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To Whom It May Concern

This is to certify that this project report, entitled "Multi Agent Based Decision Support System for SCM" by Zahoor Fouze Azeem (01-111191-071), Wasif Shakoor (01-111191-133) and Muhammad Tariq Yousaf (01-111191-035), submitted in partial fulfilment of the requirements for the degree of Bachelors of Business Administration from Bahria University, Islamabad Pakistan, during the academic year of 2023, is a bonafide record of work carried out under my permission and guidance.

This certificate is issed on the specific request of the students and issued without any risk and responsibility on part of the company.

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Abstract

Supply chain is the core of any business. From procurement to delivering the product to final consumers. Furthermore, inventory is one of the most important components of supply chain. Inventory management help the manufacturers to streamline their processes and perform operational functions effectively and efficiently. This study aims to objectify the importance of demand forecasting and safety stock in a manufacturing business. Data was collected from Mobi paints head office. The study revealed the problems of demand fulfillment faced by Mobi paints. By studying the facts from Mobi paints, trend line analysis and service level analysis was used to overcome the issues faced by the organization.

Key Words: Supply chain, Inventory Management, Demand Forecasting

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CHAPTER 1: INTRODUCTION

Mubeen Paints Industries (MPI) or Mobi Paints, established in 2003, are well known brand in paint manufacturing and selling. Mobi Paints are currently producing variety of high quality decorative, industrial, and commercial paint products including synthetic polyvinyl distempers, synthetic Enamels, Matt finishes and plastic emulsions.

Mubeen Paints Industries was established by an entrepreneur 'Tasleem Raza' in a rural area of Sargodha where competition was not much at the time and the demand was high. He started this venture as small-scale business which through time, gained success as a result of the high-quality maintenance and following the national and international standards of quality assurance.

Mobi paints aims to fulfill the demand gaps in both rural and urban areas. Mobi paints are currently operating in Pakistan through more than 1200 agents in Pakistan. As their mission statement states "the objective is to satisfy customer demand by offering quality products and services that leave little to be desired on consumer end."

Apart from the company's offered services and growth to where the firm is today, we must focus on the company's operations, particularly their supply chain. To explain in generic terms, a supply chain consists of series of operations and intermediaries which contributes to adding value in the final product and to the end consumer. The value chain is considered efficient when the overall costs incurred on supply chain is less than the revenue generated.

The aim of every organization is to make their supply chain efficient and reduce overall costs and maximize revenue; Mobi paints are no different. Therefore, effective warehousing and inventory management is considered an integral part of any organization's operations. By observing what a core component inventory and warehouse management is, let us observe that through ensuring their effectiveness, a company enjoys a multitude of advantages in their operations.

Foremost, the management of the warehouse operations become efficient, this helps the organization to mitigate any further risks factors that may affect them negatively.

Furthermore, the company can ensure transparency where their inventory is involved. This allows easy trackability of the items in transit, which is a direct by-product of ensuring a central distribution channel.

Every organization faces issues in business, Mobi Paints is no different. Their main issue is the inability to forecast customer demand. Therefore, Mobi paints are not able to keep

safety/buffer stock because the demand is not forecasted/predicted. In case of any issue or anomaly in the market, if the fluctuations are big, the firm may even be forced to shut down. With the company's rapid growth and increasing demand, it is important to forecast the right consumer demand to ensure the right production rate and additionally to keep buffer stock of both raw material and finished product, to tackle any anomaly or fluctuations in demand.

Project Rationale:

This project aims to utilize inventory management tools and techniques for the purpose of mitigating operational issues regarding inventory, and eventually providing the effective inventory management strategies for Mobi Paints.

This project aims to identify the problems faced by Mobi paints, specifically the issue of forecasting the right demand, and ensuring a smooth flow of items in transit,

The project will further provide solutions to improve operations in inventory and warehousing. The key to achieve this are the tools and techniques of inventory management that will smooth the operations.

As a paint manufacturing organization, the main goal of Mobi paints is to gain competitive advantage and fulfill customer demand on time and in full capacity. The expansion of business on large scale has made these operations difficult and complex as a result of variations in demand of different products in different regions.

The solutions will help Mobi paints with identifications of products that are required in different regions, by improving forecasting techniques.

Purpose of project:

The purpose of the project is to draft a solution to for inventory problems that currently Mobi paints are facing. Like every paint manufacturing company, Mobi paints wants their products available for their customers, however, Mobi paints are facing problems in fulfilling customer demand as a result of forecasting issues and no buffer stock keeping.

The current inventory problems being faced by Mobi paints are as a result of their inability to forecast, track trends and inability to keep buffer stock. This have additionally resulted in losing customers to competitors.

Project Goal:

The goal of this project is to present a new strategy for Mobi paints to manage inventory and improve forecasting for the market demand and mitigate the buffer stock issue. This can help in fulfilling the customer demand in all the regions where the firm is operating in and will additionally be prepared for any anomaly in the market.

It can assist them in effective and fast management during different scenarios which includes demand variation, any abnormal occurrence, which will help in mitigating stock out issues and increase the production capacity too.

Project Objectives (SMART Terms):

SPECIFIC: The objective of the project is to consider and use the relevant techniques of supply chain in the context warehousing and inventory management to make the basic core operations smooth and problem free better products and services to the end consumer.

We had the chance to interview the warehouse manager, who provided us with the detailed information on the issues faced i.e., forecasting and safety/buffer stockkeeping within the inventory.

MEASUREABLE: The results of this project will be measurable when the analysis will be done after the practical implementation of the solutions provided in this project.

ATAINABLE: With proper implementation and constant monitoring, the goal of this project is attainable and is possible to achieve with continuous improvements within the operations and inventory along with frequent evaluation of the results.

REALISTIC: The goals of this project are real and attainable.

TIMELY: As Mobi paints are expanding their operational network rapidly, providing a solution within the time to implement is important.

Projected Benefits:

The project will aid Mobi paints in identifying the solutions to the problems being faced in inventory management. The solutions provided in this project will help them make their inventory and warehousing management system effective thus curbing the negative impact the current problems give rise to.

Project Risk:

The data was mostly estimated and calculated because we have insufficient and incomplete data given by the organization as a result of which we might face some constraints.

Key Success Factors:

The new strategies of inventory management will benefit the entire supply chain i.e., improved forecasting and will help them acknowledge the need of safety/buffer stock based on the solution provided.

An inventory management method called the EOQ analyses will be used to determine the value of inventory items i.e., product with the most demand to the product with the least

demand, and its importance to the business. This tool helps us to find out the economic order quantity which helps to reduce lead times and gives us an idea of how much to manufacture and least order based on demand, risk factor, cost etc. this tool helps the manager to recognize the items which are the most beneficial for the business and those product's demands are forecasted through this and additionally helps to determine the exact amount of buffer stock to be kept in case of emergencies.

Mobi paints can use the EOQ analysis which will help them in reducing the lead time to make the in-demand paint and deliver it to the end consumer. Products can be classified according to their unit cost, total inventory value and by total sold value of a specific item.

PESTAL analysis will help in determining external factors causing problems. Government ban on import is a prime issue impacting production as major part of raw materials are imported.

CHAPTER 2: LIRTERATURE REVIEW

This chapter emphasizes on exploring and evaluating all articles used for the background study of supply chain and Inventory in general. Emphasis has been put on understanding the concept of supply chains, inventory and tools and techniques used in maintaining inventory in business.

What Is a Supply Chain?

As defined by **Chopra and Meindl (2006)**, "A supply chain includes all stakeholders engaged in explicitly or implicitly fulfilling a consumer request. The supply chain includes transporters, warehouses, merchants, and even the real customers, in addition to the manufacturer and suppliers. Each company's supply chain, such as a manufacturing, includes all operations involved in receiving and fulfilling a client request. Among these responsibilities include the development of new products, marketing, operations, distribution, finance, and customer service."

An overall description of the supply chain process is given. Resources must be extracted before conversion into raw resources. Raw materials are then converted to finished goods. Goods then transferred to retail locations for customer purchase after being held in warehouses.

Figure 1 shows how goods flow, starting from raw material till finished product until it reaches the end-user, that is, the consumer. While the product or goods flow from supplier to customer, there is an exchange of goods for money and information between all parties engaged in the supply chain.
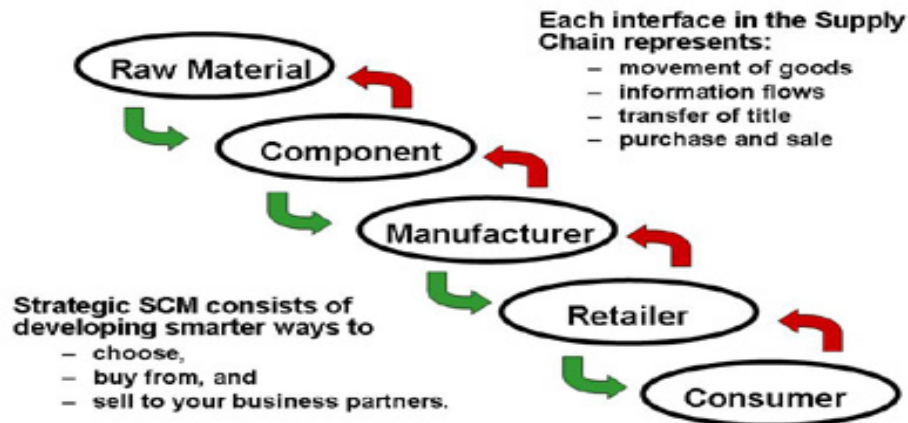
Figure 1 Information, Funds, and Product flow in SCM [Source: MIT Open Courseware [13]]

The green arrows indicate the flow of goods while red arrows indicate flow of information and funds. A supply chain is dynamic and involves a constant flow of information, product, and funds between various stages. A typical supply chain may involve a variety of stages. These supply chain stages include:

- Customers
- Retailers
- Wholesaler/distributors
- Manufacturers
- Component/raw material suppliers [chain extends till the biological/natural resources]

Supply Chain Management (SCM):

Harland and C.M. (1996): SCM is described as "the administration of a network of interconnected firms participating in the ultimate provision of product and service packages required by end customers" (Supply Chain Management, or SCM for short). All materials, stocks for work in progress (WIP), and goods produced are transferred and kept from the source of production to the site of consumption. [1]

In other words, SCM is an inter inter-enterprise system that makes use of computing technology to oversee some of the key business processes of the organization and the relationships between its suppliers, clients, and business partners.

Johnson and Pyke (1999): evaluate the role of supply chain and explain that supply chain management has received much interest in recent years for a number of reasons. One of these

led managers to realize that decisions made by one link in the network might impact the success of all the other links in the chain. Instead of pitting one company against another, businesses are starting to think about competing as a supply chain against other supply chains. Additionally, as businesses strive to streamline their operations, improved supplier and customer collaboration represents the next possibility for improvement. The costs of poor coordination can be very substantial, according to **Johnson and Pyke** (1999) [2]. The following diagram shows an illustration of a chain supply chain network, showing the degree to which, each party is interdependent upon one another in a to complete the demand and supply process, as shown in the following graph, which depicts a supply chain network example of a supply chain.
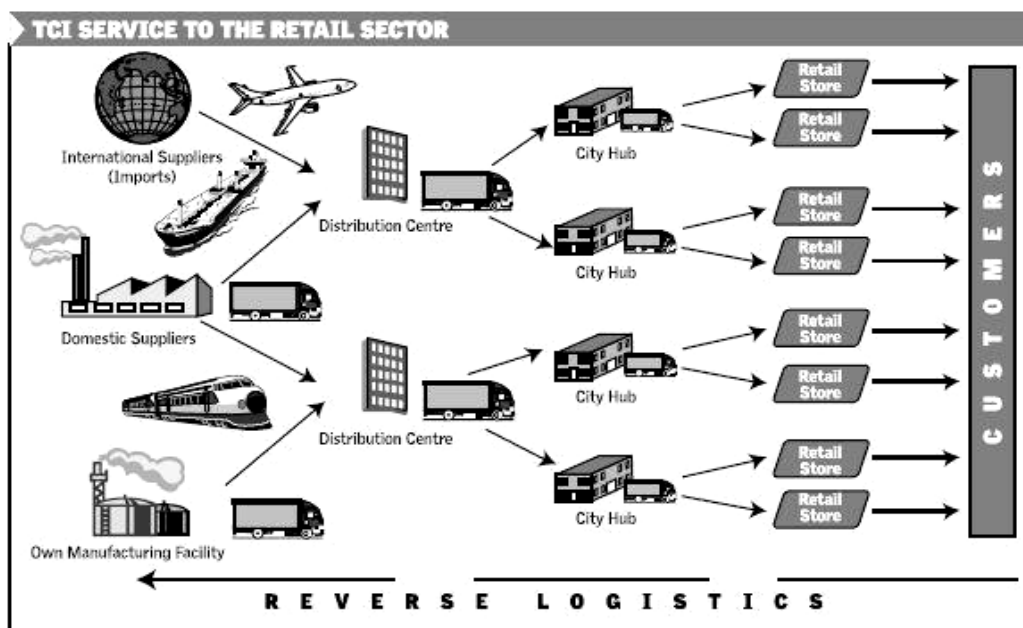
Figure 2 An example of SCM Process [Source: Chopra & Meindl (2006)]

Goal of Supply Chain Management:

Worldscibooks.com [3] describe the objective of SCM is to effectively manage processes such as fluctuating demand, inventory control, improving a company's network of business connections with clients, partners, distributors, and others, as well as gathering input on the condition of each supply chain link. Too quickly, cheaply, and efficiently get a company's products to market, SCM aims to build a network of business contacts, or supply chain.

Supply Chain Infrastructure:

Both internal and external supply chain operations are a part of the supply chain. Both the suppliers and the customers are connected. Sequential ties between the departments of

purchasing, production, and distribution make form the internal supply chain. A company's purchasing department works closely with its suppliers to buy materials, which are then sent to the manufacturing department for conversion into finished goods. Items are then sent to the distribution center so that final items can be distributed, till it reaches end consumers.
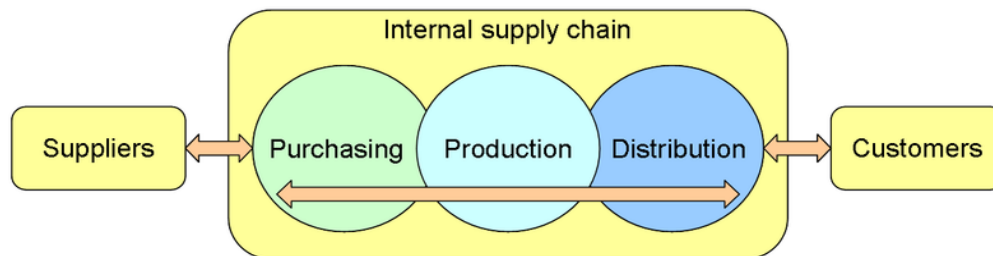
Figure 3 Supply Chain Process [Source: Wikipedia]

Drivers of Supply Chain Performance:

Sreenivasan (2006) in his report on supply chain management, he elaborates on the role that drivers of supply chain performance play. He argues that a supply chain must strike a balance between responsiveness and efficiency that best meets the demands of the company's competitive strategy in order to be successful and profitable. In order to comprehend how a company can, increase supply chain performance in terms of responsiveness and efficiency, we need to look at the logistical and cross-functional drivers of supply chain performance. These drivers include facilities, inventory, transportation, information, sourcing, and pricing. The supply chain's responsiveness and effectiveness are affected by these factors' interactions with one another. As a result, the supply chain's ability to achieve strategic fit is influenced by the structure of these drivers [4]. According to **Chopra and Meindl**, the list of supply chain drivers and their significance are as follows.

Facilities:

Facilities are the actual physical locations where products are stored, put together, or made in the supply chain network. Production sites and storage sites are the two main categories of facilities. On the effectiveness of the supply chain, decisions about the roles, locations, capacities, and flexibility of facilities are crucial.

Inventory:

Inventory includes all raw materials, finished goods, and work in progress in a supply chain. Changing inventory policies can have a significant impact on the supply chain's efficiency and responsiveness. By keeping a lot of products on hand and meeting demand from that inventory, a clothing retailer, for example, can improve its responsiveness. Having too much

inventory, on the other hand, costs the retailer more money and makes it less effective. While reducing inventory improves merchant efficiency, it reduces responsiveness [5].

Transportation:

transportation is a critical aspect of the supply chain, and different modes of transportation have different costs and trade-offs. The choice of transportation mode is determined by factors such as product type, distance, time-sensitivity, and cost.

For example, a company that ships perishable goods will use faster mode of transportation to ensure that products arrive at destination quickly and in good condition so will use airplanes. This mode of transportation is expensive than ground transportation, however it is necessary to maintain quality and safety of the products. On other hand, a company that ships non-perishable goods might use ground transportation, which is slower therefore less expensive, to save on costs and increase efficiency.

Companies should additionally consider sustainability of the transportation mode, it is impact on the environment, and society.

Information:

The information about the supply chain includes data and analysis on the buildings, inventory, transportation, costs, and customers. Because it has a direct impact on all of the other drivers, information has the potential to be the most significant driver of supply chain performance. Information affords management the opportunity to improve supply networks' responsiveness and effectiveness.

Sourcing:

Sourcing is the process of deciding who will handle a particular task in the supply chain, like production, storage, transportation, or information management. These strategic choices determine which tasks an organization outsources and which it performs internally. The choices made in sourcing have an effect on the responsiveness and efficiency of a supply chain.

Prices:

The price a company will charge for the goods and services it sells through the supply chain is determined by pricing. Pricing has an impact on the efficiency of the supply chain, which in turn has an impact on the consumer's behavior. For instance, customers who value responsiveness will be willing to wait and place an order only when customer needs a product delivered if a transportation company bases its rates on the client's planning horizon. Initial orders are less likely if prices are fixed regardless of lead time.

Decision Metrics in Supply Chain Drivers:

As mentioned by **Supply Chain Council (2008)** in the **SCOR Model**, each driver's performance in the supply chain is evaluated through a number of metrics. Metrics are those quantifiable dimensions of a supply chain which can be evaluated in order to analyze a supply chain's overall performance. This performance evaluation ultimately helps in making decisions more effective. The metrics are extracted from SCOR Model along with their weighable dimensions, here we will only discuss about inventory and information related metrics.

Inventory-Related Metrics:

A manager should track the following inventory-related metrics that influence supply chain performance:

- **Average inventory** is the quantity of inventory carried on average. The average inventory should be measured in terms of units, days of demand, and monetary value.
- **Products** having more than a certain number amount of inventory.
- **days inventory** indicate that the business is carrying a high amount of inventory This measure may be used to recognize overstocked items or causes for the high inventory, such as price cuts or being a sluggish mover.
- **The average replenishment** batch size quantifies the amount of each replenishment product.
- **The batch size** should be determined by SKU in terms of both units and demand days. It may be computed by averaging the difference between the highest and minimum inventory (measured in days) across a longer period of time.

Information-Related Metrics:

The performance of the supply chain is affected by the information-related KPIs that a manager should monitor.

- **The forecast horizon** describes the period in which a forecast is made. The forecast horizon must match the lead time of the forecast-driven decision.
- **The frequency of update** shows how often each forecast is revised. The forecast needs to be updated a little more regularly than a decision will be reviewed in order to identify significant changes and take appropriate corrective action.
- **The forecast error** quantifies the discrepancy between expected and observed demand. All responses to uncertainty, like safety inventory or surplus capacity, are driven by the forecast error, which is a measure of uncertainty.

- **Seasonal factors** measure the extent to which the average demand in season is above or below the average in the year.

- **Variance from plan** identifies the difference between the planned production/inventories and the actual values. These variances can be used to raise flags that identify shortages and surpluses.

- **Ratio of demand variability to order variability** measures the standard deviation of incoming demand and supply orders places. A ratio less than one potentially indicates the existence of the bullwhip effect.

Demand Forecasting in a Supply Chain:

Liang & Huang (2005) define that the activity of estimating the quantity of a product or service that customers will purchase is known as demand forecasting. Informal methods, such as educated guesses, and quantitative methods, such as utilizing current data from test markets or historical sales data, are both utilized in demand forecasting. Pricing decisions, assessing future capacity requirements, and deciding whether to enter a new market can all benefit from using demand forecasting.

Components of a Forecast and Forecasting Methods:

A corporation needs to understand a variety of elements that are connected to the demand prediction. The following are a few of the elements covered by **Chopra and Meindl (2006):**

    1.Past demand

    2.Lead time of product

    3.Planned advertising or marketing efforts

    4.State of the company

    5.Planned price discounts

    6.Actions that competitors have taken

Before choosing an acceptable forecasting process, a corporation must comprehend these considerations. For instance, traditionally, demand for a product called EOQ may have been low in July and high in December and January for a company. The situation is likely to change if the company decides to offer a discount on the goods in July, with some future demand shifting to that month. The company should take the aspect into account when making its projection.

Forecasting Methods:

Liang & Huang (2005) indicate the following methods for forecasting demand:

1. **Qualitative:** Human judgement and subjectivity are the main components of qualitative forecasting techniques. Qualitative techniques are particularly useful when there is a dearth of historical data or when industry professionals have information about the market that could influence the projection. Such techniques might additionally be required to project demand for a new industry out several years.

2. **Time series:** Techniques for time-series forecasting make predictions based on demand in the past. Time series are based on the idea that data about demand in the past can accurately predict demand in the future. When the fundamental pattern of demand does not significantly shift from one year to the next, these strategies perform best. These methods can serve as a solid foundation for a demand forecast and are the easiest to implement.

3. **Causal:** Causal forecasting techniques presuppose that the forecasted demand is significantly associated with specific environmental factors (the state of the economy, interest rates, etc.). Using estimations of what the future state of the environment will be, causal forecasting techniques identify the association between demand and environmental parameters and forecast future demand. For instance, demand and product pricing have a close relationship. Therefore, businesses can utilize causal approaches to assess how price promotions affect demand.

4. **Simulation:** To create a prediction, simulation forecasting techniques mimic the consumer decisions that lead to demand. Using simulation, a firm can combine time-series and causal methodologies to address such issues as: what will be the impact of a price promotion? What effects will a rival opening a nearby retailer When seats are unavailable at lower fares, airlines model customer purchasing behavior to estimate demand for higher-fare seats.

Choosing the best strategy for forecasting may be challenging for a business. In reality, a number of studies have found that utilizing a combination of forecasting techniques rather than just one improves forecast accuracy.

Aggregate Planning:

Wang, Liu, Wang & Cheung (2007) tell that "An operational activity that aggregate plans the production process, in advance of 2 to 18 months, to give management an idea of what quantity of materials and other resources are to be procured and when, so that the total cost of

operations of the organization is kept to a minimum over that period," according to the definition, "an operational activity that aggregate plans the production process."

It is decided how much inventory will be kept on hand and backlogged each period, how much will be outsourced, subcontracted, worked overtime, hired, and fired. All of these actions are governed by the company's principles, policies, and long-term commitment to the community, society, and environment.[6]

According to **Chopra and Meindl (2006)**, Certain pre-required inputs are inevitable in aggregate planning. Aggregate planning consist of:

- Information about the facilities and resources that are available.
- A forecast of demand for the period for which planning is required.
- The prices of various options and resources. This includes the cost of holding inventory, the cost of ordering, and the cost of producing using different production options like subcontracting, backordering, and working overtime.
- Organizational guidelines for utilizing the aforementioned options.

Chopra and Meindl (2006) define aggregate planning as "Aggregate Planning is concerned with matching supply and demand of output over the medium time range, up to approximately 12 months into the future. Term aggregate implies that the planning is done for a single overall measure of output or, at the most, a few aggregated product categories. The aim of aggregate planning is to set overall output levels in the near to medium future in the face of fluctuating or uncertain demands. Aggregate planning might seek to influence demand as well as supply."

Objectives of Aggregate Planning:

The primary goal of the aggregate planner, according to **Graves, Kelter, and Hetzel (1998),** is to determine the following operating parameters across the given time horizon:

- **Production rate:** is the quantity of units produced for each unit of time (such as per week or per month)
- **Workforce:** the total number of employees or production units required
- **Overtime:** the anticipated amount of overtime production
- **Machine Capacity Level:** the quantity of machines required for a given level of production
- **Subcontracting:** the capacity that must be subcontracted over the planning horizon
- **Backlog:** a demand that is not met when it emerges therefore is postponed to a later

time.

- **Inventory on Hand:** is the projected inventory that has been kept throughout the several planning horizon periods.

Inventory management introduction and challenges:

Modern industrialization has resulted in a variety of managerial issues. Inventory management is one of the many issues, and it significantly affects business operations as a whole. Globalization has created an unpredictably volatile market where prices keep rising daily and hence the price per unit of the product keeps increasing.

These circumstances push managers to manage with the resources at their disposal. In a market with high degrees of unpredictability (uncertainty), funds are a big barrier to expansion and is necessary for operations. Inventory management, makes up a sizable portion of working capital. As a result, the financial management of the business additionally depends on an effective inventory management system.

By utilizing more proper inventory management methods, businesses may decrease their inventory without raising other expenditures. Inventory management basically seeks to maintain sustainable stock levels while balancing an organization's conflicting aims. For example, the procurement department wants one thing while the marketing department. wants something else, the finance department is worried about other issues, hence to align the activities of all the departments involved in operations, inventory management plays its role, each decision is made with regards to inventory.

Definition:

Inventory management basically is a management process that enables businesses to decide which goods/products to order, when to order and in what quantities should the required items be ordered. Inventories, to put it simply, are basically resources that have been given a generic description and an economic worth to them like their per unit price or their mass etc. The following forms of inventory make up the majority of inventories generally: raw materials inventory, work-in-progress inventory, finished goods inventory, MRO inventory, and safety stock/buffer stock.

Inventory is tracked with the goal to recognize and react to patterns and trends in time without causing delays.

Benefits of having inventory management:

Following are some of the benefits of having an efficient inventory management:

- Cost reduction: having a grip on the market trends and knowing what is required and stocking for that demand and not producing useless extra stock and saving lead times. Doing such things will help organizations save cost.

- Better cash flows: having an efficient inventory management allows firms to invest in stocks that actually bring in better returns.

- Lead time: the best benefit of inventory management is that it allows firms to effectively manage production and operations and allows inventory to reach customers on time and satisfying their needs on time.

Process involved in inventory management:

Inventory management process depends on how the operations are conducted, if production is according to demand, then the process begins the moment an order is placed by a customer and continues till it is shipped. However, if demand is being forecasted than the situation is different. Software is used to keep track of how products are moved from the supplier through the manufacturing process and to the consumer. Stock receiving, picking, packing, and shipment are all tracked by inventory management in the warehouses [11].

Inventory management techniques:

Following is some of the main techniques used normally for inventory management:

- ➢ **Forecasted demand:** It is a technique for predicting required inventory levels for a future period by using historical data, trends, and known imminent occurrences. Predictive analytics of this kind aids in predicting consumer demands.

- ➢ **Economic order quantity (EOQ):** It refers to optimal order quantity that a firm should place to reduce inventory cost. Holding costs, shortfall costs, and order costs are some examples of inventory costs. This technique outlines the precise quantity of inventory a firms need to order to save storage cost and other expenditures.

- ➢ **Minimum order quantity (MOQ):** To keep prices low, a firm that relies on minimum order quantity would order small amounts of stock from distributors in every purchase.

- ➢ **Reorder Point technique (ROP):** Firms utilize ROP formula to determine the bare minimum quantity of stock required before restocking and then control and handle according to their stocks.

- ➢ **(FIFO (First In First Out)) and (LIFO) method:** FIFO refers to the practice of moving the older inventory first. LIFO implies that rates constantly increase, therefore the most recent inventory acquired is the costliest and hence sold first.

> **Just In Time Inventories (JIT):** It is a method in which items are obtained from suppliers just when the material is required. The primary aim is to lower holding costs of stocks meanwhile increasing the total inventory turnover. Firms utilize this approach to keep inventory levels as low as possible before restocking.

Following are some other basic methods and techniques used for inventory management:

> **Lean Manufacturing and Lean 6 sigma method:** in this technique (lean manufacturing) the aim is to remove anything (product or service) that does not bring value to the end consumer. The eliminated product is termed as waste. To eliminate waste and achieve efficiency, lean 6 sigma is used which integrates lean management principles and 6 Sigma approaches.

> **Buffer Stocks:** buffer stocks or safety stocks is a concept that is of the view that buffer stock will make sure that there always will be an extra (additional) stock reserved in case a firm is unable to refill those goods in case of emergency or uncertainty

> **Cross-Docking:** Cross-docking is basically a method that momentarily does away with the requirement to keep inventory. Products are delivered to a warehouse where products are organized and prepared for rapid dispatch. By employing this technique, you can transfer the goods from the supply truck to the delivery vehicle without any intermediate stops. The need for a warehouse is eliminated using this technique and it saves organizations funds.

> **Drop-shipping:** Using this retail strategy, firms do not directly control and manage their product inventory. Alternatively, firms provide details like order date, delivery location, and product number to a 3rd party vendor that completes the purchase on its behalf. A supplier engaged in drop-shipping dispatches products to clients from their warehouses.

Inventory management and Demand planning in accordance:

Inventory management's most critical component is doing demand planning. This is the method of deciding when and how much to charge for each item. Inventory management tracks the movement of commodities from supplier to manufacturing to customer order fulfilment as soon as the demand is identified.

Formulas:

It is critical to understand inventory management algorithms in maximize levels of inventory. Several management and accounting experts have tested methods to simplify stock

computations.

Key Performance indicators:

A supply chain must have an effective inventory management system to ensure smooth flow of operations and managing lead times. Experts have set up a few key performance indicators or in short agendas that when fulfilled lead the organization towards smooth lined operations. It is critical to understand which computations provide the most transparency into your company operations.

Inventory management process differs from other processes in operations:

Inventory management is frequently mixed up with related operations. Inventory management is in charge of a firm's inventory. Supply chain management is in charge of overseeing the entire process, from supplier to end customers. Inventory control include warehouse management, which concentrates on commodities in a particular location.

Controlling inventory vs Managing inventory:

Inventory control is a component of the inventory management process. Inventory control oversees the flow of products within the facility. In simple terms one is the process applied within the firm while the other is the process applied during the whole supply chain operations on a bigger scale.

Supply chain management vs Inventory management:

Supply chain management is the act of controlling external supply connections as well as the movement of inventory within and outside of firm. Inventory management might concentrate on trends and demands for the firm or a portion of it. For a well-functioning supply chain, inventory management is important. Inventory management is concerned with the movement of commodities into, across, and beyond the warehousing. Demand planning, procurement, manufacturing, quality, fulfilment, warehousing, and customer support are all components of the supply chain that require stock accuracy.

Warehousing management vs inventory management:

Inventory management is enhanced by warehouse management. Warehouse management is in charge of managing inventory in a warehouse. Inventory management oversees inventories and patterns across multiple warehouses or a firm. A well-planned and precisely managed facility is essential for optimizing an organization's warehousing activities. When every item has its own location in the facility, it prevents personnel from wandering around inefficiently and increases worker productivity. However, these systems are only as good as the stocks data that power them.

Difference between Logistics and Inventory management:

The technique of regulating operations in a warehouse as well as restocking and distribution systems is known as logistics. Inventory management is in charge of inventory levels and its location. How businesses manage their logistics, impacts the process of inventory management. Inventory management and logistics have a symbiotic connection. Inventory management is required for logistics to carry out operations. Excellent logistics systems enhance a warehouse and its operating capabilities.

Enterprise resource planning (ERP) vs Inventory management:

ERP is a form of software used by organizations to manage daily operations such as accounting, purchasing, project management, and overall supply chain operations. Inventory management, on the other hand, is a component of ERP system that provides an overview of inventory levels, inventory being used, and current stock status, making it accessible to the entire firm. Inventory management aids in the efficient planning of a firm's restocking requirements. ERPs provide firms with a precise number of stocks in inventory, ensuring that their stock management strategy is up to date. ERP systems streamline data for effective stock management.

Previous application of Forecasting Demand

AkzoNobel efforts to manage Inventory and Improve Customer Service:

AkzoNobel, a specialized chemical and paint manufacturer, worked with Terra Technology to improve their inventory management and customer service, ultimately leading to a higher return on investment (Painting a Better Picture of Demand | CHEManager, n.d.). [7]

According to Alain Crottaz, Director of EMEA Planning, Terra Technology's Multi-Enterprise Inventory Optimization and Demand Sensing solution was selected by AkzoNobel for implementation in Europe and Africa.

According to Crottaz, AkzoNobel sought a unified solution as part of their broader supply chain efficiency initiative. The goal was to achieve improved customer service, reduced excess inventory, particularly safety stock caused by incorrect forecasts, and to convert point-of-sale data into value for both AkzoNobel and its customers.

AkzoNobel was seeking a single solution to improve its supply chain efficiency and achieve three goals: higher customer service, reducing excess inventory, and transforming point-of-sale (POS) data into value for the company and customers. The company's traditional forecasting methods by item-group were prone to errors and disruptive to the supply chain. The new solution aimed to eliminate these errors and enhance accuracy by forecasting each

item at each depot. The company also sought to reduce inventory by more than 10% to improve working capital and free cash. Using POS data, AkzoNobel wanted to extract valuable information on future orders and respond to market changes in a timely manner. After considering several options, the company chose Terra's Demand Sensing solution, which was the only one with references from multinational companies with large and complex supply chains. The solution was deployed throughout AkzoNobel's EMEA region, starting with the UK and France, and reduced forecast error by 29% in the first week of use. The solution also included a Multi-Enterprise Inventory Optimization tool to convert the accurate forecasts into lower safety stock.

Jeddah paint Factory:

Jeddah Paints Factory, located in Jeddah, Saudi Arabia, is a paint manufacturing company that aims to improve its business and align with the 2030 vision by implementing a scientific forecasting method. The study focuses on the water-based paint production line, which produces three sizes of paint (Abdulaziz & Aseel, n.d.). [8]

After analyzing 5 years of production and sales data, researchers applied four forecasting techniques here we will only talk about them using regression model and used the Mean Absolute Deviation (MAD) to determine the most accurate method. This method was then used to forecast the next 5 years. The goal of the study is to improve the efficiency and accuracy of the company's forecasting efforts for a more successful and sustainable business.

Result:

The research also included the use of a regression (trend projection) model. The regression model is a relationship between the variable being forecasted and the factors that influence its value. It requires expertise to identify the important factors and the relationship. Regression is appropriate for medium- to long-term forecasts and requires a long time series of data. In the research, there was a noticeable gap between the actual and the forecasted data when using the trend method, as shown in Figure 7. Although Figure 8 shows a closer match between the actual and the forecast, it still isn't considered the best method until the Mean Absolute Deviation (MAD) is applied. Figure 9 shows a better match between the actual and the forecast, but it still cannot be considered the best method without the use of the MAD. $Y=a+bx$, Where a =intercept, b = slope of the line, x = time period and y = forecast period x .

Figure 7. Trend projection for Small Size

The mean absolute value for the method Trend projection in the small size is **865.06**

Figure 8. Trend projection for medium Size

The mean absolute value for the method Trend projection in the medium size is **1257.723**

Figure 7. Trend projection for large Size

The mean absolute value for the method Trend projection in the large size is **320.093**

Conclusion:

In the aftermath of Saudi Arabia's announcement of the 2030 vision, many industries, including the paint industry, have set goals for their companies. Jeddah Paints Factory, established in 1975, specializes in the manufacture and export of paints. The company faces challenges due to their reliance on traditional methods, leading to supply and demand issues. To address these challenges and align with the 2030 vision, researchers analyzed JPF's 5-year production and sales data and applied four quantitative forecasting methods (simple moving average, simple exponential smoothing, and trend projection regression). After evaluating the accuracy of each method, the moving average method was found to be the best choice for JPF, providing slightly more accurate forecasts than the other three methods. The error was lower in the moving average method and the MAD was 41.68 for Small size, 386.733 for Medium size, and 279.561 for the Large size. Forecasting is critical for companies as it helps them predict their future and set new goals in light of changing circumstances.

CHAPTER 3: PROBLEM DEFINATION AND REQUIREMENT ANALYSIS

Broad Problem Area:

Mobi paints was established as a medium enterprise whose target market was Sargodha and its surrounding areas. As the business flourished, Mobi paints decided to expand their business in other cities of Pakistan. This expansion came with its own constraints. Sudden expansion caused issues in fulfilling customer demands as a result of fluctuations and inability to forecast the demand. As a result of this, the company's production shifted to daily production depending upon the order input from the customer, which increases the lead time and shortage of products. The problem of not being able to keep buffer stock additionally caused a shortage of products in the market which ultimately caused a loss of customers and potential sales. The government ban on import is additionally causing a major issue as the majority of the raw material is imported, which is additionally disrupting production and increasing the cost of overall operations.

As stated, the expansion was based on the success of Mobi paints in Sargodha, which initially was successful, however, later started to create obstacles as the demand started to increase, Mobi paints were not able to fulfill that demand as a result of inventory related issues like forecasting demand, safety/buffer stock.

Mobi Paints started their business in Sargodha and its surrounding areas, as the business grew, Mobi paints started operating in the major cities of Punjab. Mobi Paints operate through warehouses in all the cities, which are supplied by the main production plant in Sargodha. in terms of inventory management, each warehouse has the responsibility to forecast demand based on previous data as well as predict a specific number of safety stock which will be used in case of any anomaly. However, as a result of inability to do that, Mobi paints are facing problems which are affecting the business.

Hence, it stands to reason that the sudden expansion by Mobi paints led to decrease in high quality customer experience and satisfaction because their operations were affected adversely. Although Mobi paints consider themselves to be the kind of manufacturer that is very responsive to consumer's needs and demands, the rapid expansion led to several issues including stock out and slow-moving inventory.

Furthermore, there has been an increase in demand fluctuations in different cities and in different time intervals, which makes it difficult to facilitate such demands. Customers often

faced product unavailability. This problem could have been mitigated if the expansion had been slow and planned, assessed with proper supply chain and inventory management techniques including efficient forecasting.

Inefficient Demand Forecasting:

For any organization involved in production, specifically paints, the goal is to deliver products in a quick, efficient, and responsive manner to ensure that the firm does not lose their customers. To guarantee effective execution of operations on all fronts of business, the organization among other things must ensure that the firm have proper demand forecasting algorithms to predict the demand accurately for products.

Let us ponder the negative effects of poor demand forecasting and how the implications are not only short-term, however, long-term in nature. The inability to understand customers regarding their basic needs will cause a business to lose a significant value in terms of sales, and operations and its costs.

Specific problem faced by Mobi paints:

Demand is not forecasted, and production is done according to customer order:

One of the concerns of Mobi paints is slow-moving stock and how Mobi paints are handling operations. This resulted in numerous flaws in the smooth operation of warehousing operations. The warehouse's performance is negatively impacted by the space required for stock, the expenses required to keep inventory, and the personnel involved. For Mobi Paints, general flow of product is rapid, and slow-moving stock is very small in comparison to fast moving stock. Mobi paints must address these issues in order for warehouse management to run smoothly.

Having no or little safety stock:

Another major issue that Mobi paints face is that Mobi paints do not produce any safety stock. This error is major since when the company does not produce any safety stock, customers who purchase Mobi paints might end up being dissatisfied since product is not available. With too much safety stock, however, Mobi paints risk spoilage, dead stock, and excessive storage expenses. The idea is to have just enough safety stock to avoid either of these two situations.

Error in critical thinking about Forecasted demand being same in multiple warehouses:

The present demand management strategy is one of the primary issues influencing the smooth operations of the warehouse in Mobi paint. Their present strategy is a very lean method since Mobi paints believe that the demand for each item is identical across all warehouses. This

way of defining the benchmark demand as the same for all warehouses is additionally producing inefficient management of slow-moving stock.

Items	Demand in warehouse A	Demand in warehouse B	Demand in warehouse C
Mobi Distemper, super emulsion	500 units	500 units	500 units
Mobi Enamel	250 units	250 units	250 units
Mobi fine filter Drum	370 units	370 units	370 units

The following table shows Mobi paint presume demand for each commodity is the identical throughout all warehouses. Because each location has its own specific unique requirements, it is practically impossible for the demand for every product to be the same in all of the warehouses, so Mobi paints should look for a hybrid strategy rather than focusing on the lean methodology to eliminate loss.

Governmental Regulations:

PEST Analysis:

- **Political:** Political instability has been one of the major issues faced by Pakistan based businesses. Recent ban on imports have impacted the operational aspects of Mobi paints as well. As majority of raw material for making paints is imported from different countries. So, Mobi paints have to utilize the limited number of raw materials available in Pakistan.

- **Economical:** Economic situation of Pakistan is in a bad shape. With continuous downfall of Pakistani currency against the US dollar and increasing international debts, cost of business has increased greatly which has impacted small and medium based enterprises in a negative manner. Increased prices of petroleum products have additionally become an issue.

- **Technological:** With the current economic and political situation in Pakistan, technological development has been ignored by the top officials of the country.

Technological advancement is only possible when you have a proper body of R&D in the country, which unfortunately, Pakistan does not have.

- **Social:** Social assessments are done for information like preference, consumer behavior and buying power, demand, people's values, and beliefs etc. As a result of current political and economic situation in Pakistan, paint industries have suffered a lot as a result of import ban and as a result of increased costs of basic utilities. Mobi paints are no different, as a result of these policies, demand of paint products has additionally decreased and as well as production of paints have additionally become difficult.

CHAPTER 4: DESIGN AND IMPLEMENTATION

Mobi paints requires a detailed analysis of its operations to evaluate what steps should be taken to rectify its problems. The following techniques were used for this purpose:

- Agile Supply Chain
- Demand Forecasting
- Safety Stock
- EOQ Analysis

Agile Supply Chain:

Agility, in supply chain management, for any organization, means the ability of supply chain to respond and mold its operations as quickly and efficiently as possible for different purposes inclusive of meeting changes in the current market and the ever-varying customer demand.

Furthermore, it means making supply chain processes and operations so effective and responsive, it will resist the occurrence of unforeseen setbacks along with any abnormal events that may lead to below average customer experience.

To be agile is essential for any manufacturing business in today's market conditions. It can help them reduce overall costs of supply chain, streamline supply chain processes, improve customer satisfaction, therefore, it can help the business meet market demands easily.

In case of Mobi paints, the firm have issues with inventory management and subsequently import of raw material, that is obstructed as a result of government policies. These issues often lead to mismanagement in operations, meeting customer demand, and providing customer with the good quality product.

The consumer of Mobi paints often complained about unavailability of products and long lead times. Their supply chain is not efficient in regards to meeting customer demands in different regions that is as a result of difference in demand of each product in every region. Demand and supply will, as is the case with most businesses, tend to vary according to the region, lifestyle etc.

Mobi paints can make their supply chain agile through following factors:

- Working on improvement of logistical operations of the company
- Using modern technology for automation of records and inventory
- Increasing transparency and visibility of operations

Importance of Agility for Mobi Paints:

Since Mobi paints problems lies with inventory management and no demand forecasting, it additionally affects the operations as production has to be on daily basis according to placed order, increased management costs, hence it is better for Mobi paints to use agile supply chain for following reasons:

Meeting Customer Demand Effectively:

As a result of the inability to forecast the exact demand of paint products from consumer, Mobi paints are forced to produce paints on daily basis based upon the customer orders. Which results in producing equal amount of each product, which is not viable as every region has its own demand, which causes some products to go out of stock and some are not sold for some days. This increases the overall costs for the business.

To avoid this, it is important to keep in check the consumer demand and the anticipated consumer demand and run the supply chain operations accordingly, with the logistics operations as fast, effective, and responsive as possible. This can be achieved by adapting the agile supply chain method, which does not only focus on achieving accurate supply of products in the right market, at the right time however, it helps in reducing costs in overall production and supply chain processes.

Reduced Supply Chain Costs:

By adapting the agile supply chain method, we must organize their inventory according to the customer demand. This can help Mobi paints in cutting costs like logistics and transportation costs, as when the exact demand is forecasted and known, we know when to order, how much to order and what exactly to order, which helps in reducing reordering costs, operational costs, and logistics costs.

It additionally helps in reducing other costs:

- Labor costs
- Warehouse costs
- Order fulfillment costs
- Inventory Management cost
- Shipping costs

Demand Forecasting:

As we begin with our analysis, the data of the three most selling paint products was provided by the company in question, that is Mobi paints, and the data was chosen from one random warehouse. Below we have used the data to calculate the forecasted demand for the few paint
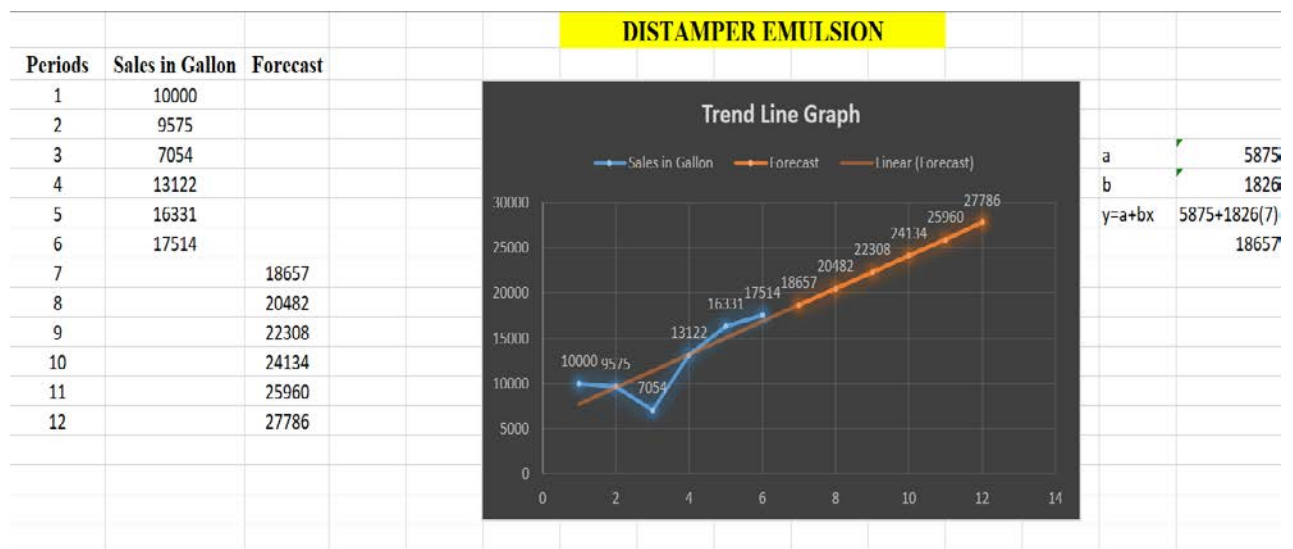
products.

To derive a trend line for the demand forecasted, we will use the linear regression model to find out the trends of the most selling items of Mobi paints. Monthly demand was used in the analysis to derive the regression equation. The model we chose was viable as the R-square values of all the products were greater than 80%, which means that the variations in the dependent were explained by the independent variable up to 80% accuracy.

The following paint products were used in the analysis and their subsequent forecasted demands and established trend lines.

Trend Line Graph and Regression Equation:
Our data was based on the sales of the three products. Trend line graphs were used to determine the upward trends in sales and predict the demand through the regression equation.
Distemper Emulsion:

Periods	Sales in Gallon	Forecast
1	10000	
2	9575	
3	7054	
4	13122	
5	16331	
6	17514	
7		18657
8		20482
9		22308
10		24134
11		25960
12		27786

DISTAMPER EMULSION

Trend Line Graph

a	5875
b	1826
y=a+bx	5875+1826(7)
	18657

Distemper, commonly known as whitewash, used in almost all of the households in Pakistan, is one of the most selling paint products of Mobi paints.

Through this data, we can observe that because distemper contributes so much to the Mobi paints revenue, it is essential to know the demand trend this item possesses, and related effect upon Mobi paints inventory.

The model we chose will calculate the linear equation, consisting of slope and intercept of the estimated data of monthly sales. The equation will give a general trend of demand for distemper Emulsion to Mobi paints. This will help the company to produce the safe forecasted numbers for distemper for the upcoming month, therefore helping them in managing inventory of raw material and finished good accordingly. The equation calculated from the graph is given below:

$$y = 5875 + 1826x$$

Let us suppose, the company wishes to know the monthly demand for the upcoming 13th month, Mobi paints can simply use the equation to produce the safe number

=5875+1826(13)

=29,613

For the following example, we came to know that Mobi paints will require **29,613** units of distemper emulsion in the next month.

MOBI Enamel:

Periods	Sales in Gallon	Forecast
1	7700	
2	7372	
3	5431	
4	10103	
5	12806	
6	13486	
7		14473
8		15899
9		17325
10		18751
11		20177
12		21603

ENAMLE

Trend Line Graph

— Sales in Gallon — Forecast — Linear (Forecast)

a	4492.6
b	1425.83
y=a+bx	4492.6+1425.8*7
	14473
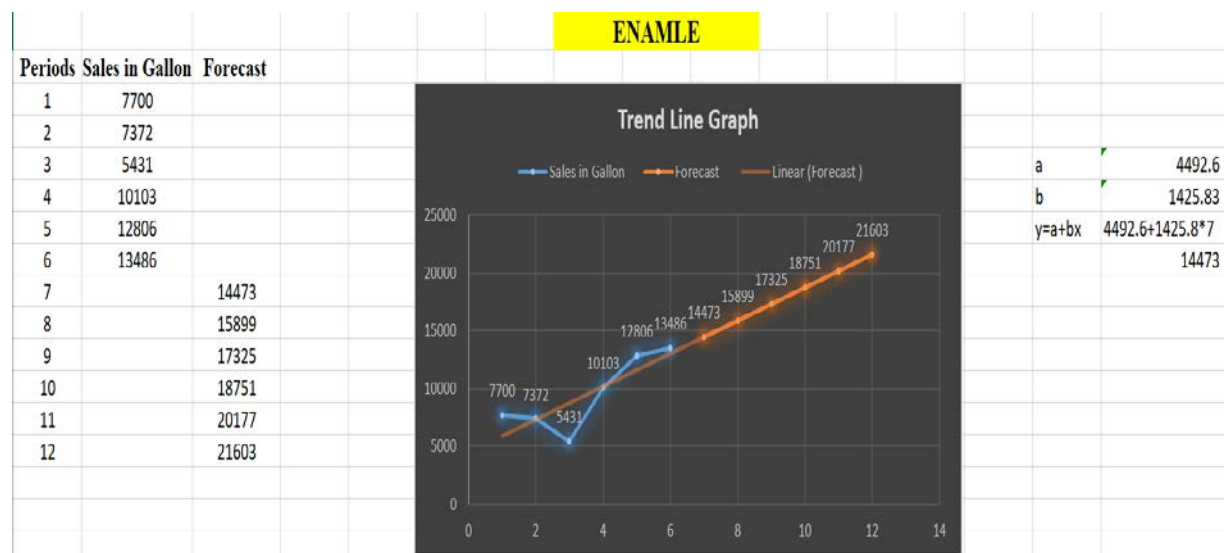
Mobi synthetic enamel is the 2nd most selling paint product of Mobi paints. it is an oil-based product and is a modern premium type of paint which additionally costs a lot more than normal ones. From production to SKUs of enamel, as a result of high inflation the costs of production and storing additionally increases. So, it is important for the company to know the exact demand of the product to stable the costs for themselves.

Following Is the trend line equation that was calculated through the graphs:

$$y = 4492.6 + 1425.8x$$

The mentioned equation can be used to calculate the demand for any upcoming month. For example, Mobi paints wants to know the forecasted demand for the **16th** month, Mobi paints can simply calculate it by:

=4492.6+1425.8(16)

=27,305

So, the forecasted demand for the 16th month is 27,305 units.

MOBI Fine Filter Drum Weather Save Shield:

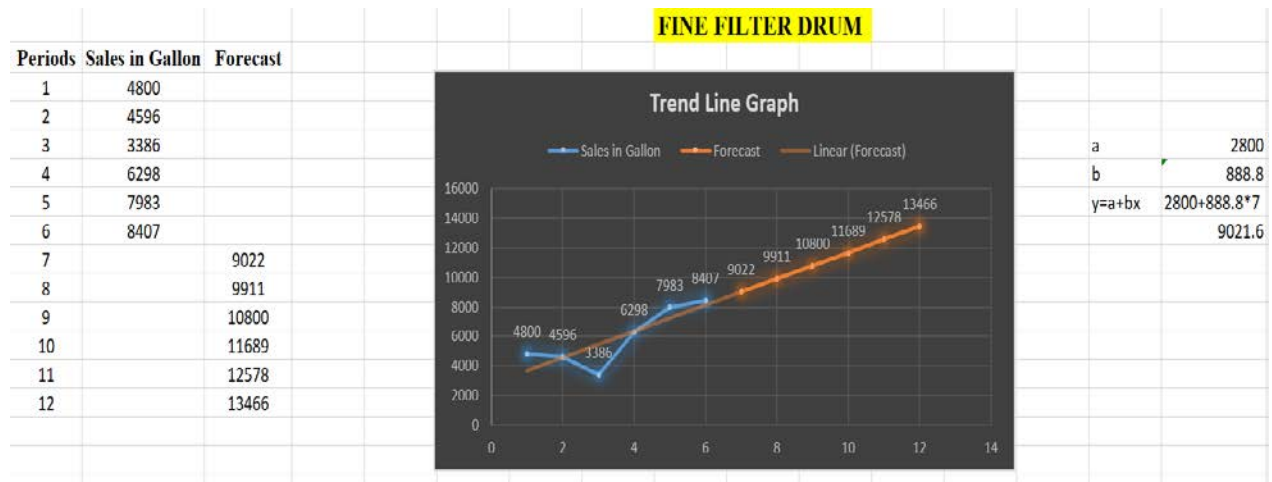| Periods	Sales in Gallon	Forecast
1	4800	
2	4596	
3	3386	
4	6298	
5	7983	
6	8407	
7		9022
8		9911
9		10800
10		11689
11		12578
12		13466

a	2800
b	888.8
y=a+bx	2800+888.8*7
	9021.6

Mobi Fine Filter Drum is one of the paints used for the protection of external walls of house. It is one of the most selling paints of Mobi Paints.

Following is the trend equation that was calculated through the graph:

$$y = 2800 + 889x$$

The mentioned equation can be used to calculate the demand for upcoming months. For example, if the company wants to know the demand of **15th** month, the equation can be simply used:

=2800+889(15)

=16,215

So, the forecasted demand for the 15th month will be 16,215 units.

Safety Stock and Service Level:

Managers are familiar with the idea of service level, especially when dealing with inventory management. It is a tool for measuring performance where specific objectives are set and expressed as percentage.

The additional stock that each firm keeps on hand in order to minimize potential future risk as much as possible is known as safety stock. While it is not always the only strategy to combat risk, safety stock is extremely important to maintain any inventory.

As a result, this is critical for Mobi paint, especially for those goods which are fast moving items means there is a high demand in the market of that product. To account for this, we used safety stocks formula:

$$= (Z) \, (\sigma) \, \sqrt{LT}$$

Were,

Z is service level.

σ is standard deviation.

LT is lead time.

This equation define that how much service level should be maintained so that we are able to determine the order without running out of stock.

The 98% service level was set up to demonstrate what Mobi paint could accomplish if its inventory control and general warehouse operations were made more effective. Especially for certain products that are fast moving, a 98% service level will guarantee that paint is always available and never goes to scarcity.

SAFETY STOCK AND SERVICE LEVEL FOR DISTAMPER:

DATA:		
	AD for service level	6135
	Standard deviation	3749
	Service level	98%
	Lead time supllier	2 days
	Z	2.04
	Safety stock	(Z)(σ)(√LT)
		(2.04)(3749)(√2)
		10816
	SERVICE LEVEL	(LT)(D)+(Z)(σ)(√LT)
		(2)(6135)+(2.04)(3749)(√2)
		23085

Mobi Paint must have 10816 units of distemper as safety stock on hand in order to maintain a 98% service level. Doing so will prevent unpredictable stock outs and ongoing shortages.

SAFETY STOCK AND SERVICE LEVEL FOR ENAMLE:

DATA:		
	AD for service level	4743
	Standard deviation	2930
	Service level	98%
	Z	2.04
	LT supplier	2
	Safety Stock	$(Z)(\sigma)(\sqrt{LT})$
		$(2.04)(2930)(\sqrt{2})$
		8453

Mobi Paint must have 8453 units of distemper as safety stock on hand in order to maintain a 98% service level. Doing so will prevent unpredictable stock outs and ongoing shortages.

SAFETY STOCK AND SERVICE LEVEL FOR FINE FILTER DRUM:

Data:		
	AD for service level	2958
	Standard Deviation	1826
	SERVICE LEVEL	98%
	Z	2.04
	LT	2
	SAFETY STOCK	$(Z)(\sigma)(\sqrt{LT})$
		$(2.04)(1826)(\sqrt{2})$
		5268

Mobi Paint must have 5268 units of distemper as safety stock on hand in order to maintain a 98% service level. Doing so will prevent unpredictable stock outs and ongoing shortages.

CHAPTER 5: TESTING AND IMPLEMENTATION

Implementing Agility in supply chain will help Mobi paints meeting supply and demand of various products in the most efficient and effective way possible.

As we know that demand and supply of every paint product varies from person to person and region wise. Therefore, adapting agile supply chain process will assist them in responding proactively to any anomaly or unforeseen events. Moreover, this additionally proves to be a useful process in mitigating the mismatch in demand and production and supply of products considering the market changes and requirement of products in certain regions.

By opting for this, the company would additionally be able to reduce waste and stock out issues. Which have been one of the major problems faced by Mobi paints. Along with the usage of new techniques and technologies, Mobi paints can observe the trends in sales of the products and can assess which product has the most demand region wise. Furthermore, Mobi paints can additionally assess which products have minimum to no demand should be brought to warehouse in minimum amount.

Demand forecasting method was used to forecast demand of the paint products by using the data available of the most selling products of Mobi paints. For that purpose, the graphs were used, through which certain trend lines were delivered.

These trend lines of different products along with their sales data helped us with producing the linear equation for the data which is additionally known as trend line equation. Whatever value is being put in the place of 'x' will show us the sales of required month which can help us in analyzing data and the required demand.

Safety stock is an essential part of inventory which helps in mitigating stock out issues in unforeseen and unpredictable events and to manage different service level. It was calculated using the formula:

$$= (z)(\sigma)\sqrt{LT}$$

The more the service level, the more responsive supply chain must be in order to meet demand and the market changes. As this leads to more changes of inventory getting out of stock which results in inconveniences and poor feedback from the customers.

The safety stock was calculated for the standard service level of Mobi paints

CHAPTER 6: RECOMMENDATIONS

ACCURATE PRODUCTION AMOUNT THROUGH EOQ FOR DISTAMPER EMULSION:

DATA:	
Annual demand	11615
Ordering cost	50000
Holding cost	174
E.O. Q	=√2*Demand*Ordering Cost/Holding Cost
	=2584
ROP	=(LT) (E.O.Q)
	=2*2548
	=5096

Therefore, the economic order point for DISTAMPER is 2584, as shown in the table. This is the smallest batch of units we can order to keep our costs as low as possible. Additionally, in order to keep up with demand, we must reload the product when our inventory falls to 5096.

EOQ FOR ENAMLE:

DATA:	
ANNUAL Demand	9024
Ordering Cost	50000
Holding cost	150
EOQ	=√2*Demand*Ordering Cost/Holding Cost
	=2453
ROP	=(LT)(EOQ)
	= (2) (2453)
	=4906

Therefore, the economic order point for ENAMLE is 2453, as shown in the table. This is the smallest batch of units we can order to keep our costs as low as possible. Additionally, in order to keep up with demand, we must reload the product when our inventory falls to 4906.

EOQ FOR FINE FILTER DRUM:

DATA:	
Annual Demand	5627
Ordering cost	50000
Holding cost	125
EOQ	=√2*Demand*Ordering Cost/Holding Cost
	=2122
ROP	=(LT)(EOQ)
	= (2) (2122)
	=4244

Therefore, the economic order point for FINE FILTER DRUM is 2122, as shown in the table. This is the smallest batch of units we can order to keep our costs as low as possible. Additionally, in order to keep up with demand, we must reload the product when our inventory falls to 4244.

Better Inventory Management System:
MOBI paints should have a superior inventory management system that allows them to anticipate efficiently, measure inventory levels, and even place PO. Spending in an effective inventory management system will additionally aid in stock tracking and will provide transparency. Inventory tools and ideas such as LIFO, FIFO become even more accessible.

Preventing Pilferage and other Damages to Stock:
First, to minimize theft and fraud and loss, every staff must be adequately trained in managing fragile stock. When Mobi Paints gets stock, it may not transfer stock immediately to a rack before documenting it in their databases; in fact, warehouse staff are occasionally unconcerned about them as a result of non-seriousness or lack of proper work ethics.

Employees log stock when the firm gets it and do not securely store the stock. As a result, demand gaps occur because MOBI Paints' inventory management system believes the item is available when it may not be.

To avoid inefficiency and possible bottlenecks, Mobi paints should increase the participation of managers and team leads who will act as supervisors. As a result, the staff will be aware that he staff are being monitored. Mobi paints can further educate staff on corporate rules regarding theft, sloppy inventory management, and possible waste reduction.

Finally, Mobi paints should strengthen leadership transparency, have increased security measures in place such as Surveillance cameras throughout the warehouse, limit employee access to inventory, and deal with any fraud as quickly as possible according to the company rules and regulations.

MADSS SCM:

To thrive in today's competitive business climate, a company must employ cutting-edge technology to meet expanding customer demands, evaluate firm performance, and obtain up-to-the-minute information from suppliers and distributors. The rising usage of enterprise resource planning (ERP) and sophisticated planning and optimization technologies has been enabled by the Internet. The capacity to collect real-time information and access to massive computer systems enables businesses to create complex supply chain systems that can be used to make real-time decisions. Such systems are adaptive in nature, providing optimal solutions to minimize risk, optimize profitability, and establish strong customer relationships. The scope of business information systems in third world countries like Pakistan is limited to Management Information Systems (MIS) only because of multiple factors and to tackle this the proposed model of the internet-based systems has been named multi-Agent based Decision Support System for Supply Chain Management (MADSS SCM). This system helps to manage demand planning and forecasting, inventory management system, transportation management systems, procurement planning and management systems and supplier relationship management system.

Demand Planning and Forecasting System:

After planning facility location and distribution network, the next step is to forecast customer overall demand. For this purpose, a decision support model named Demand Planning and Forecasting System has been designed. It focuses on two major sub-modules, demand planning and aggregate planning. Demand planning focuses on forecasting customer demand over a set forecast horizon, that is, the time allocated for the forecast. Based on the forecasted

demand of consumer, aggregate plans are made which is actually a division of demand forecast into selected time spans like a month, week, day or number of days specified.

Demand planning considers four types of techniques to forecast demand ahead of time; qualitative, time-series, causal and simulation models. The choice of forecasting technique and forecast horizon depends upon the level of uncertainty in the market. This uncertainty can be figured out by carrying out an analysis of current sales and observed demand of a product or all products in aggregate. The sales and demand data is captured by transaction processing systems and the averages and aggregates are calculated in MIS system. Transaction processing system (TPS) and Management Information System (MIS) data both are used by the decision support model to obtain results.

Seasonal factors, are critical while making demand forecast. Such information is provided usually by sales history, customer feedback and latest trends in product demand captured through internet. A standard deviation of inbound demand and supply order allocations is measured by the ratio of fluctuation to order variability. A bullwhip effect may exist if there is a ratio that is lower to 1. What-if analysis in this system can cater for queries such as impact of change in price of substitute on sales, impact of increased demand variability on executed forecast plan and other custom hypothesis generated by user. Planned price discount model evaluates the effect of discounts offered on demand of product as well as calculating expected net income as a result of offered discounts. It additionally enlists options for discounting rates to be offered on different products.

Forecasting method selection model evaluates, on the basis of demand fluctuations, order variations, market trends and seasonal factors, as to which model among the four discussed earlier will be the best selection for forecasting demand for selected period.

The decision support model effectively develops a demand forecast after analyzing all the above models according to the set forecast horizon. The system additionally determines the optimal forecast horizon after internal and external data analysis. The forecast model selection additionally influences the span of forecast horizon best suitable for demand forecasting. A relatively smaller decision model is to evaluate the frequency of forecast during a given period. If the rate of change in forecast is high, it means the demand forecast is deviating rapidly from the forecast plan initially set for that period and assumes the initial forecast plan being unsuccessful. Another way of evaluating effectiveness of the initial forecast plan is to evaluate demand variability in comparison with order variability. This model evaluates standard deviation and in case of presence of bullwhip effect, it suggests changes in forecast plans in order to remove these effects from overall supply chain.

After demand forecasts is developed, it is time to execute these forecast. Execution of forecasts typically refer to aggregate plans which is a division of demand forecast in quarterly, bimonthly, monthly, weekly or even daily demand forecasts. This model additionally caters for the seasonal factors and change in price of substitutes. Aggregate plan execution reports typically involve demand of each product, sales and purchase forecasting based on overall aggregate plan of product demand. The purpose of this model is to predict such forecasts. However, practical implementation may vary after execution of sales and purchasing processes from time to time.

Inventory Management System:

The purpose of decision support model for Inventory Management System (IMS) is to help senior level managers or executives decide optimal levels of inventory, as well as tracking inventory levels and purchase requisitions sent to procurement department. For a manufacturing firm, inventory and production processes are interdependent in terms of capacity planning of inventories, maximum production level which can be compensated by inventories, as well as calculation of cost of goods manufactured.

The proposed IMS model contains data of raw, semi-finished as well as finished goods inventories. Although the location of inventory storage may be different, the data is kept as one unit which is logically divided into data of raw material, data of semi-finished material and data of finished goods inventories. The TPS data needed for successful execution of IMS decision model includes the recorded current capacity of inventory, daily stock in and stock out, categorization and sub-categorization of an item, store keeping units' data, issuance of raw and semi-finished material, the quality result of raw material inventory tested, purchase request data and its status.

MIS data calculated from raw TPS data is useful in further calculations for decision-making. Another important aspect here is identification of seasonal factors. During peak seasons, the safety inventory will be increased in order to increase responsiveness in the overall supply chain while in off seasons, the safety inventory goes down to quite an extent. Customer feedback is evaluated regarding availability of products in the market. The customer, as viewed by the decision support system, could be any distributor, retailer, or end-chain consumer themselves.

On the basis of TPS, MIS, customer feedback and external data, the decision support model determines the optimal amount of safety inventory needed, re-order levels or replenishment levels of inventory, amount of seasonal inventory, amount of cycle inventory, size of batch in

a lot, maximum needed capacity of an inventory or SKU and maximum storage levels. IMS automatically processes stock issuance reports, tracks batches of lots deliverables by tracking products with the same lot number, tracks the usage of raw material by production department, and on the basis of the usage of raw material, it generates purchase requisitions to procurement department in order to purchase raw materials from suppliers. These purchase requisitions can then be tracked from the point of initiation of purchase request to the point of delivery of raw materials.

Transportation Management System (TMS):

The transportation management system is an information-rich system which not only plans transportation facilities and routing however it additionally provides minute-to-minute information of the transportation facilities to other modules of the entire system like facility planning and network design system, sale and customer support system, procurement planning and execution system, and demand planning and forecasting system. Transportation, either owned by company or outsourced by a third party plays an important role in the overall performance of the supply chain.

Logistic departments normally calculate lead time as the time taken to transport a product to the customer. A firm naturally increases a customer's satisfaction and wins his loyalty by minimizing lead time through effective transportation management. The proposed decision support model for Transportation Management System is designed to cater for all such issues competently by incorporating responsiveness and efficiency into the entire supply chain. The transportation facilities will be using active Radio Frequency Identification (RFID) technology.

TPS data contains the enlisting of different transportation modes and their cost, for example, rail, air, truck, package carriers (involve third party logistics), water, or intermodal (use of two or more transportation modes). Other data needed by the decision model is tariff rates, available transportation facilities (e.g., trucks, water etc.), capacity of a full truck load, inbound transportation cost (cost of transportation of purchased items), outbound transportation cost (cost of transportation of items to be sold), inbound and outbound shipment sizes, and RFID primary data. Different calculated data from MIS serve as input data to Decision Support System (DSS) model which additionally includes history of transportation facility and transportation modes.

The most important type of data used by DSS model is the data derived from GIS and Global

Positioning System (GPS) systems. Geographic Information System (GIS) systems provide the routing data through analysis of transportation mediums available in the selected area, the distance to be covered by in medium to the set distribution location, the quality of transportation mediums, geographical conditions of the routes (for example, a hilly area, snowy area, deserts, plains, coastal areas etc.) as well as detection of fueling spots and pit shops within the route. Global positioning system will work with RFID technology to detect the current location of transportation facility and estimated time needed to reach destination. What-if analysis can evaluate hypothesis of the users based on information relating to transportation costs, routing, transportation modes, and transportation facilities. Transportation cost-benefit analysis compares the cost incurred in order to transport goods to consumer and the total business benefit a company gains. It additionally analyzes the effectiveness of a transportation mode and facility and suggests other ways to decrease fixed cost.

Transportation feasibility analysis determines whether it would be feasible for a firm to invest in facilities of selected mode like if a company wants shift its carrier delivery from trucks to air, the decision model evaluates feasibility of shifting over to that mode and displays graphical results to the user. Tracking through GPS system provides minute-to-minute location information to the system and calculates total processing cost. Designing a complete transportation network is another facility of the decision support model which helps the user to use simulation-based GIS technology to plot the complete transportation network based on areas where the firm sales its products as well as the areas from where it purchases its materials.

Routing management module allows a user to develop transportation routes from one place to another and from one mode to another if the selected mode of transportation is intermodal. The data is extracted from GIS system based on the selected mode of transportation. The task of GIS system here is to provide data on transportation mode's available routes, total distances, and condition of medium. A customization route is then generated by TMS decision support model based on data given by GIS system. Shipment mode selection is additionally suggested by TMS decision model on the basis of estimated costs and ease of use. Designing optimal routes is again a job of decision model in which user requirements are brought into consideration. If a user needs easiest routing instead of shortest routes, the decision support model will display options where only smooth transportation mediums are mentioned. Transportation efficiency analysis evaluates the overall performance of the transportation system with respect to cost, efficiency, and responsiveness.

Procurement Planning and Management System:

Procurement Planning and Management System is designed to efficiently utilize information system for advanced planning and execution of procurement procedures. The overall responsiveness of a supply chain truly depends on how well an organization runs its purchasing department. Since purchase departments need a lot of collaboration and information sharing with internal and external entities like inventory, production, transportation and suppliers, such systems need to be developed which ensure extensive and timely information sharing with all the other entities.

In the proposed decision support model for procurement planning and management system, the data is retrieved and sent to all systems related to above stated entities. The procurement process runs in coordination with inventory management system. The system automatically alerts inventory management system whenever a raw material reaches a re-order level. A purchase request is then generated which is communicated to procurement planning and management system. The next task of the system is to request for quotation from suppliers. Upon request of quotation, system chooses a quotation on the basis of supplier history, supplier scoring, raw material price offered by the supplier, quality of material to be delivered by the supplier and cost of material in total including shipment cost, size, tariffs, and average supply lead time.

What-if analysis can evaluate the effect of cost on selecting different suppliers, change in shipment sizes on total cost, purchasing the same material from two or more suppliers and many other hypotheses created by the user in context to transaction processing and MIS data. Supplier selection model is a complex one which takes input from supplier relationship management system in the form of supplier history, supplier scoring and supplier's primary data. The transportation management system then provides information on the expected average inbound transportation cost of each supplier based on their location and transportation mode used. The decision model enlists best candidate suppliers and the last selection is left on human beings to select one of them considering the calculated aspects as well as personal judgment. Another decision support model is the contract generation for supplier; the system evaluates duration for which a contract may remain consistent with respect to prices and delivery efficiency.

Purchase evaluation model presents graphical report of the impact of purchased material on the cost of goods manufactured and sold. It additionally compares it with other purchase

options that could be adopted in replacement which shows the effectiveness of purchase decision.

Supplier Relationship Management (SRM):

In order to select a supplier during procurement process, the system needs supplier's primary data, history, and scoring/rating. This information among other types of data is efficiently managed by the proposed Supplier Relationship Management System decision model. The primary data this system needs is supplier master data and location while MIS data include historical data of supplier e.g., lead time, frequency of purchase with a supplier, performance history etc. which acts as an input to the decision support model.

Decision support model includes supplier scoring model which takes all decision metrics and plots it to evaluate supplier's overall performance. Supplier scoring normally rates a supplier rather than monitoring its performance. Supplier performance evaluation model does this for SRM by monitoring the previous history and current performance of the supplier related to material deliveries, discounts offered by supplier, the overall duration for which the supplier has been serving, flexibility in terms and conditions by supplier (normally shown as an aggregate of terms imposed historically), supplier classification (that is, the type of material supplier have to offer), and the percentage of ordered delivered in time. The supplier selection model is included in this system as well other than procurement planning and management system just to facilitate the user.

The system additionally evaluates the overall cost of "keeping" the supplier or the opportunity cost of selecting this supplier. The same cost is evaluated in comparison with other suppliers to get what's-best analysis result. A manager can use these models to effectively maintain supplier relationships and gains attention for supplier who are most cost-effective for the firm.

Benefits of Multi-Agent Based Decision Support System (MADSS):

- MADSS is basically an internet-based ERP server system that helps manufacturers and Distributors to manage stock mgt, transportation mgt, demand analysis and projections, procurement planning mgt, and supplier relationship management.
- Its state-of-the-art tool that helps tackle multiple supply chain issues by keeping the whole supply chain ecosystem in loop and connected. The proposed system provides extensive decision support for managers and executives of the firm in order to make and implement effective strategies, search out for different options, making optimal

decisions, and monitoring performance which eventually increases profitability of the organization and supply chain as a whole.

- Using the proposed system, a company rightly chooses what to produce, for whom to produce, where to produce and how much to produce which earns a positive name for the organization.

- MADSS SCM model has the capabilities to streamline a business' processes and make the best use of available resources causing a business to run smoothly and effectively.

- The proposed model eliminates the need of physical existence of company's offices in all over the world. The internet technology combined with multi-agent processing virtually removes the physical boundaries of a firm to access customers from all around the worlds.

Overall, by using MADSS, the risk factors or supply chain uncertainties are minimized and is beneficial for firms.

Limitations:

- Since MADSS SCM is a huge model which incorporates number of computers, small and medium size firms will not be able to implement the model in its true design. The firm can achieve distribution by combining multiple components into an agent while some small organization might even dispose-off self-management agents.

- Operating system platform selected for the proposed model is Windows NT/XP/Server/Vista or later versions in order to support easy creation and maintenance of agents.

- An ideal supply chain infrastructure has been followed which focuses on manufacturing firms. Minor changes will be needed to implement this model in areas where manufacturing is outsourced and only parts are assembled or re-sold to other entities.

- Scope of MADSS is limited to designing an overall model only. Functional algorithms which are required to implement models as well as programming code and software engineering part has not been described as a result of constraints.

- Efficient algorithms should be created in order to make it possible to be implemented.

CHAPTER 7: CONCLUSIONS

In order to fully understand the problems and find solutions, a thorough analysis of the current operations of one MOBI Paints warehouse was conducted, using various concepts like agility, EOQ analysis, demand forecasting methodologies, safety stock, and service levels to be maintained. Recommendations were then made to ensure the operations ran smoothly and to mitigate the said problems.

The warehousing issues that currently exist across the company's entire network of warehouses can be reduced if MOBI Paints applies these tools and techniques to the rest of its storage facilities and their inventories, along with carrying out a thorough pilot programmed initially, monitoring the progress, and making changes accordingly.

The suggestions provided at the conclusion will not only assist MOBI Paints in managing their stock operations in a more efficient and productive way, as well as ensure that similar difficulties do not arise in the future in order to stop the ongoing problems from occurring repeatedly.

As a result, potential consumers will additionally enjoy a great shopping experience. This will additionally break the loop in which customers used to give bad reviews and harm the reputation of the business as a whole as a result of inventory shortages and stock outs.

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