CHAPTER-1

INTRODUCTION

1.1 Operations Research

Operations research is a discipline to apply advance analytical techniques for good decision making. In operations research, various alternatives are generated and the best possible alternative is chosen amongst them. It is all about good decision making. In practice, in the practical scenario mathematical model of the system or problem is formulated. After that analysis is done using various mathematical techniques. Algorithms and computer programs are now applied for finding the optimal solutions. These models do better job. In real business situations, for instance, planning and scheduling of industrial manufacturing, schedules of railways and airlines, logistics activities, management of inventories, supply chain management etc., these models add value to the operations. The application software does not run accurately without a proper mathematical model which clearly simulates the real situation and provides correct and accurate data.

In these models I have used the methods and scientific techniques to make the applications work correctly. The various applications are chosen for optimal and effective management of the supply chain. It
includes various scenarios for future applications and related work in managing business.

Operations research give specific solutions to specific problems in the real practical world. It has scientific methods for doing them and now also in the world of information technology different tools are also available to accurately solve the given problems. It can also design problem solving models. The various implementation systems are also developed for successfully implementing the available system. It can further perform the work of maintenance of these models under dynamic conditions. It also attempts to identify and predict the problems before hand.

By using techniques such as mathematical modeling to analyze complex situations, operations research gives executives the power to make more effective decisions and build more productive systems. Operation research has enhanced organizations and experiences all around us.

When the businesses are planned, organized and controlled, operations research play a key role by using analytical techniques and various simulation modeling techniques, computer algorithms and other scientific tools.
Due to the inherent complexities of the large business enterprises, it is imperative to efficiently utilize the resources of the firm. The various important resources are land, capital, money, manpower, machines, equipments, lubricants, spare parts etc. Operations research experts and analysts apply these tools and techniques to better coordinate and control these resources and achieve the stipulated goals of the organization.

The experts and analysts are part of the top management of business organization and play an important role in planning, organizing, forecasting, and controlling the numerous activities of the firm. They are also involved in scheduling, allocation of resources, designing various operational facilities, price fixing, managing databases, coordinating logistics, and distribution systems. They are behind the success of entire supply chain management.

**BUSINESS MODEL**

- An organization chooses a business model that is aligned with their strategy. By a business model the way of operation is meant in this case, also referred to as basic structures. The four most important defined basic structures are as:

- Make-to-stock. In this structure, products are manufactured, regardless of any order placed by a client. It is even possible that products are produced, but there is no demand at all. In this
structure the pressure is on the sales department when the demand drops. Paperclip manufacturers are an example of a make to stock environment.

- **Deliver-from-stock.** The deliver from stock variant looks similar to the make-to-stock structure. However in this case the assortment is much bigger and products are not being manufactured first. This structure is usually found at a wholesaler or retailer: a builder's merchant for example has this structure.

- **Assemble-to-order.** Some manufacturing companies only assemble. They combine different components based on the desired configuration of the client. Using a limited number of components, they are able to produce various different end-products. Dell computers for example offer various components where the clients are able to pick from; accordingly their combination of components will be assembled.

- **Make-to-order.** A make to order structure is most common for products that have to be tailored to the consumers’ desires. In this case products are only produced on demand. Building a luxuries yacht is a make-to-order example. Variations to this list exist few authors also mentioned a fifth structure called ‘purchase and make to order’. This is an even more specific case of the make-to-order structure. The order in which the above four structures are
presented also represent their rank in relation to the amount of influence a customer has. In case of the make-to-stock structure, the interaction with the client takes place at the end of the production process. The client also has no influence during the production process, whereas in the make-to-order structure the client is already being involved at the beginning of the production process. The point in the process at which the client gets influence is called the decoupling point or Push/Pull-boundary.

The basic structure is very defining for the amount of stock that is kept. In case of make-to-order for example materials cannot be held in stock very easily, because the materials required depend heavily on the order that is placed by the client. If in the ideal situation the required materials are delivered precisely at the moment when they are required, no stocks will exist. This principle is called Just-In-Time (JIT) delivery. Using JIT, the make-to-order structure could in theory thus do without any inventories, if all materials and (sub) components are delivered perfectly in time.

The JIT principle aims to eliminate all unnecessary materials from the production process. This can only be achieved when all materials are handled at a specific station and it is possible to pass them on immediately after they are finished at that station. The principle of JIT is
to have items when they are needed and not have those when they are not needed. When this theory is carried through consequently there will be no stocks at all. The basic structure may however sometimes dictate otherwise. For example the make-to-stock structure by definition always contains a stock in the end, although during and before production there does not need to be any stock. Keeping stock as small as possible is often desired, because this reduces costs and risks.

1.2 Inventory

It is important for the organizations for managing the available resources & use them optimally. The various resources are land, labor, money, machine, equipments etc. Information is also a very useful and effective resource in the current market business scenario. Competing with other companies become easier. If these available resources are managed properly and utilized optimally.

Different perspectives on inventory management also cause the ideal stock levels to be ambiguous. From a sales perspective high service levels are important. The sales department wants to offer their clients the best service. Running out of stock is thus not desirable, and therefore seen from this perspective, high safety stocks seem a perfect solution and not a problem. The management on the other hand needs to satisfy several different objectives: where customer service is being just one of them.
Management often wants to reduce costs as much as possible in order to generate more profit or be more competitive. Maintaining large inventories costs money and consumes working capital that can also be applied for other means.

Additionally an inventory manager also has another perspective on the matter. The inventory manager responsible for purchasing raw materials might for instance be evaluated by his superiors on the prices he pays for purchased goods. In that case buying large quantity is more beneficial, but additional stock might be the result. From his own perspective he might judge that the purchases are done perfectly, but the stock levels might become too high and in the end cost more money. There will always be tensions between different perspectives and therefore a universal answer to the question ‘what is the correct amount of stock?’ cannot be given.

Inventory is of utmost importance for any industry. It definitely helps in providing perennial supply of goods and quality products to consumers. But stock of goods generally uses financial resources and is a costly affair. Ideally each firm should try to minimize the inventories and strive for Just-in-Time inventory system. It means that the goods should be supplied at the time needed for manufacturing and delivered the finished goods to the customers when needed by them.
India is a country of scarce resources and it is the primary responsibility of each organization, whether it is a public or private sector or a government department to ensure optimum utilization of resources for production of goods and services. Materials account for a major portion of this total cost and inventories account for the major part of the working capital. Therefore, materials management and inventory control play a critical role in the management of productivity. Supervisors can contribute towards the optimum utilization of materials and working capital management through inventory control.

Inventory is a primary part of many of today's businesses. Essentially, inventory is the storage of products that are sold to consumers to help the business make a profit. Further, in some instances, inventory also includes what the company uses to keep the business up and running.

Inventories include raw materials, component parts, work in process, finished goods, packaging and packaged materials, and general supplies. The control of inventories, vital to the financial strength of a firm, in general involves deciding at what points in the production there exists the problem which need attention. The problem of money, capital, equipments have to be looked into. The determination of economic quantities to be produced. How much quantity is to be purchased at the
lowest price and from the most competitive vendor. The recruitment and
selection of manpower is managed properly. The training programs have
to be scheduled. Generally, single item models for inventory control are
developed. They are solved using mathematical techniques called
calculus. In multi items the order quantities are dependent on each other
and enhances the complexities of the problem at hand. If the problem is
very large then it should be broken into smaller manageable segments.
Various simulation methods can be used to solve such problems.

To many small-business owners, inventory is simply the stuff they
keep on the shelves to generate sales. Despite the investment required to
maintain appropriate levels of inventory, they put little effort into
monitoring it. But ignorance about inventory can be costly. Inventory
control impacts cash flow directly.

1.3 Importance of Inventory

To be successful in the long run, every organization needs a clear
and explicit vision which is formulated by top-management. This vision
defines how the company should evolve and where it should position
itself in the market on the very long run. This vision forms the basis for
development of the strategy and objectives of the organization. The
strategy is subsequently translated to the lower levels of the organization:
examples are unit plans, budgets, and operational action plans. As
described the objectives of good inventory management are twofold: namely offering a good service level against the lowest possible costs. Measurement of performance is crucial for steering, business success and achieving the goals (e.g. like the two mentioned above for inventory management) in the end (Fawcett et al., 2007). Measuring performance is also a useful means when evaluating certain changes made to the business (e.g. an ERP implementation for example).

To make good performance measurement for inventory management possible a good technique or tool for measurement should be available. The books and journals are studied to create an overview of the most commonly used techniques available to measure performance. The following techniques are found: Key performance indicators (KPIs), Balanced scorecard (BSC), Return on investment (ROI). The other useful methods are Net present value (NPV) and Critical Success Factors (CSFs). From these methods KPIs are selected, because they are basically key to most of the other measurement techniques as well, as will be explained during the following sections. Each method is shortly discussed in each of the following sections. From these sections it also follows why KPIs are the most suitable measure to use in this case.

In small businesses, inventory management is sometimes underestimated and due weight age is not given to it. The management
fails to recognize the importance of inventory management and cannot realize the forthcoming problems which will be there due to its absence. Generally, outdated and old systems do not allow the inventory to be optimally utilized. They do not have sufficient knowledge of latest products, equipments and technology to be used in the production systems and also handling of the inventories. For better business management and informed decisions, up-to-date inventory management along with information systems should be properly used. It helps to serve their customers well and keep them satisfied. The cost of production is also minimized. It also helps to maintain the various records accurately and effectively. With this kind of efficient inventory control system, the manufacturer also knows about the latest condition of inventory. The purchase history will be at a glance. The quantities utilized, the products stolen or information about the scrap can be easily known. When the raw materials, goods or equipments is to be reordered can be known accurately and arrangements can be done accordingly. All the above discussed activities when performed well leads to higher profit margins in the business organization.

The system of inventory management gives vital information regarding the proper utilization of materials. It also coordinates the various available resources along with manpower. The customers are also
considered an important stakeholder and properly communicated about the products. The information systems also provide timely and accurate information to the production managers so that timely actions and good decisions can be taken. All the internal activities are well managed.

Getting stock appraised is particularly important if a company is being sold or stock is being cleared out. Inventory appraisal changes rapidly taking current business scenario into account. For a company with more funding and better working capital will have increased inventory appraisal. It displays both positive and negative aspects associated with assets, as well as validating the company's profit and loss statement. The appraisals are also good for displaying cash flow.

The stock is kept for continuous support for stakeholders in the supply chain. For this some optimal quantity is needed as lot of money and other resources are needed to invest in the firm. The company want to reduce the holding cost, carrying cost, ordering cost, setup cost and various other cost for overall efficiency of the supply chain and reduction in total costs. In supply chain and inventory control it is of utmost importance to consider about the time as when to order and the quantity which should be optimum, that is, how much quantity to order. It relates
to the capital invested in the inventory and have effect on the profits of the organizations.

It is a very simple concept - don't have too much stock and don't have too little. Since there can be substantial costs involved in straying above and below the optimal range, careful inventory management can make a huge difference in the profitability of a business. Although the concept is simple, the process of getting the right balance can be quite a complex and time consuming task without the right technology.

There are two main reasons why an inventory control system needs to order items some time before customers demand them. First, there is nearly always a lead-time between the ordering time and delivering time. Second, due to certain ordering costs it is often necessary to order in batches instead of units. This means that we need to look ahead and forecast the future demand. We also need to determine how uncertain the forecast is. If the forecast is more uncertain, a large safety stock is required.

1.4 Two objectives of inventory control:

The first one is for obtaining highest level of customer satisfaction in providing customer service and should avoid stock below the optimum level. Because it can lead to late delivery and orders can be backlogged.
Eventually the sales can be lost. It can lead to production bottlenecks and finally they get unsatisfied and prejudiced customers. The will decrease the profit margins of the company.

The second important goal of inventory control is to enhance the overall efficiency in manufacturing of products & reduce the cost of production. The cost of purchasing and ordering should be curtailed. The cost of giving quality service to the customers should also be reduced and customer satisfaction should be increased to the highest level possible. But caution should also be exercised to avoid over stocking or piling of excessive inventories. It leads to non functional capital investments in inventories & leads to wastages of resources especially capital resources.

The twin objectives usually have conflicts. It leads to fixed bottlenecks in manufacturing and also have higher inventory cost. The overall effectiveness is also lower. The purchasing and ordering function is not optimal in nature. Therefore inventory control becomes a challenging task for manager. He tries to control stock and various supplies in such a manner to accomplish highest level of consumer satisfaction, customer services. The manager has to strike a balance between overstocking and under stocking. He has to control the inventory cost. The cost reduction and maximization of profits should be his primary concern. The fundamental goal of the analysis of inventories in production is to specify
the time of ordering and the quantity of order. Since it also relates to vendor rating and vendor relationships. These is always a long term healthy relationships with the suppliers. It leads to suppliers relationship management. It is beneficial in the long run.

The deliveries of raw materials on time play a crucial role in the supply chain management. It leads to the profitability of the entire supply chain and helps to optimize the various processes.

1.5 Supply Chain

Supply chain management addresses the management of materials and information across the entire chain from suppliers to producers, distributors, retailers and customers. Research on supply chain management has been mainly focused on three major issues. One is the behavior of information flow. The second issue deals with inventory management. The third issue is orientated to planning and operations management. In this research the second issue, namely inventory management will be discussed.

The supply chain includes different complex activities to be performed. The various flows such as cash flow, information flow and the most important the materials flow have to be properly managed. The production can only start if the raw materials arrive at the right time from
the suppliers. In the manufacturing unit, huge capital is invested in procuring raw materials, buying equipments & machines, hiring skilled manpower, and managing huge databases. There is also high operating cost involved in the entire supply chain. The demands of the customers can only be satisfied through proper management of supply chains. It poses a great challenge for the business houses and therefore effective strategies are formulated to achieve the objectives of the firm. All these require great expertise and competent personnel having good knowledge and insights.

Key components of supply chain management include planning demand and supply, along with inventory management. From raw material to finished product, planning and managing the process is key to implementing successful supply chain management systems. Once the strategies are determined, one can learn about the forecasting and planning processes. Finally, one will discover different types of inventory management and how to maintain optimal levels of inventory across the supply chain. In other words, one will understand what is required to get the right materials to the right place, at the right time.

The entire process of supply chain management includes planning, organizing, directing, coordinating, implementing and control of supply chain processes. The processes and operations of the supply has to be so
designed that it assures that the products are properly delivered to the right customer and at the time needed by that customer. The purchasing function and procurement of raw materials, machines & equipments, lubricants, spare parts should cover all aspects, right from requisition of goods to the final delivery of the goods with expected quality to the right customer.

The production company also have processes which include procurement of raw materials, equipments etc. & then the next phase of work-in-progress inventories and finally the finished products or goods.

The current business scenario has rapidly changed. The competition is far more higher than ever before. It not only requires cheaper products or services in the market but also qualitative products and according to the taste and preferences of the consumers. To compete with the competitors the organization have to develop core competences to have competitive advantage & and to sustain in the ever changing market and reap the profits for their firms. For this, manger has to be more focused and should concentrate to optimize the processes and have innovative ideas to cater to the needs of the organization as well. The supply chain manager has to innovate and create and restructure the whole processes and operations in order to create core competency of the firm. This is the only way for the company to survive in this competitive world. These supply chain
decisions can further affect the strategic alliances management to strategic alliances with other companies. It influence the decisions for mergers and acquisitions. It helps to form strategic partners and enhance the goodwill and positioning of the company in the market.

The supply chain management also leads to value addition. The productivity definitely increases but it is the value differentials which add to the profile of the company. The competitive advantage in the market and low cost profile in total productivity gives an edge to the overall performance of the company. So due to flexible and innovative thinking which leads to value addition and customized adaptation make improved use of supply chain processes. The life cycle of the entire chain is also improvised and improved. Now a days the products are to be offered according to the taste, needs, and preferences of the consumers and cannot be forced on them. So it leads to market segmentation and good quality products with a large variety to be offered in order to satisfy the current and potential customers.

A strong supply chain is important for an existing business as is defined today. Clearly there is a shifting competitive environment, and efficiency and cost advantage are to be maintained. That's how most people would traditionally view the supply chain. But there's another element that's becoming increasingly important, and that's safety and
security. In a business a strong supply chain is needed to make sure that changing regulations and requirements for safety and security can be effectively dealt with.

1.6 Purpose of Supply Chain Management

The basic purpose and goal of supply chain management is always to obtain the benefits of vertical integration without the associated costs. In a non-integrated supply chain in an uncertain business, each stage in the process will keep a stock of goods to be able to meet an unexpected hike in demand. Hence, supply chain management definitely needs some extra concern on the part of the managers. Hence, supply chain management is the systematic, strategic coordination of the traditional business functions and the tactics across these functions within a particular company and across businesses within the supply chain for the purposes of improving the long term performances of the individual companies and the supply chain as a whole.

➤ The purpose of supply chain management is to be lean by driving out excess inventory and unnecessary costs and by reducing cycle time. Supply chains run from suppliers through to customers or stores and require process, technology and people for success. This is true regardless of the industry.
➢ To improve customer value and satisfaction.

➢ To maximize supply chain profitability.

➢ The purpose of any supply chain job is to drive value into the supply chain and/or reduce cost from it by managing it holistically. As such, an important element of supply chain interim management jobs is that they take a system-wide view of business improvement.

➢ The purpose of supply chain strategic network design problems is to configure the supply chain network as a whole, from supplier through production, warehousing and distribution facilities, down to end customers, which can be downstream subsidiaries.

1.7 Importance of Supply Chain

The importance of supply chain focus on the loss due to the absence of efficient supply chain strategy and benefit due to well managed supply chain for the business organization. Generally the question arises how good is the integration of supply chain that is beneficial for the firm. The critical importance in the business scenario is to manage competition through and with the partners. Independently and on its own it is not possible to have all the resources to compete alone with the competitors. Many challenges are there for the upstream and
downstream arrangement of getting the input, processing it into output and then pushing it to the downstream for distribution with effective chain partners.

SCM is an important and critical function of an organization having the responsibility of shipping goods. Intense teamwork is required for assuring that supply chain is working at its peak efficiency. In any supply chain management, it is required that all the functional elements work in synergy with highest efficiency. Actually it the satisfaction and value addition to the customers which is responsible for the profit for the firm. Normally the warehousing techniques, information flow, shipping and transportation systems and delivery systems create a huge difference in the overall performance of the supply chain.

In practice, the overall efficiency of supply chain will have a positive effect on the business. It is important to keep operating smoothly and in the integrated manner. Teamwork will definitely assure successful operations in the entire supply chain, right from procurement to the time of delivery to the consumers. It is further important that the same efficiency is maintained throughout the process. The delivery of goods from suppliers should be on time since any delay from suppliers will create scheduling and routing problems in the manufacturing processes. It will further affect the efficiency of the supply chain.
1.8 Objective of supply chain

The major objective of supply chain is to maximize the overall efficiency and profits of the organization. For all the supply chain the value is closely associated and correlated with the profitability of the supply chain. The higher the supply chain profitability the more successful is a supply chain. Supply chain success should be measured in terms of supply chain profitability and not in terms of the profits at an individual stage. For a sustainable supply chain, due attention must be given to all its stakeholders. Generally cost is incurred when there is flow of information, products are produced and distributed in the supply chain. Therefore, the suitable management of these flows is required for successful supply chain.

The objective for creating a supply chain is to increase competitiveness. This is because no single company is solely responsible for the competitiveness of its products in the eye of the ultimate customer; rather the supply chain as a whole, takes on shared responsibility. In order to meet consumer demands and improve competitiveness, a supply chain must overcome and eliminate organizational barriers, align strategies with one another, and speed information and financial flows.
Manufacturers were the drivers of the supply chain managing the pace at which products were manufactured and distributed. Today, customers are calling the shots and manufacturers are scrambling to meet customer demands for options, styles, features, quick order fulfillment and fast delivery. Manufacturing quality a long-time competitive differentiator is approaching parity across the board, so meeting customers' specific demands for product delivery has emerged as the next critical opportunity for competitive advantage.

Supply chain management has been both an important and a productive aim of corporations. By working to coordinate the production, shipment and delivery of the goods required to meet their business needs, companies have been able to more easily meet the demands of their customers.

Effective supply chain management solves many of the problems encountered by businesses today. First, the vendors involved in the chain will actually have a clear idea of what the buyer needs and can then adequately provide for these needs. Shorter product lifecycles and increased competition from low-cost economies are making life extremely difficult for many manufacturing and supply chain companies; now there is almost always someone who can provide the same item cheaper. The need to react quickly as market conditions change means a
flexible supply chain is essential in the battle for market share. But many companies find themselves trying to hit a moving target.

Supply chain efficiencies can also help businesses reduce the amount of floor space devoted to excess inventory and increase inventory turnover. The financial responsibility, however, should be shared with the supplier. This means closely matching supplier product deliveries to customer sale forecasts. For this to be achieved, suppliers need continual visibility into inventory needs, allowing for real-time replenishment.

If the principles of supply chain management are not adhered to, then the efficient and controlled processes cannot be achieved as desired by the company. The right products with proper quality has to be delivered properly & at the right time as desired by the customer at the right place makes the consumer happy and satisfied. It is essential for the business to run smoothly. Otherwise some other alternative course of action has to be taken by the companies. Today business cannot exist in isolation and cannot achieve its goals without team work and synergy so all the departments and all the processes have to work together with team work and it should lead to synergy. The goal of customer satisfaction can be only achieved it all the persons, processes involved in the supply chain work in tandem. The group cohesion can also help the firm to survive in the current scenario and leading to value oriented leadership in the
market. If this strategy is not followed then the result could be otherwise and will not favor the fate of the organization.

At best, supply chain strategy can be the enabler of the business strategy. If the business strategy is to be the low cost provider, the supply chain strategy should support this. And just like when developing a business strategy, one should look at core competencies, focus and means of differentiation when developing a supply chain strategy. Being able to strategically source parts at an attractive price may support both supply chain strategy and business strategy, but only if one has the capabilities to do so effectively. One might focus on a particular market or segment in which to gain supply chain efficiencies or may want to differentiate the organization operationally by providing lower costs to customers or providing services that other industry players are unable to do.

1.9 Business Environments

1.9.1 Stocking of Perishables

Most of the existing inventory models in the literature assume that items can be stored indefinitely to meet the future demands. However, certain types of commodities either deteriorate or obsolete in the course of time and hence are unstable. For example, the commonly used goods like fruits, vegetables, meat, foodstuffs, perfumes, alcohol, gasoline,
radioactive substances, photographic films, electronic components, etc., where deterioration is usually observed during their normal storage period. The inventory model is developed taking into account the deterioration rate as it has a definite impact on the system.

Inventoried goods can be broadly classified into three meta-categories based on

(a) Obsolescence,

(b) deterioration,

(c) no Obsolescence/deterioration,

Obsolescence refers to items that lose their value through time because of rapid changes of technology or the introduction of a new product by a competitor. Style goods must be sharply reduced in price or otherwise disposed off after the season is over. For example, spare parts for military aircraft are style goods and they become obsolete when a replacement model is introduced.

Deterioration refers to the damage, spoilage, dryness, vaporization, etc. of the products. The products like foodstuff, green vegetables, human blood, photographic films, etc., having a maximum usable lifetime are known as perishable products and the products like alcohol, gasoline, radioactive substances, etc having no shelf-life at all are known
as decaying products. Also, the shelf-life of some products can be indefinite and hence they would fall under the no obsolescence/deterioration category.

1.9.2 Partial Backlogging

If an item required by a customer is not currently available in the organization stores, then the customer either goes to another place (a lost customer), or alternatively, places a backorder for the item. Some organizations are either sole supplier, providing a competitive price, or offering a discount for delaying the delivery of certain items. If this is the case, an organization does not lose the sale when its inventory is depleted. Instead, the customer has to wait for his order to be filled whenever a new order arrives. Therefore, backordering or shortages are the demand that will be filled some time later than desired.

An important issue in the inventory theory is related to how to deal with the unfulfilled demands which occur during shortages or stock outs. In most of the developed models researchers assumed that the shortages are either completely backlogged or completely lost. The first case, known as backordered or backlogging case, represent a situation where the unfulfilled demand is completely back ordered. In the second case, also known as lost sale case, we assume that the unfulfilled demand is completely lost. Generally for latest fashionable products like mobile phones, cosmetics, electronic goods and also for high technology latest
and innovative products which have a fad and the product life cycle is very short, the consumers normally do not wait for the product and they purchase from the other shop or go for the substitute products offering the same features or level of satisfaction. Therefore the waiting time should be minimized otherwise backlogging will not be accepted and there will be loss of sales it would lead to loss of profits as well as to the organizations.

1.9.3 Demand

Demand of a product is the number of units taken from its inventory and can be categorized according to its size and pattern. Demand size is the quantity required to satisfy the demand for inventory. When the demand size is known, the system is referred to as deterministic and when it is not known it is called non-deterministic system. Sometimes it depends on various parameters namely time, stock, price, etc. then the system is referred to as probabilistic or stochastic. It is possible in some cases to ascertain its probability distribution.

1.9.4 Inflation

"Inflation is defined as that state of disequilibrium in which an expansion of purchasing power tends to cause or is the effect of an
increase in the price level." It is well recognized that inflation in world is on structural as well as monetary phenomenon. In the short run localized demand-supply imbalance in wage goods often due to seasonal variation in production coupled with market rigidities and regulatory failures have supported inflationary expectations that have resulted in a more widespread impact on the consumer than the initial inflationary impulse, in the medium to long run the movement and outcome of monetary aggregates demand and consequently change in price level in the economy. A small amount of inflation is often viewed as having a positive effect on the economy. One reason for this is that it is difficult to re-confer some prices, and particularly wages, downwards, so that with generally increasing prices it is easier for relative prices to adjust. Many prices are "sticky downward" and tend to sneak upward, so that efforts to achieve a zero inflation rate (a constant price level) penalize other sectors with falling prices, profits, and employment. Efforts to achieve complete price stability can also lead to deflation, which is generally viewed as a negative outcome because of the significant downward adjustments in wages and output that are associated with it. After selecting a suitable method and identifying relevant metrics for inventory management in the previous part, the knowledge that was acquired is now used to design a framework in this section. The framework represents a theoretical view on reality. In this case the framework is a combination of the business
processes identified earlier and the method applied to that. The framework is a useful tool which gives organized method of performance measurement of inventory management.

Problems at the forecasting can lead to too much stock, or too little stock according to the direction of the bias. This is also the reason why the focus in this process step is on both cost control and service level. If one would forecast too much, this causes unnecessary stocks. Forecasting too little may lead to stock-outs at the warehouse and that will affect the service level negatively. Here the dependency between operations is immediately visible. The other way around, delivery times are incorporated in the forecast to cope with the latency of delivery and in that way forecasting is influenced as well.

**Forecasting/planning: MRP (Improved planning)**

Through measuring the forecasting accuracy the improvements at this point can be made visible. According to this hypothesis, ERP software has automated MRP functionalities, which should result in better forecasts and planning: the accuracy, which compares the forecast to the actual demand a measure to evaluate how the forecasting process’ performance is improving (or worsening).

**Purchase: Vendor contracting registration**
Better vendor contracting should result in a structured way of dealing with contracts. As a consequence fewer faults can be made and therefore the ordering process is running smoother. The order lead times in this case should improve as a consequence. Also less personnel is needed because vendor contracting is fixed within the system which should reduce the amount of work (register vendors, looking up contracts and prices etc.). Also if all vendors are registered correctly and in the same way, the number of supplier-contracts can be reduced. This is because correct and centralized registration creates more insight in the active contracts and this prevents redundant activities from occurring.

**Purchase: Assign approved vendors**

The number of contracts might be reduced, because only a selected group can be used. The quality, completeness and on time delivery of orders should improve as well. Only a few vendors which proved to be reliable on the above criteria are approved and therefore these metrics should improve as well.

**Purchase: Advanced Budget control**

Because budget overrun restrictions can be build in ERP the number of budget-overruns should decrease.
Goods receipt: Three-way-match (between purchase, goods receipt and invoices)

Because the three-way-match can be performed automatically within ERP there should be fewer mistakes at this point. This improvement should yield an increased number of verification mismatches and therefore fewer personnel as a consequence, because much more can be done automatically instead of manually.

Goods receipt: Vendor Reliability monitoring

If the vendor reliability is monitored frequently and correctly there will be sufficient data about each vendor. This information can be used in price negotiations for example. Also if a vendor for instance fails to deliver good quality or quantity products, or deliveries frequently arrive too late, these failures can also be discussed and are grounded by the collected data. As a consequence vendor reliability monitoring should eventually lead to better on time delivery, less quality rejections and less incomplete orders.

Storage: Inventory turnover visibility

Within inventory control it is much easier to calculate turnover rates, because all information needed is available in real time. In theory the turnover can thus be better monitored which should result in smaller
safety stocks and therefore less overstocking. If the turnover rate is very low, there does not need to be a very large amount in stock and the average stock and number of days of inventory can be lower.

**Storage: Dead stock visibility**

This point of improvement is strongly related to the previous point. Because inventory control provides better insight in the turnover rates, it is easier to identify dead stocks. Dead stocks are actually stocks that are constantly overstocked: stock is kept that does not need to be there. Removing or lowering this stock eventually also should lower the total stock value.

### 1.10 Composition of the thesis

An integrated inventory model considering a supply chain model experiencing continuous cost decrease is studied in this thesis. The goal of the study is to determine the optimal or near-optimal economic lot sizes in order to minimize the inventory cost of the system. Chapter 1 is introductory in nature. It includes introduction to Operations Research (O.R.), meaning and functions of Inventory, objectives, importance and purpose of inventory management, various costs and terms related to
inventory, introduction to supply chain, importance, purpose and objective of supply chain.

In chapter 2, review of literature is done and many research papers are studied thoroughly.

In chapter 3, a model is developed for producing items which have linear demand by effect of decay is also considered. In this model, the deterioration is dependent on time. Furthermore, to suit the current environment, one of the parameter that is inflation is taken into account. There will be shortages and backlogging would be allowed. Far managerial usefulness & insights sensitivity analysis has been performed and numerical examples are solved.

Chapter 4 deals with inventory model consisting of two ware houses. The model is developed for decaying items. The demand rate is constant. Weibull distribution is used for the deterioration rate.

Shortages are allowed with complete backlogging. I have considered infinite planning period in this system. A numerical example is given to demonstrate the system. Sensitivity analysis supports the entire method. I believe that my study will be further beneficial to develop other inventory models with Weibull distribution function.
In chapter 5, a model for inventory system allowing partial backlogging for products having deterioration which is not instantaneous is developed. The lead time is zero. The rate of production is dependent on the demand. Weibull distribution is considered in this model. There are shortages in the system but are partially backlogged. To illustrate the system, numerical examples are provided. The sensitivity analysis is also carried out.

In chapter 6, supply chain model with Inflation and time dependent demand rate has been discussed. In this we develop an order model with time depend demand and inflation. Deterioration rate is understood to be unvarying. Shortages are allowed and in some measure backlogged The numerical example are solved to show the results. Sensitivity analysis is also performed regarding various parameters.

In chapter 7, an inventory control system with quadratic rate of demand and variable rate of demand and variable holding cost is developed. The inflation rate is not variable. Shortages are not allowed. There is immediate replenishment. The sensitivity analysis is approved for suitability and adaptability of the model. This model can be further extended to exponential rate of deterioration, probabilistic demand and price dependent demand.