
c11(2)	177357064.5		c11(2)	111561376.5	
c11(3)	176468182.1		c11(3)	111415104.4	
c11(4)	176319236.8		c11(4)	110225058.8	
c11(5)	175990430.2		c11(5)	109614405.9	
c11(6)	175686605.6		c11(6)	109005141.8	
c11(7)	175408319.2		c11(7)	108453245.3	
c11(8)	175200410.1		c11(8)	108021831.7	
c11(9)	175074288.7		c11(9)	107729971.9	
c11(10)	175002577.8		c11(10)	107574588.3	
c11(11)	174988208.6	174988208.6	c11(11)	107530883.9	107530883.9
c12(1)	190424137.3	min	c12(1)	126364872.9	min
c12(2)	189726172.9		c12(2)	125471042.7	
c12(3)	188730286.4		c12(3)	123685799.1	
c12(4)	188589786.9		c12(4)	123923142	
c12(5)	188211701.3		c12(5)	123206697.7	
c12(6)	187858597.5		c12(6)	122491642.1	
c12(7)	187531031.9		c12(7)	121833954.1	
c12(8)	187273843.7		c12(8)	121296749	
c12(9)	187098443.2		c12(9)	120899097.7	
c12(10)	186977453.2		c12(10)	120637922.7	
c12(11)	186913804.8		c12(11)	120488426.8	
c12(12)	183401527.5	183401527.5	c12(12)	115073290.5	115073290.5

SAFTY STOCK

Reorder policy and safety stock calculation at 95% service level and 99% service level:

MONTHS	04020003NP	02000199TU	02000221RU	02000330QW	04020001NAS	02000213RV	04030142C
	8474051	1012163	533475	843230	6192342	264215	1570475
	7153435	1475428	850460	1310751	6636107	263682	2626034
	8673133	1171510	860222	1095251	7491289	336775	2141743
	12065669	1520365	1206329	828345	11463006	252770	1530048
	5591288	990238	669828	651714	1998560	191811	622919
	4386954	1183607	419616	854541	2043061	129310	515692
	10216504	1272120	776049	1266933	5630212	319492	1606468
	12202382	1756541	919905	1347985	6543044	338835	2444123
	6115558	1625076	631699	1347798	4352853	288921	2349473
	10837316	1193041	683093	1291191	4587356	331412	1758187
	8966598	1543478	682573	1192773	1149543	199201	1683692
	10222753	1385403	761358	1278455	3942346	240064	1899328
AVERAGE	8742136.75	1344080.83	749550.58	1109080.6	5169143.25	263040.7	1729015.2
STD. DEV	2526591.15	244535.691	201276.02	247195.33	2841193.53	65630.5	652170.39
Z(95%)	1.6451	1.6451	1.6451	1.6451	1.6451	1.6451	1.6451
LEAD TIME	1 DAYS	1 DAYS	1 DAYS	1 DAYS	1 DAYS	1DAYS	1 DAYS
SAFETY STOCK(monthly)	758899.964	73450.0027	60456.304	74248.865	853395.559	19713.11	195889.27
Z(99%)	2.33	2.33	2.33	2.33	2.33	2.33	2.33
SAFETY STOCK	1074713.36	104015.948	85614.97	105147.25	659721.1715	1295280.6	27916.65

Procurement policy:

Suggestions:

The order for may is to be placed in the beginning of april so that the order could reach in hand by the beginning of month since the model suggest that the demand of indivisual month is to be met in the beginning of that month itself but since the lead time is of 28 days thus the product is to be ordered a month prior to its demand

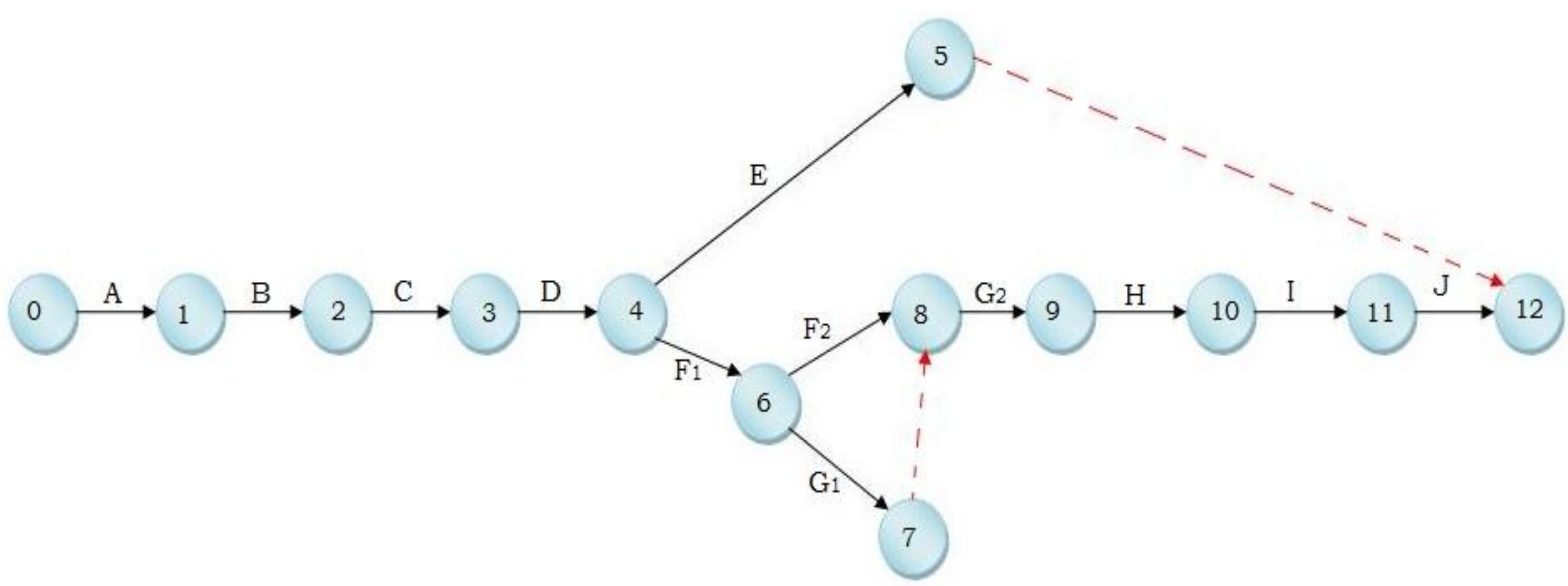
PERT ANALYSIS OF THE WAREHOUSE's ACTIVITIES

Process Flow Chart of Loading a Vehicle:

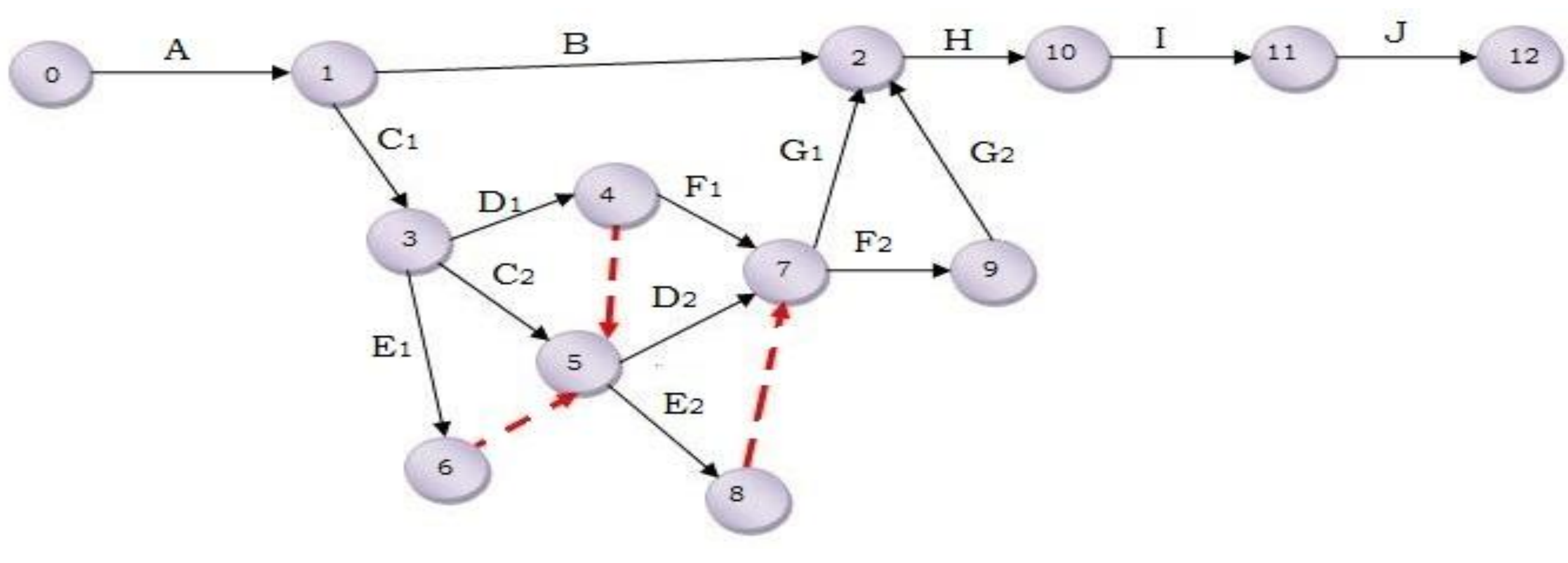
For loading a vehicle following activities are performed in warehouse. This is a basic network the time respective of each activity and human resource will be analyzed in TATT timing analysis.

No	Activity	Activity Description
1	A	Preparation of documents(Pick list , Check List)
2	B	Decking of Vehicle
3	C1	Picking of first SKU(Stock Keeping Unit)
4	C2	Picking of remaining SKU
5	D1	Movement of First loaded pallet to the Stack area
6	D2	Movement of remaining loaded pallets to the Stack area
7	E1	Stock Updation in BIN card of First SKU
8	E2	Stock Updation in BIN card of remaining SKU's
9	F1	Recounting of First SKU at the Stack area
10	F2	Recounting of remaining SKU's at the Stack area
11	G1	Loading of First SKU in Vehicle
12	G2	Loading of remaining SKU in Vehicle
13	H	Document Preparation
14	I	Invoice Generation and Billing process
15	J	Dispatch of Vehicle

AS IS LOADING PROCESS



The given network is the proposed network for loading process in which some activities are being processed in parallel manner so overall reducing the total time taken in loading process.

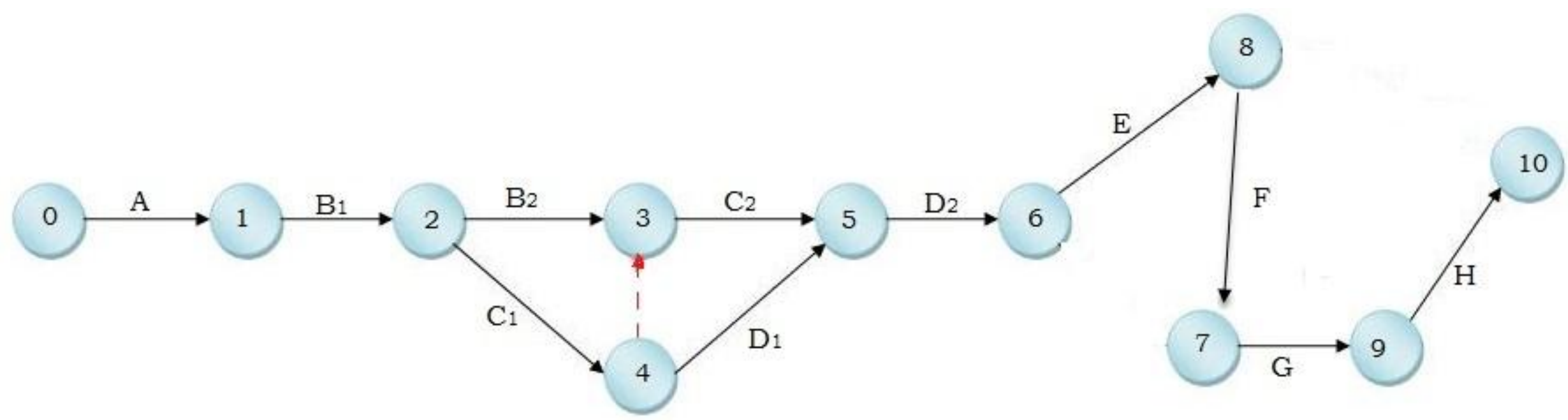


Process Flow Chart of Unloading a Vehicle:

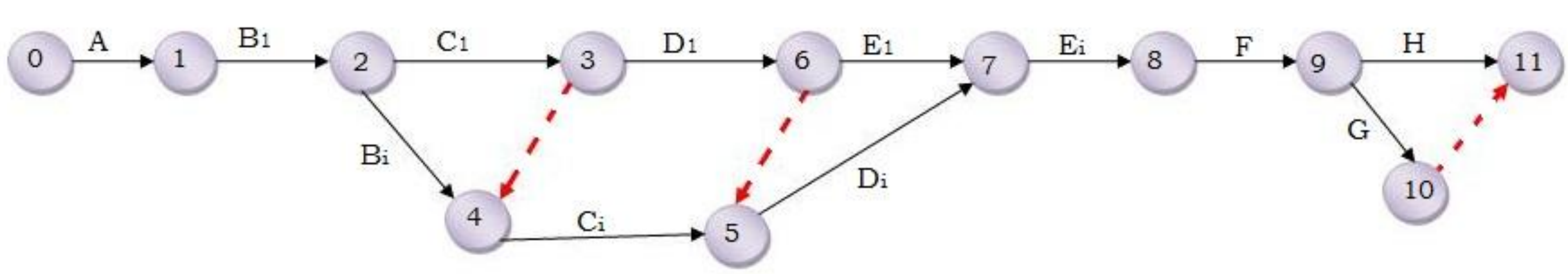
Following table represents the basic flow of Unloading process and all the activities that are having key role in it. The network depicting the flow of activities.

NO	ACTIVITY	ACTIVITY DESCRIPTION
1	A	Preplanning of decking of vehicle
2	B1	Unloading of First SKU
3	B2	Unloading of remaining SKU's.
4	C1	Checking of First SKU.
5	C2	Checking of remaining SKU's.
6	D1	Binning of stocks of first SKU
7	D2	Binning of stock of remaining SKU's
8	E1	Bin Master update of first SKU.
9	E2	Bin Master update of remaining SKU's.
10	F	Document preparation
11	G	GRN Process
12	H	Dispatch of Vehicle.

AS IS UNLOADING PROCESS



PROPOSED UNLOADING PROCESS FLOW CHART



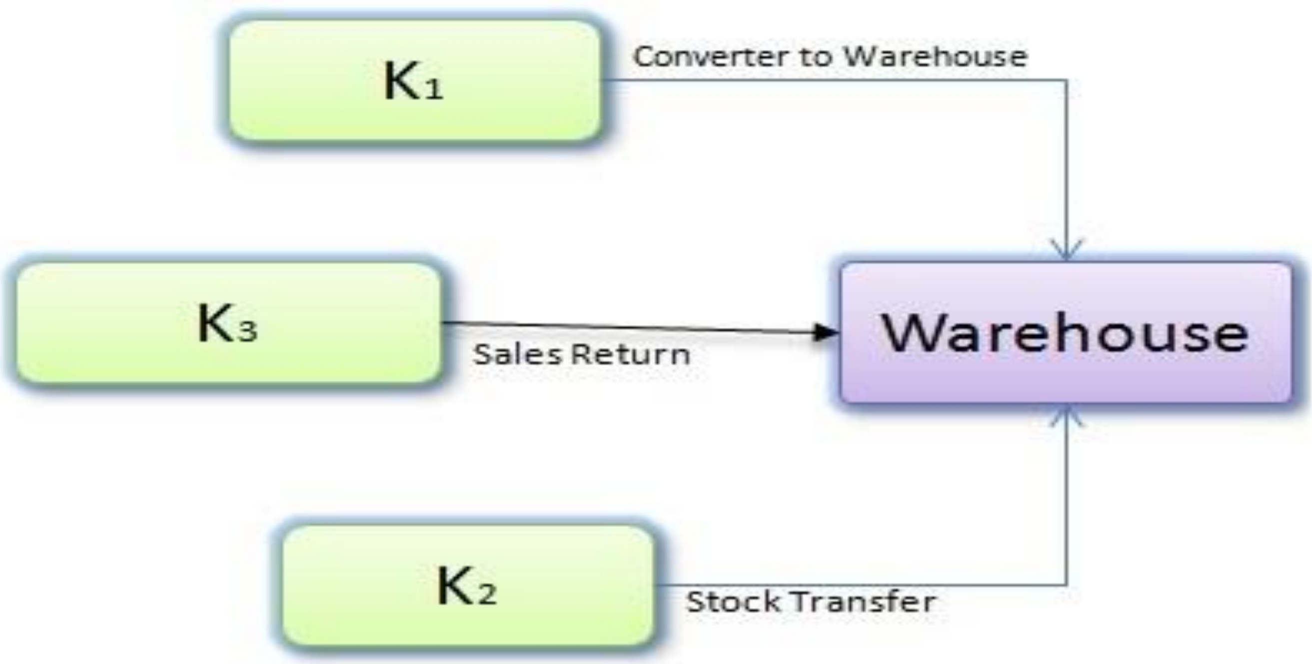
Receiving process (goods type and truck type)

Receiving Process is divided into some sub processes. The warehouse can receive from three resources

1. K1- Goods are transported from convertor to warehouse.

2. K2- Goods are transported from one warehouse to another.

3. K3- Goods are received from sales return.



TYPE OF INWARD RESOURCES

Based on the truck type there are two categories 15ton and 21Ton. Following table represents the time taken by each activity with different order size. Data is collected in real time environment. Simultaneously PERT analysis represents the min time (a), max time (b), most probably time(m). Expected time (Et) and variance (var).

- **Preplanning of space for binning based on transit information**
  Choosing the Deck on the basis of locations of SKU's.
- **Unloading of stocks**. Unloading of truck, counting of quantity of SKU, Checking the physical condition of SKU's. Damaged SKU required maintenance.
- **Binning of stocks.** Based on the SKU quantity the bin are updated.
- **Bin master update**. After placing the SKU at the right place in warehouse bin cards are updated.
- **GRN process.(Good Receipt Note)** A good receipt note no is allotted to each order that comes from convertor or other warehouse.

UNLOADING OF 15 TON TRUCK

Activities	Time taken by Vehicles									PERT RESULT				
Total Time	**116m**	**116m**	**110m**	**135m**	**132m**	**123m**	**109m**	**210m**	**105m**	**a**	**m**	**b**	**Et**	**Var**
Planning for Decking A	10	10	10	10	15	10	10	8	5	5	10	15	10	2.77
Unloading of First Pallet B1	15	13	10	12	20	10	9	12	11	9	12	20	13	3.36
Unloading of Remaining Pallet	65	67	70	59	80	100	80	97	52	52	80	100	79	64
Checking of First SKU C1	2	2	2	2	2	2	2	2	2	2	2	2	2	0
Checking of remaining SKU C2	6	8	6	10	6	6	5	7	5	5	6	10	7	0.694
Binning of Stocks of first SKU D1	5	4	5	5	10	4	5	7	5	4	5	10	6	1
Binning of Stocks of remaining SKU	30	29	30	30	40	40	48	50	30	29	30	60	35	26.6
Updation of Bin Card of first SKU	1	1	1	1	1	1	1	2	1	1	1	2	1	0.027
Updation of Bin Card of remaining	4	2	7	11	3	6	7	4	5	3	4	11	5	1.77
Document preparation F	10	5	5	6	5	3	3	4	2	3	5	25	8	13.44
GRN Process G	3	2	3	10	3	2	2	7	2	2	3	10	4	1.77
Dispatch of truck H	6	6	5	10	7	4	6	2	9	5	6	10	7	0.69
Weight	15 ton	16 ton	16 ton	15 ton	15 ton	15 ton	15 ton	15 ton	15 ton					
Truck NO	**HR38L2623**	**HR38H8085**	**WB23A8760**	**UP17P3517**	**HR385H4787**	**HR38H8085**	**RJ11GA4642**	**HR15H1976**	**MP07HHB2950**					

*****ALL ENTRIES IN MINUTES**

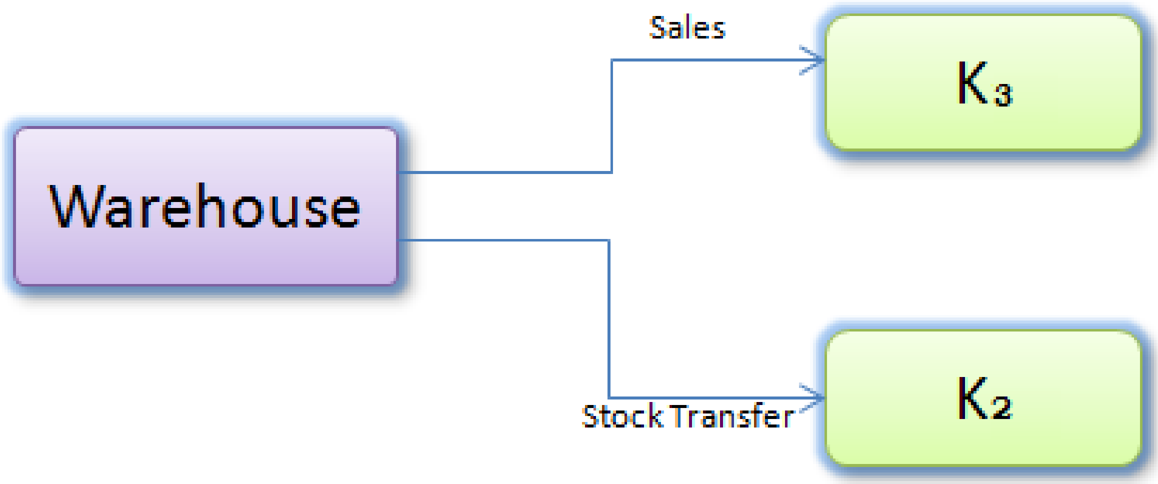
UNLOADING OF 21 TON TRUCK										
Activities	**Time taken by Vehicles**					**PERT RESULT**				
Total Time	**150m**	**115m**	**160m**	**125m**	**185m**	**a**	**m**	**b**	**Ex.t**	**var**
Planning for Decking A	8	7	10	15	5	5	**10**	**15**	**10**	**2.77**
Unloading of First Pallet B1	10	11	20	8	15	8	**15**	**20**	**15**	**4**
Unloading of Remaining Pallet	117	89	122	92	100	89	**100**	**122**	**102**	**30.25**
Checking of First SKU C1	2	2	3	2	2	2	**2**	**3**	**2**	**0.027**
Checking of remaining SKU	8	8	8	9	5	5	**8**	**9**	**8**	**0.44**
Binning of Stocks of first SKU D1	3	5	7	4	7	3	**7**	**7**	**6**	**0.44**
Binning of Stocks of remaining SKU Di	48	40	60	40	45	40	**40**	**60**	**43**	**11.11**
Updation of Bin Card of first SKU E1	1	2	2	1	1	1	**1**	**2**	**1**	**0.027**
Updation of Bin Card of	4	4	4	11	6	4	**4**	**11**	**5**	**1.36**
Document preparation F	20	10	13	5	5	5	**13**	**20**	**13**	**6.25**
GRN Process G	5	3	3	4	2	2	**3**	**5**	**3**	**0.25**
Dispatch of truck H	9	6	8	5	5	5	**6**	**9**	**6**	**0.44**
Weight	**21ton**	**21ton**	**21ton**	**21ton**	**21ton**					
Truck Type	**AP27T W6785**	**FE26TA 5189**	**AP27P W6966**	**M806H E2279**	**HR38J 6679**					

***** ALL ENTRIES ARE IN MINUTES**

DISPATCH PROCESS BY TRUCK TYPE AND GOOD TYPE

Receiving Process is divided into some sub processes. The warehouse can send orders to two destinations.

- K2- Goods are transported from one warehouse to another.
- K3- Goods being dispatched for sales to retailers.



OUTWARD DESTINATIONS

- **Printing of picking list:** Printing of pick list and checklist on the basis of SAP orders.
- **Generating location wise picking sequence:** Supervisor manually searches the locations of the SKU from physical stock register and assigns the picking sequence for SKU's
- **Picking activity.** Picking is performed in series manner but in intense deadline environment picking is performed in parallel manner.
- **Update on bin cards.** Bin cards are updated based on the quantity picked from the stock.
- **Movements to loading area.** When pallets are loaded with the picked CFC's then simultaneously they are moved to stack area.
- **Loading activity.** It involves the cross checking of SKU at stack area and loading of vehicle.
- **Counting and reconciliation of stocks before document preparation:** Counting activity is performed after picking activity ends. It is performed by supervisor.
- **Invoice generation:** After the loading activity invoice generation process takes place which generally provides the handling of invoice form arrival to post.
- **Release of Vehicle (Total order Turnaround Time).** After invoice generation process the vehicle is released

PROCESS OF LOADING OF K2																					
Activities	**TIME TAKEN BY EACH VEHICLE**																**PERT RESULT**				
Total Time	2h37m	2h50m	3h12m	3h44m	2h28m	3h9m	2h43m	4h3m	2h44m	3h7m	3h15m	2h37m	2h44m	2h43m	2h43m	2h50m	a	m	b	Ext	var
Printing List (A)	10	8	10	8	16	18	10	10	10	8	7	5	7	9	7	6	5	10	18	11	4.69
Decking (B)	8	10	10	5	5	5	8	7	8	10	5	7	4	5	10	8	4	5	10	6	1
Picking of First SKU C1	6	8	7	4	2	5	2	8	6	5	7	8	12	15	4	7	2	8	16	8	5.44
Picking of Remaining SKU's C2	20	20	22	56	48	40	29	58	30	38	40	25	28	30	38	40	20	40	58	40	40.11
Movement to loading area of first pallet D1	2	4	9	5	2	4	3	10	5	6	4	8	5	4	10	12	2	4	12	5	2.77
Movement to loading area of remaining pallet D2	16	20	41	30	15	35	15	48	20	25	30	15	20	18	17	25	15	20	48	24	30.25
Updating of bin card of first SKU E1	1	1	1	1	1	1	1	2	1	1	1	2	2	2	1	1	1	1	2	1	0.0277
Updating of Bin Card of Remaining SKU's E2	3	4	2	5	6	3	4	8	3	4	2	3	4	3	2	3	2	3	8	4	1
Counting of First SKU F1	2	3	3	2	2	2	1	3	2	1	2	3	4	3	2	1	1	2	4	2	0.25
Counting of remaining SKU's F2	6	8	10	15	6	7	4	5	4	4	6	8	3	2	3	3	2	6	15	7	4.69
Loading of First SKU G1	10	8	10	5	4	8	10	9	10	10	12	10	15	16	8	7	4	10	16	10	4
Loading of remaining SKUs G2	50	48	40	50	16	32	45	43	40	50	56	40	38	28	37	34	16	40	50	38	32.11
Document Preparation H	5	6	5	5	5	6	8	6	5	6	5	6	4	5	6	6	4	5	15	7	3.36
Invoice Generation & billing process	10	15	12	18	10	13	15	16	10	12	10	12	14	18	16	12	10	15	18	15	1.77
Dispatch of Truck	8	7	10	15	10	10	8	10	10	7	8	5	4	5	7	5	5	10	10	9	0.694
Truck No	HR55K 9350	UP77 N5666	UP34C 7674	UP27T 2789	GJ9V8 718	HR858 190	JK14B 1885	CJ04J 4626	GJ9V7 638	HR55 F5696	HR55L 5315	UP14A T6645	HR37B 4172	MP07 HB204 9	PB11B K7612	GJ1CV 4175					
Truck Weight	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON	15 TON					

** all entries in minutes

PROCESS OF LOADING OF K3(PARCEL <1 TON)

Activities	TIME TAKEN BY EACH VEHICLE										PERT RESULT				
Total Time	1h41m	57m	1h46m	1h36m	1h47m	2h17m	2h7m	1h58m	2h5m	1h33m	a	m	b	Ext	var
Printing List (A)	4	3	4	5	6	8	7	5	7	4	3	4	8	5	0.69
Decking (B)	5	4	5	5	6	10	8	7	8	5	4	5	10	6	1
Picking of First SKU C1	3	1	2	2	3	4	5	3	5	2	1	3	5	3	0.44
Picking of Remaining SKU's C2	5	5	7	6	8	10	10	7	8	7	5	7	10	7	0.69
Movement to loading area of first pallet D1	3	2	3	2	3	5	6	4	3	3	2	3	6	3	0.44
Movement to loading area of remaining pallet D2	4	4	5	5	9	8	8	6	5	6	4	5	9	6	0.69
Updating of bin card of first SKU E1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	0.0277
Updating of Bin Card of Remaining SKU's E2	2	1	2	2	2	3	3	2	3	2	1	2	3	2	0.11
Counting of First SKU F1	1	2	2	1	2	2	3	2	2	2	1	2	3	2	0.11
Counting of remaining SKU's F2	3	3	2	3	3	3	3	3	3	3	2	3	3	3	0.0277
Loading of First SKU G1	10	8	7	8	6	10	11	15	12	9	6	10	15	10	2.25
Loading of remaining SKUs G2	40	10	50	40	38	45	40	42	45	35	10	40	50	37	44.44
Document Preparation H	5	4	5	5	7	7	6	5	6	4	4	5	7	5	0.25
Invoice Generation & billing process	5	4	5	6	7	10	6	6	7	5	4	6	10	6	1
Dispatch of Truck	10	5	6	5	6	10	10	10	10	5	5	10	10	9	0.694
Truck No	UP14DT 1236	UP14D T3707	UP14DT 3707	UP14DT 3707	UP14D T3707	UP14D T1236	UP1493 08	UP14D T1236	DL1LL0 865	HR55F0 411					
Truck Weight	2200KG	1900KG	55CFC	60CFC	50CFC	56CFC	1500KG	20CFC	35CFC	5720KG					

***all entries in minutes

PROCESS OF LOADING OF K3(LCV <=3 TON)													
Activities	TIME TAKEN BY EACH VEHICLE								PERT RESULT				
Total Time	1h5m	1h40m	2h7m	1h41m	1h41m	2h23m	1h36m	2h25m	a	m	b	Ext	var
Printing List (A)	5	5	7	5	4	6	5	5	4	5	7	5	0.25
Decking (B)	7	7	10	7	6	10	6	8	6	7	10	7	0.44
Picking of First SKU C1	2	2	4	2	3	5	3	4	2	2	5	3	0.25
Picking of Remaining SKU's C2	4	6	7	5	7	11	8	15	4	7	15	8	3.36
Movement to loading area of first pallet D1	2	2	3	3	4	4	3	5	2	3	5	3	0.25
Movement to loading area of remaining pallet D2	3	7	10	8	9	15	7	11	3	7	15	8	4
Updating of bin card of first SKU E1	1	1	1	1	1	2	1	2	1	1	2	1	0.027
Updating of Bin Card of Remaining SKU's E2	1	2	2	2	2	3	1	2	1	2	3	2	0.11
Counting of First SKU F1	1	1	2	1	1	2	1	2	1	1	2	1	0.027
Counting of remaining SKU's F2	2	3	4	3	2	3	3	3	2	3	4	3	0.111
Loading of First SKU G1	5	6	8	7	6	10	5	7	5	6	10	7	0.69
Loading of remaining SKUs G2	15	40	45	40	39	45	35	60	15	45	60	43	56.25
Document Preparation H	5	5	6	5	6	7	5	6	5	6	7	6	0.111
Invoice Generation & billing process	7	7	8	6	5	10	5	7	5	7	10	7	0.69
Dispatch of Truck	5	6	10	6	6	10	8	8	5	6	10	7	0.69
Truck No	UP14DT 3707	UP14DT 3707	UP14D T1236	UP14D T1236	UP14D T3707	UP14A T9233	UP14D T3707	HR4649 68					
Truck Weight	3TON	77CFC	115CFC	81CFC	81CFC	3TON	100CFC	3TON					

*** ALL ENTRIES ARE IN MINUTES

PROCESS OF LOADING OF K3(FTL>=5, <=9 TON)											
Activities	TIME TAKEN BY EACH VEHICLE						PERT RESULT				
Total Time	2h14m	2h11m	2h14m	2h08m	1h58m	1h42m	a	m	b	Ext	var
Printing List (A)	6	6	7	5	5	5	5	5	7	5	0.11
Decking (B)	7	7	10	10	10	8	7	7	10	8	0.25
Picking of First SKU C1	2	3	4	5	3	2	2	3	4	3	0.11
Picking of Remaining SKU's C2	15	11	10	14	10	8	8	10	15	11	1.36
Movement to loading area of first pallet D1	3	4	3	4	3	2	2	3	4	3	0.11
Movement to loading area of remaining pallet D2	10	10	8	8	10	9	8	10	10	10	0.11
Updating of bin card of first SKU E1	1	1	1	1	2	1	1	1	2	1	0.027
Updating of Bin Card of Remaining SKU's E2	2	2	3	3	2	1	1	2	3	2	0.11
Counting of First SKU F1	2	2	2	2	2	3	1	2	3	2	0.11
Counting of remaining SKU's F2	4	3	4	4	3	3	3	3	4	3	0.027
Loading of First SKU G1	10	10	8	8	10	7	7	10	10	10	0.25
Loading of remaining SKUs G2	48	48	50	40	38	38	40	48	50	47	2.77
Document Preparation H	6	7	8	7	6	5	5	6	8	6	0.25
Invoice Generation & billing process	8	7	6	7	6	5	5	7	8	7	0.25
Dispatch of Truck	10	10	10	10	8	5	5	10	10	9	0.69
Truck No	UP30T7 931	UP14D5 169	UP86D T0386	HR38J4 787	UP38H 9920	UP42T 5598					
Truck Weight	3TON	77CFC	115CFC	81CFC	81CFC	3TON					

***ALL ENTRIES IN MINUTES

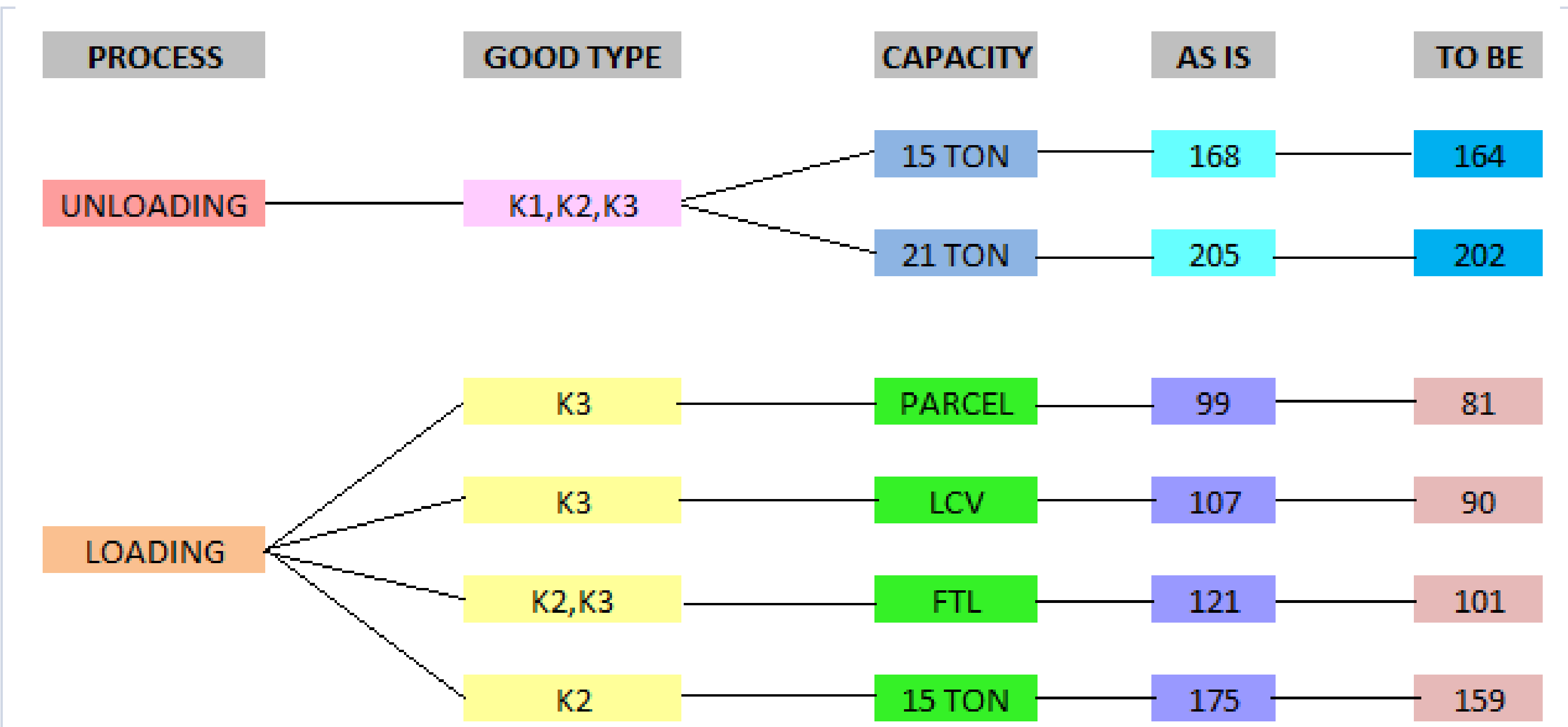
CRITICAL PATH REPRESENTATION OF LOADING & UNLOADING

Following charts represents the critical activities in “as in” and” to be” processes. In chart blue shade shows the critical activities in “AS IN” process while light yellow represents critical activities in “TO BE” process.

UNLOADING												
AS IS	A	B1	B2	C1	C2	D1	D2	E		F	G	H
TO BE	A	B1	B2	C1	C2	D1	D2	E1	E2	F	G	H

LOADING															
AS IS	A	B	C		D		E		F1	F2	G1	G2	H	I	J
TO BE	A	B	C1	C2	D1	D2	E1	E2	F1	F2	G1	G2	H	I	J

Based on both network and ttat analysis following chart shows the proposed activity policy is much better than current implemented one. For both loading and unloading process the policy reduces the ttat timings.



TTAT TIMING COMPARISION B/T "AS IS" & "TO BE" PROCESS

*** ALL THE ENTRIES IN MINUTES

SOLUTIONS

STORAGE ARCHITUCTURE: CUSTOM

Custom storage architecture was based on guess of random flow of SKU. So it was not so efficient and organized as the current rough chart of warehouse can represent itself.

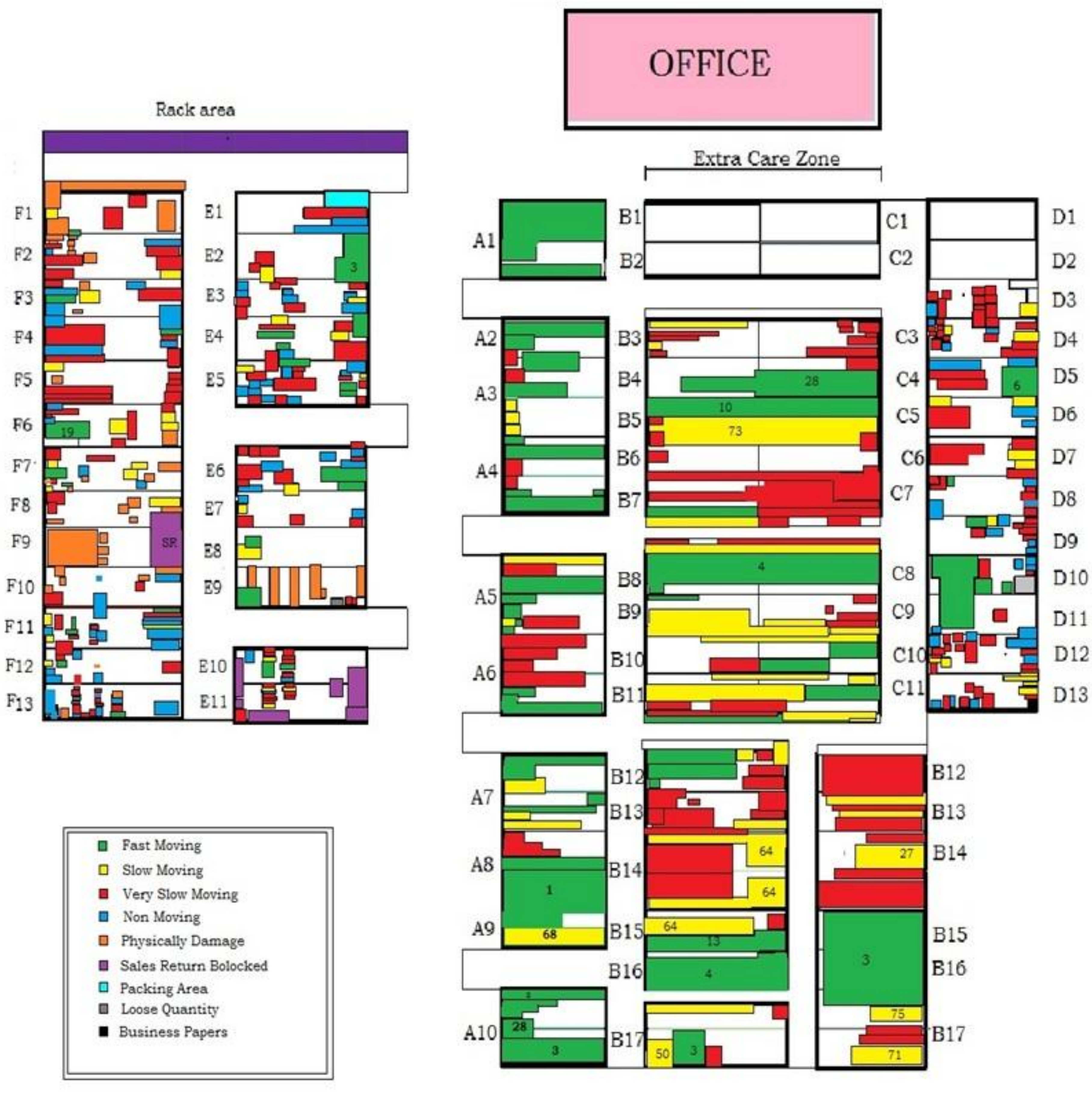
For current storage of SKUs the management observed the basic flow of SKU from last some years, conclude to the point which SKU should be where in the warehouse.

Below is the current storage layout of warehouse that is simply representing the problems that are affecting the efficient operation, throughput of warehouse, ttat timings.(The layout is the rough sketch of warehouse , quantities of SKU cannot be exactly observed .).

Based on three months FSN analysis we categorized the whole SKU's in FAST ,slow and very slow products. The SKU's that has no moving record are being considered as non-moving products. Rests are all sales return and damage and loose quantity.

Problems with architecture:

- Not efficient and well planned.
- I have identified some SKU that are located more than 2 locations with having little quantities.
- Fsn is implemented based on experience of flow of SKU.
- No proper management of damage and sales return material in terms of space optimization.
- No proper record maintenance of SKU's physical location in soft copy.
- Current layout affecting the picking process that is taking more time than it usually takes.



*** PRODUCT'S CURRENT PLACE IN WAREHOUSE ON THE BASIS OF FSN RANKING
***THIS SKETCH IS DRAWN ON A PERTICULAR DATE

PROPOSED ARCHITECTURE

Analyzing the above flaws in the storage layout we are introducing the proposed layout that can overcome most of the problem identified above.

GREEN: Fast moving products.(FORWARD AREA)

FADE GREEN: fast moving products (BACKWORD AREA)

YELLOW: Slow moving products.

BLUE: fast moving than dead and slow moving than slow .

RED: no movement or very few in a year.

BLACK: backup or emergency area for seasonal storage.

PROPOSED

*** PROPOSED STORAGE ARCHITECTURE FOR EFFICIENT OPERATION

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Name and address of the Company	**Pnb L block connaught circus new delhi**
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