

**KAUNAS UNIVERSITY OF TECHNOLOGY**  
**MECHANICAL ENGINEERING AND DESIGN FACULTY**

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**Supply Chain Optimization in Manufacturing Enterprise**

Final project for Master degree

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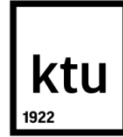
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SUPPLY CHAIN OPTIMIZATION IN MANUFACTURING ENTERPRISE

**DECLARATION OF ACADEMIC HONESTY**

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**MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT  
Study programme INDUSTRIAL ENGINEERING AND MANAGEMENT**

The final project of Master studies to gain the master qualification degree, is research or applied type project, for completion and defence of which 30 credits are assigned. The final project of the student must demonstrate the deepened and enlarged knowledge acquired in the main studies, also gained skills to formulate and solve an actual problem having limited and (or) contradictory information, independently conduct scientific or applied analysis and properly interpret data. By completing and defending the final project Master studies student must demonstrate the creativity, ability to apply fundamental knowledge, understanding of social and commercial environment, Legal Acts and financial possibilities, show the information search skills, ability to carry out the qualified analysis, use numerical methods, applied software, common information technologies and correct language, ability to formulate proper conclusions.

1. Title of the Project

Supply Chain Optimization in Manufacturing Enterprise

Approved by the Dean on 15<sup>th</sup> of May, 2015, Order No. Nr. ST17-F-11-2

2. Aim of the project

To analyse supply chain optimization peculiarities in manufacturing enterprise and enhance the performance of an existing supply chain.

3. Structure of the project

Summary, Introduction, 1. Supply chain management aspects in manufacturing enterprise, 2. Investigation of supply chain in company X 3. Supply chain optimization of company Y, Conclusions, References, and Appendixes

4. Requirements and conditions

To prepare final project according to KTU regulations and requirements.

5. This task assignment is an integral part of the final project

6. Project submission deadline: 2015 June 1st.

Given to the student Prasanth Manickkavachagam

Task Assignment received

Prasanth Manickkavachagam

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Prasanth Manickkavachagam. Supply Chain Optimization in Manufacturing Enterprise. Master of Industrial Engineering final project/ supervisor Assoc. Prof. Dr. Rasa Mankutė, Kaunas University of Technology, Faculty of Mechanical Engineering and Design, Department of Production Engineering.

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## **SUMMARY**

The main objective of this work is to analyse supply chain optimization peculiarities in Manufacturing Enterprise and enhance the performance of an existing supply chain.

Supply Chain Management, it is a concept that all organizations are keen about improvising in the modern trends. It is almost impossible for a company to survive in the market without a strong foundation earthed to Supply Chain. Companies have the urge to dwell in knowledge of how to operate sustainably with a given Supply Chain.

A thorough knowledge about what a Bull-Whip effect is and how it can be curbed by a company, is inevitably a knowledge that companies have to acquire. Companies that have been well established have an effective method to curb the Bull-Whip effect.

Management in highly organized companies, such as Company X, need to have the cutting edge of strategy and on the field training for over 20-30 years. Knowledge and financial domains have to be strong in order to establish the company over long period of time.

In the case of Company Y, the company software integrates a software that is used by all types of companies. The possibility of integrating this software to the entire Supply Chain is easy, cost effective and highly efficient. All companies which have the caliber and interest to grow can integrate a Software that Company Y integrates to optimize their supply and curb the Bull-Whip effect.

Key words:

Supply chain management, Bull-Whip effect, inventory management, logistics.

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## SANTRAUKA

Pagrindinis tikslas – išanalizuoti tiekimo grandinės valdymo optimizavimo ypatumus gamybos įmonėje ir pagerinti tiekimo srautų valdymą įmonėje.

Pirmame skyriuje “Tiekimo grandinės valdymo aspektai gamybos įmonėje” analizuojamos tiekimo grandinės valdymo problemos, neapibrėžtumo efektas, apžvelgiamos kompiuterinės sistemos, skirtos tiekimo procesams valdyti.

Antrame skyriuje “Tiekimo srautų tyrimas įmonėje X” pateikiama informacija apie įmonę, analizuojami tiekimo grandinės valdymo aspektai, kompiuterinės sistemos taikymo įmonėje problemos.

Trečiame skyriuje “Tiekimo srautų optimizavimas įmonėje Y” aprašoma ir analizuojama naujai kuriama kompiuterinė sistema, skirta gamybos srautų valdymui, pateikiami jos privalumai.

Reikšminiai žodžiai

Tiekimo grandinės valdymas, neapibrėžtumo efektas, atsargų valdymas, logistika.

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# INTRODUCTION

Supply chain encompasses the companies business activities needed to design, make, deliver, and use of product or service. Majority of the businesses survive and thrive because of supply chain. Supply chain is an art of bringing products to the market. It consists of all the stages involved in fulfilling the customer's requirements. Supply chain is a network of facilities and a distribution of procurement of materials, conversion into intermediate and final component, distribution to the customers.

The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across business within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole [1]. Supply chain management is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served. A supply chain is the global network of organizations and activities involved in [1] designing a set of goods and services and their related processes [2], transforming inputs into goods and services [3], consuming these goods and services [4] and disposing of these goods and services [2].

**Objectives:** To analyse supply chain optimization peculiarities in manufacturing enterprise and enhance the performance of an existing supply chain.

**Tasks:**

1. To understand the basics of Supply Chain management, the constituents, the critical components for optimization and to be familiar with the latest software for supply chain management and other software that are used in individual constituents of supply chain.
2. To investigate the Bull-Whip effect in the supply chain of manufacturing industries and to derive an effective solution to curb it.
3. To analyse the market need for technological software in the area of Supply Chain.
4. To integrate the ideas into a software that can create a sustainable supply chain, to analyse the implementation possibilities and integrate it for a Sustainable Supply Chain.
5. To investigate on the necessary advancements that are required in the advancements of a supply chain.

# 1. SUPPLY CHAIN MANAGEMENT ASPECTS IN MANUFACTURING ENTERPRISE

## 1.1. Characteristics of Supply Chain Management

There are Six main components that focus in Supply chain process. Depending on the type of Supply Chain, they may be explained as follows.

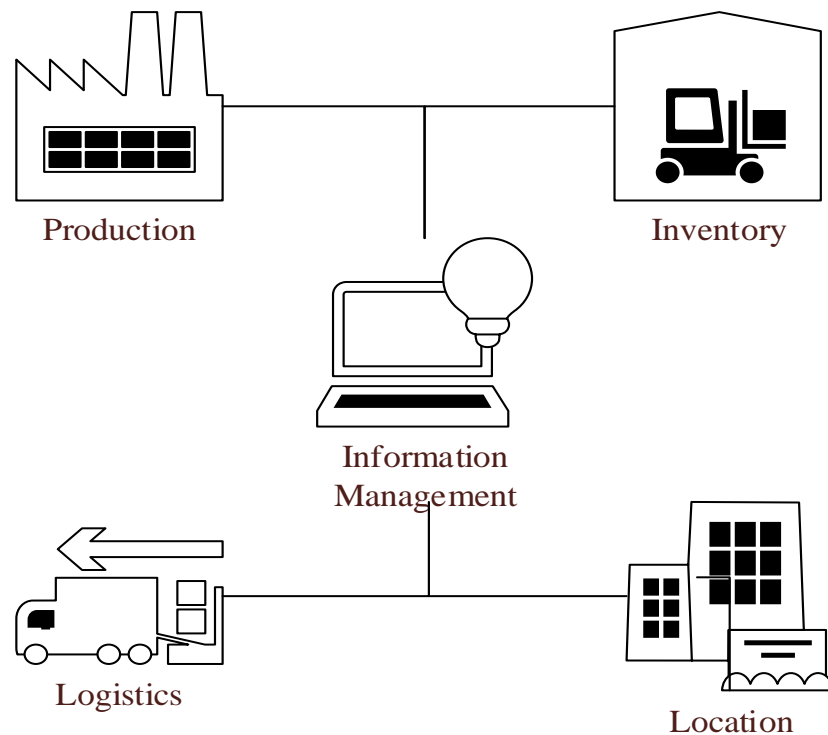


Fig 1.1 Components of Supply Chain

### 1.1.1. Inventory

Inventories are spread in every area of the supply chain. It includes any product from raw material to work in progress until the finished goods. They may be in the manufacturer or in the distributor or the retailers. No matter which part they may be in, they constitute as inventory of a supply chain.

The reason why inventory is considered to be one of the essential factors of the supply chain is because, it is considered to be one the least resale value. Stagnation in any area of the supply chain can be highly volatile for the company.

Managers, must have a strong control and knowledge of how effectively the inventory has to be managed. The technical paper revolves strongly on the essentiality of inventory management in companies. The computerization of inventory management is one of the effective tools to calibrate and reduce errors as much as possible.

### **1.1.2. Production**

A supply chain that is good is a one that involves analysing, the type of product the company wants. It is also about the quantity in which it is needed, the procedure in which it has to be produced and at what time the produce has to be produced. This activity is the key for the creation of master production schedules. The master production schedules in turn are the base to account the capacity of the plant, the balancing of the workload, the maintenance and also the quality control.

The key activity in the whole process of supply chain, is to prioritize and plan with the concern of time. The process involves developing a production schedule for a short term and to keep the work the work in progress in control. The marketing side allows the production plan to plan according to the requirements. The reason behind the market to be the initial step is because, the company can meet the customer order due dates, process the order, plan the production and operations. The effectiveness can be achieved only if the company is closely knit [3].

Inventory is spread throughout the supply chain and includes everything from raw material to work in process to finished goods that are held by the manufacturers, distributors, and retailers in a supply chain. Again, managers must decide where they want to position themselves in the trade-off between responsiveness and efficiency. Holding large amounts of inventory allows a company or an entire supply chain to be very responsive to fluctuations in customer demand. However, the creation and storage of inventory is a cost and to achieve high levels of efficiency, the cost of inventory should be kept as low as possible. In the forth coming chapters the Inventory Management as a form and how the effects of it will be given in the form of Bull-Whip Effect.

### **1.1.3. Purchasing**

Purchasing is an area of the supply chain where raw materials and auxiliary goods are bought for manufacturing. However efficient the purchasing sector of the supply chain management company is, is the profit level. Purchasing is a functional group (i.e., a formal entity on the organizational chart) as well as a functional activity (i.e., buying goods and services). The purchasing group performs many activities to ensure it delivers maximum value to the organization. Examples include supplier identification and selection, buying, negotiation and contracting, supply market research, supplier measurement and improvement, and purchasing systems development. Purchasing has been referred to as doing “the five rights”: getting the right quality, in the right quantity, at the right time, for the right price, from the right source [3].

The clear definition of purchasing is given by Elliott-Shircore and Steele [6] who stated that purchasing is the process by which a company (or other organisation) contracts with third parties to obtain goods and services required to fulfil its business objectives in the most timely and cost-effective manner [4].

### **1.1.4. Transportation**

Transportation refers to the movement of everything from raw material to finished goods between different facilities in a supply chain. In transportation the trade-off between responsiveness and efficiency is manifested in the choice of transport mode. Fast modes of transport such as airplanes are very responsive but also more costly. Slower modes such as ship and rail are very cost efficient but not as responsive. Since transportation costs can be as much as a third of the operating cost of a supply chain, decisions. It majorly involves two types of transportation (It is explained in section 2.1.4):

1. Inbound Transportation.
2. Outbound Transportation.

### **1.1.5. Location**

Location refers to the geographical siting of supply chain facilities. It also includes the decisions related to which activities should be performed in each facility. The responsiveness versus efficiency trade-off here is the decision whether to centralize activities in fewer locations to gain economies of scale and efficiency, or to decentralize activities in many locations close to customers and suppliers in order for operations to be more responsive.

When making location decisions, managers need to consider a range of factors that relate to a given location including the cost of facilities, the cost of labour, skills available in the workforce, infrastructure conditions, taxes and tariffs, and proximity to suppliers and customers. Location decisions tend to be very strategic decisions because they commit large amounts of money to long-term plans.

Location decisions have strong impacts on the cost and performance characteristics of a supply chain. Once the size, number, and location of facilities is determined, that also defines the number of possible paths through which products can flow on the way to the final customer. Location decisions reflect a company's basic strategy for building and delivering its products to market.

#### **1.1.6. Information**

Information is the basis upon which to make decisions regarding the other four supply chain drivers. It is the connection between all of the activities and operations in a supply chain. To the extent that this connection is a strong one, (i.e., the data is accurate, timely, and complete), the companies in a supply chain will each be able to make good decisions for their own operations. This will also tend to maximize the profitability of the supply chain as a whole. That is the way that stock markets or other free markets work and supply chains have many of the same dynamics as markets.

Information is used for two purposes in any supply chain:

1. *Coordinating daily activities* related to the functioning of the other four supply chain drivers: production; inventory; location; and transportation. The companies in a supply chain use available data on product supply and demand to decide on weekly production schedules, inventory levels, transportation routes, and stocking locations.

2. *Forecasting and planning* to anticipate and meet future demands. Available information is used to make tactical forecasts to guide the setting of monthly and quarterly production schedules and timetables. Information is also used for strategic forecasts to guide decisions about whether to build new facilities, enter a new market, or exit an existing market.

### **1.2. Supply Chain Optimization by Computerization of its components**

Supply Chain management simply means that effective management of all the six component of supply chain. It involves how effectively we are able to utilize the resources and manufacture components with highest profit margin. In this paper we will be discussing about

the five main management systems and how to computerize them. Computerizing a component is one of the best way to optimize a process.

### **1.2.1. Logistics management and computerization of logistics management**

Every organisation has to move materials. Manufacturers have factories that collect raw materials from suppliers and deliver finished goods to customers, retail shops have deliveries from wholesalers, a television news service collects reports from around the world and delivers them to viewers. Most of us live in towns and cities and eat food brought in from the country. When you order books from a website, a courier delivers them to your door, and when you buy a mobile phone it is from a store rather than a factory. It has probably travelled around the world to reach you. Every time you buy, rent, lease, hire or borrow something, someone has to collect it and deliver it to your door. Logistics is the function responsible for this movement.

Every organisation delivers products to its customers. Traditionally, these products are described as either goods or services. Then manufacturers like Sony, Ford and Guinness make tangible goods, while the BBC, Qantas and Vodafone provide intangible services. But this view is misleading, and it is more realistic to describe every product as a complex package that contains a mixture of both goods and service. For example, Toyota manufactures cars, but they also give services through warranties, after-sales guarantees, repairs and finance packages. McDonald's provides a combination of goods (burgers, cutlery, packaging, etc.) and services (when they prepare food, sell it and clean the restaurant). Then we can describe a product package as lying on the spectrum At one end of this spectrum are products that are predominantly goods, such as cars, domestic appliances, clothes and furniture and at the other end are products that are predominantly services, such as insurance, banking, education and telephone services. In the middle are products with a more even balance, such as Restaurant meals, hospitals and some websites.

The inputs include raw materials, components, people, equipment, information, money and other resources. Operations are the manufacturing, serving, transporting, selling, and training, and so on. The main outputs are goods and services, for instance, The Golden Lion restaurant takes inputs of food, chefs, kitchen, waiters and dining area; its operations include food preparation, cooking and serving; the main outputs are meals, service, customer satisfaction, and so on.

Figure 1.2 shows the working of logistics.

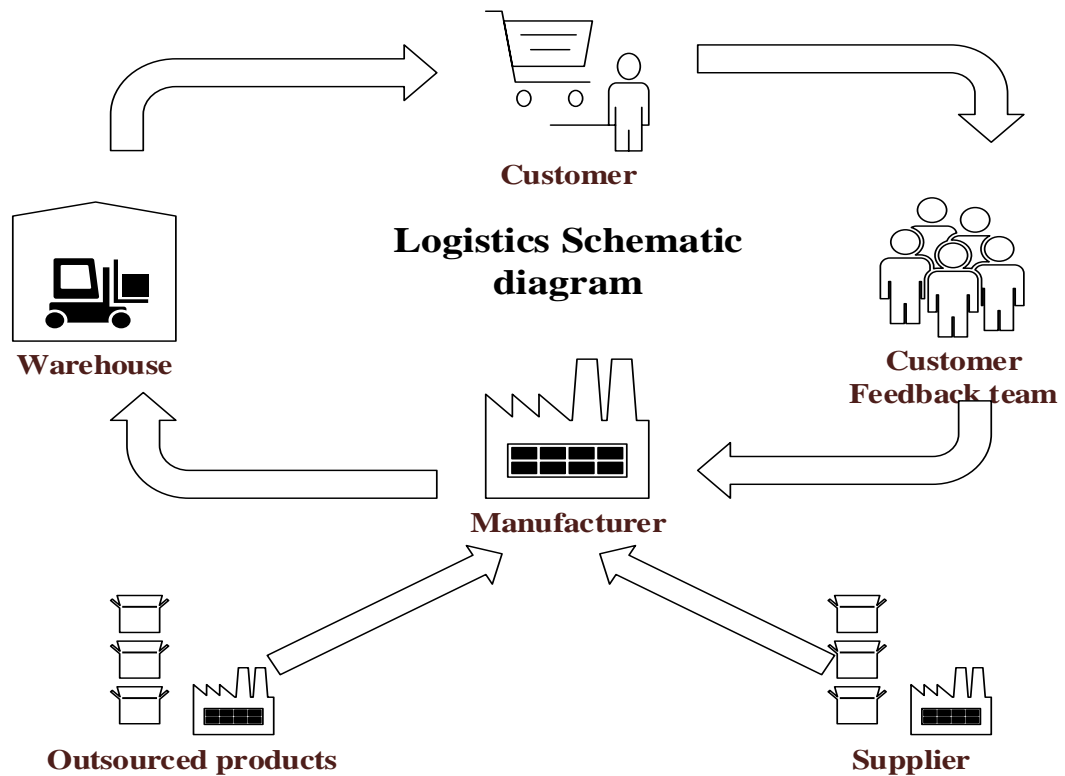


Fig 1.2. Logistics Management Scheme

### 1.2.2. Computerization of Information

An integrated supply chain is an association of customers and suppliers who work together to optimize their collective performance in the creation, distribution, and support of an end product. All supply chains are integrated to some extent by focusing and coordinating the relevant resources of each participant to optimize the overall performance of the chain. Therefore, supply chain integration is a continuous process that can be optimized when supply chain members work together to improve their relationships and when all participants are aware of key activities at all levels in the chain.

Information Technology (IT) is playing an increasingly critical role in the success or failure of the supply chain. IT ranks highly as the essential ingredient and backbone for the success of supply chain integration [23]. IT has become one of the keys to operating success. It is impossible to achieve an effective supply chain without IT. Since suppliers are located all over the world, it is essential to integrate the activities both inside and outside of an organization. This requires an integrated information system for sharing information on various value-adding activities along the supply chain [22]. As the concept of competing between supply chains grows more intense and widespread because of inevitable global competition, IT utilization has changed its role from back office and operational support to strategic imperative.

Firms have started to utilize IT to directly influence the processes of comprising the value chain [5]. Increasingly, IT is used to facilitate internal coordination within a firm and enhance external integration with external constituencies (e.g., customers and suppliers) and also to enhance decision making among supply chain members. This phenomenon is evident by the increased usage of information systems for integration purposes; for instance, information systems infrastructure (e.g., data communication tools, network connection, standard data structure, and unified coding standards), information systems software (e.g., enterprise-wide information system such as SAP), and information systems applications (e.g., centralized database management systems, Electronic data interchange (EDI), web-based or internet-based information systems). Although the advances in formation technologies are considered a key driver of supply chain integration; what is the best way to deploy these technologies and to coordinate supply chain-wide activities is still under research [6]. The information flow is shown in the Figure 1.3

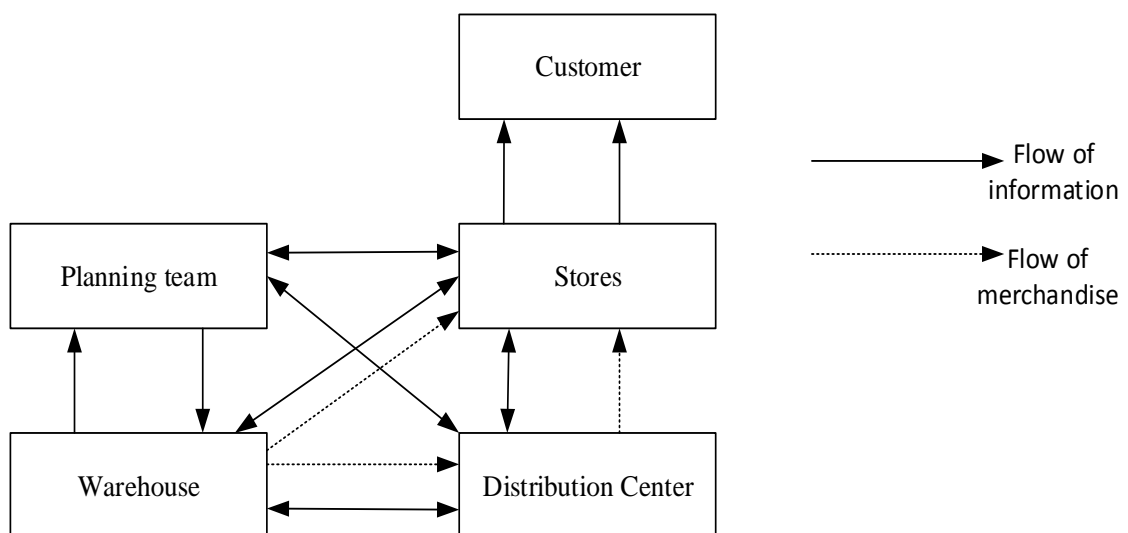


Fig 1.3 Information Integration

### 1.2.3. Computerization of Manufacturing process

The secular price decline in the real cost of computing has created vast economic incentives for employers to substitute labour for computer capital. Yet the tasks computers are able to perform ultimately depend upon the ability of a programmer to write a set of procedures or rules that appropriately direct the technology in each possible contingency. Computers will therefore be relatively productive to human labour when a problem can be specified – in the sense that the criteria for success are quantifiable and can readily be evaluated [2].



The extent of job computerisation will thus be determined by technological advances that allow engineering problems to be sufficiently specified, which sets the boundaries for the scope of computerisation.

#### 1.2.4. General Aspects of Inventory Management

Inventory management is a component that spreads over an entire enterprise. They are generally given an identification system and are tracked by using the Information Services (IS). The three areas of the Information Services, which help track the supply chain are:

- **Acquisition** are the areas, where the personnel are assisted in purchasing the software and hardware of the produces. The main purpose of acquisition is to ensure that the company follows correct needs and guidelines for finance are followed.
- **Redeployment** are procedures that are involved in ensuring the assets are assessed, and kept track of when they are moved from one location to another. The product when moved by its original owner it automatically updates in the new location, where it is being moved. The redeployment is a process, when a product is moved from one place to another, the data base at the old system is deleted and is updated automatically in the new system. There are many software which do this essential process. The major players in the market are SAP and Oracle DataBase Management. In this work the researcher has also presented a case of Inventory management in a software called as 360report.
- **Termination** it is the process that is responsible for deleting the component, when the product is being destroyed or replaced. The money shown in the inventory column is automatically erased.

The inventory system that is kept as a record in the data base of the owner and is defined in the location where the asset is placed. The importance of the existence is mentioned in the inventory record. Depending on the criteria like time frame of the existence of the produce or so the criteria is set. The planning of the companies' strategy revolves around this. The logistics department works on this plan that the inventory system provides.

The inventory management system is a database. The important element of a database is how well it is update and how often it is updated. This determines the strength of the inventory management. No matter what the inventory management is set, it is highly vital that the operating system is manned by educated professionals. Above which it would be high optimization is it is computerized. With this idea in mind dawned the inventory management system [3, 4] The Integration of inventory management is shown in Figure 1.4.

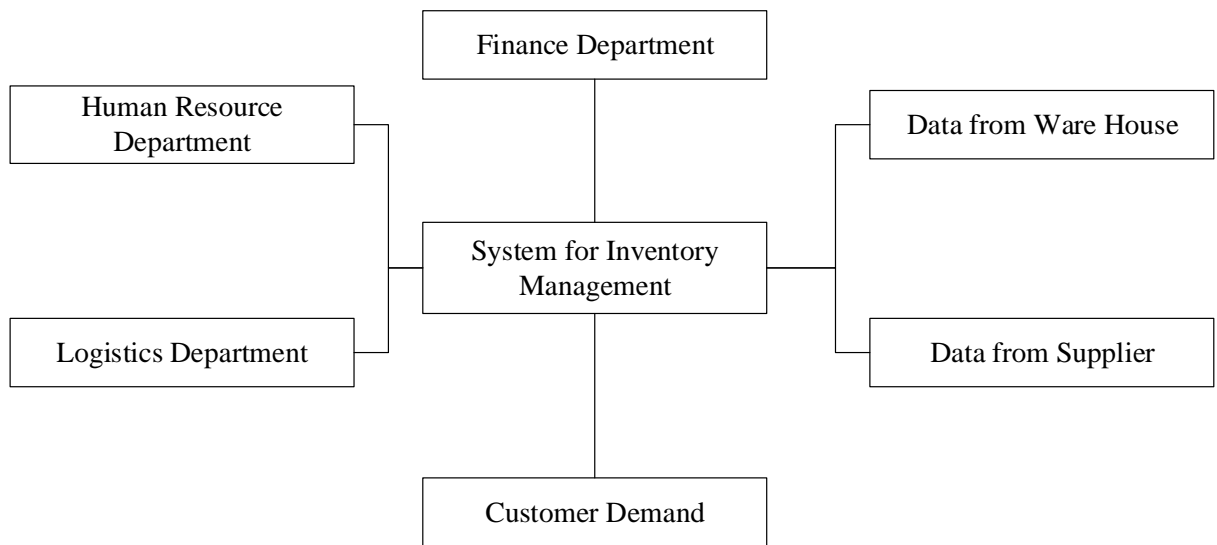


Figure 1.4 System of inventory management

### **Benefits of Computerization of Inventory**

The benefits of Computerization of Inventory are [8,9]:

1. Up-to-date information about data processing resources through the creation and archiving of records in a centralized repository.
2. Financial records specific to a single component, or groups of components.
3. Service records for all components in the inventory.
4. Data used to support configuration diagrams of the hardware and software components contained within specific locations, or the entire data processing environment.

## **1.3. Problems in the Supply Chain by the Impact of Bull-Whip Effect**

### **1.3.1. Bull-Whip effect in a manufacturing enterprise**

The literature analysis was majorly done from the technical presentations [21, 22, 23, and 24] Bull-Whip effect is the variation in the order of the company's requirements over time.

The reasons for Bull-Whip effect are given below in Figure 1.5.

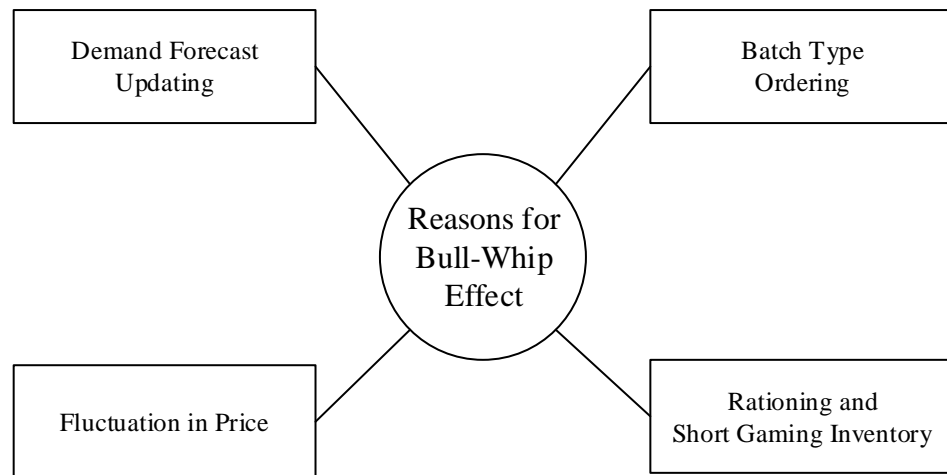


Fig 1.5 Reasons of Bull-Whip effect

Supply Chain has a numerous explanations amongst various authors. The term Supply Chain is been predominantly in various organizations at various levels. One of the Authors, La Londe and Masters proposed that a supply chain is a set of firms that pass materials forward. Normally, several independent firms are involved in manufacturing a product and placing it in the hands of the end user in a supply chain – raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies are all members of a supply chain [22]. In this the author does not mention about customers as a component in the Supply Chain. But in this another definition notes; a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer [21]. Here it clearly mentions the involvement of the customer.

In this technical paper, it focusses more on how the customer plays a major role in organizational Supply Chains and how they have a dramatic effect on the whole supply chain majorly the suppliers of the company. This effect of customers is called as the “Bull-Whip Effect”. One of the authors mentions that the Bull-Whip effect refers to the tendency of orders to increase in variation as one moves up a supply chain [22] The effect of the customer can also be when one moves down the supply chain as well. In the case a customer orders go down for a particular point of time it is clear that the demand on the market of the producers and the suppliers of the producers are influenced greatly.

In an inventory management organizational context text performed by [24]. It a “Beer Distribution Game”. This was where each player was asked to vary his inventory level and to

order as their only form of communication. Under the linear the cost structure the experiment shows the variances of orders amplify as one moves up in the supply chain confirming the Bull-Whip effect.

In the survey that was conducted by a company which manufactures and sells fast moving products for consumers. It was clear that the shipment of the product was the most fluctuating one in the company.

### **1.3.2. Reasons of Bull-Whip effect**

The reasons for Bull-Whip effect as shown in figure 1.5 is divided into four different categories

#### **Demand forecast updating**

Distortion in the information arises between the manufacturer and supplier. When there is a particular demand from the consumer, automatically the supplier updates the demands. This is not an issue when the supplier initiates this to the manufacturer in advance but when it is not made so, the manufacturer makes products in surplus or lesser than what is required. This could lead to heavy losses from the manufacturer. When the manufacturer is a start-up firm, which just has one customer at the moment, the loss becomes drastic. If the firm manufactures lesser than required, it could also lead to problems.

Procter and Gamble had a similar issue in the year 1990 with problem of extreme demand variation in the famous product- Pampers Diapers.

#### **Order batching**

In the case of manufacturing system, it is more evident that suppliers and manufacturers. It is hard for suppliers to manufacture a product for supplier's products individually. The logistics and operational cost become a hindrance for it. They are more into manufacturing a product as a batch. Instead of ordering frequently customers order in bulk for each month or week. This results in stacking up orders, if the batch is not sold. It could lead to disruption in the whole supply chain.

#### **Price Fluctuation**

It is stated that nearly 80% of the operations the organizations buy the products in advance and in bulk. In case the price of the product that the supplier gives when buying a product in advance the manufacturer provides a fair amount of discount for its customers. When there is a price fluctuation and it becomes harder to give the discount. The discounts and special

offers have to be met by the manufacturer. The typical example was Motorola was not able to supply their customer during Christmas of 1992 and 1993. This gave them a big setback in their career. Their stocks dropped down by 10%. In the case of Hewlett and Packard, they could not supply for their printer laser jet printer.

### **Rationing and Shortage gaming**

In a company they ration their products and have safety stocks to avoid problems when there is a shortage. The problem arises when the rationing and shortage of stocks are not done as per the requirement. The typical example is when a company producing nearly 100 products every day and they store a safety stock of 1%. This becomes a problem for the company in case of calamity; for instance there is a problem somewhere in the line, then it becomes difficult to compensate for that product loss. Typical example is during the Tsunami in Japan. They had a shortage of automobile in Indonesia and China. The problem was that ships were not able to reach Japan. When product demand exceeds supply, a supplier needs to ration its product to customers. Knowing that, customers may order more than they really need. Later, when there are no shortages, orders disappear. Introducing rationing methods based on past sales rather than on orders placed takes away the incentive for customers to inflate order sizes [13, 14].

### **1.3.3. Theoretical Solution for Bull-Whip effect**

Different authors have depicted the solution in different ways and the way to curb the Bull-Whip effect. Main solutions are [25, 26, and 27]:

#### **Avoid Multiple Demand Forecast Updates**

In the paper by Lee, H. L., Padmanabhan, V., & Whang, S.[25] the authors have mentioned that Ordinarily, every member of a supply chain conducts some sort of forecasting in connection with its planning (e.g., the manufacturer does the production planning, the wholesaler, the logistics planning, and so on). Bull-Whip effects are created when supply chain members process the demand input from their immediate downstream member in producing their own forecasts. Demand input from the immediate downstream member, of course, results from that member's forecasting, with input from its own downstream member.

### **Breaking Order Batches**

In the case of breaking order batches, generally when orders are placed in small and frequent orders, it can be cut down into minimum. In the case of P & G they have introduced a standard ordering terms across all the units. This simplifies a lot of processes and General Electric is electronically matching buyers and suppliers throughout the company.

### **Stabilize Prices**

The best way a prize may be stabilized, would be to reduce the Supplier discount, the simplest way to control the Bull-Whip effect caused by forward buying and diversions is to reduce both the frequency and the level of wholesale price discounting. The manufacturer can reduce the incentives for retail forward buying by establishing a uniform wholesale pricing policy. In the grocery industry, major manufacturers such as P&G, Kraft, and Pillsbury have moved to an everyday low price (EDLP) or value pricing strategy. During the past three years, P&G has reduced its list prices by 12 percent to 24 percent and aggressively slashed the promotions it offers to trade customers. In 1994, P&G reported its highest profit margins in twenty-one years and showed increases in market share. Similarly, retailers and distributors can aggressively negotiate with their suppliers to give them everyday low cost (EDLC). From 1991 to 1994, the percentage of trade deals in the total promotion budget of grocery products dropped from 50 percent to 47 percent [21] .

### **Eliminate Gaming in Shortage**

Situations when a supplier faces a shortage, instead of allocating products based on orders, it can allocate in proportion to past sales records. Customers then have no incentive to exaggerate their orders. General Motors has long used this method of allocation in cases of short supply, and other companies, such as Texas Instruments and Hewlett-Packard, are switching to it. "Gaming" during shortages peaks when customers have little information on the manufacturers' supply situation. The sharing of capacity and inventory information helps to alleviate customers' anxiety and, consequently, lessen their need to engage in gaming. But sharing capacity information is insufficient when there is a genuine shortage. Some manufacturers work with customers to place orders well in advance of the sales season. Thus they can adjust production capacity or scheduling with better knowledge of product demand. Finally, the generous return policies that manufacturers offer retailers aggravate gaming. Without a penalty, retailers will continue to exaggerate their needs and cancel orders. Not

surprisingly, some computer manufacturers are beginning to enforce more stringent cancellation policies.

We contend that the Bull-Whip effect results from rational decision making by members in the supply chain. Companies can effectively counteract the effect by thoroughly understanding its underlying causes. Industry leaders like Procter & Gamble are implementing innovative strategies that pose new challenges: integrating new information systems, defining new organizational relationships, and implementing new incentive and measurement systems[26].

#### **1.3.4. Effects of Information distortion**

The entire solution of Bull-Whip can be summarized as distortion of information system. The major reason for Bull-Whip effect is the information that is not completely being passed either moving upstream or downstream. In the technical presentation of Rachel Croson, [28,29], in the beer game conducted by the survey the results showed up without the information being shared amongst the participants. This is shown in the Figure 1.6.

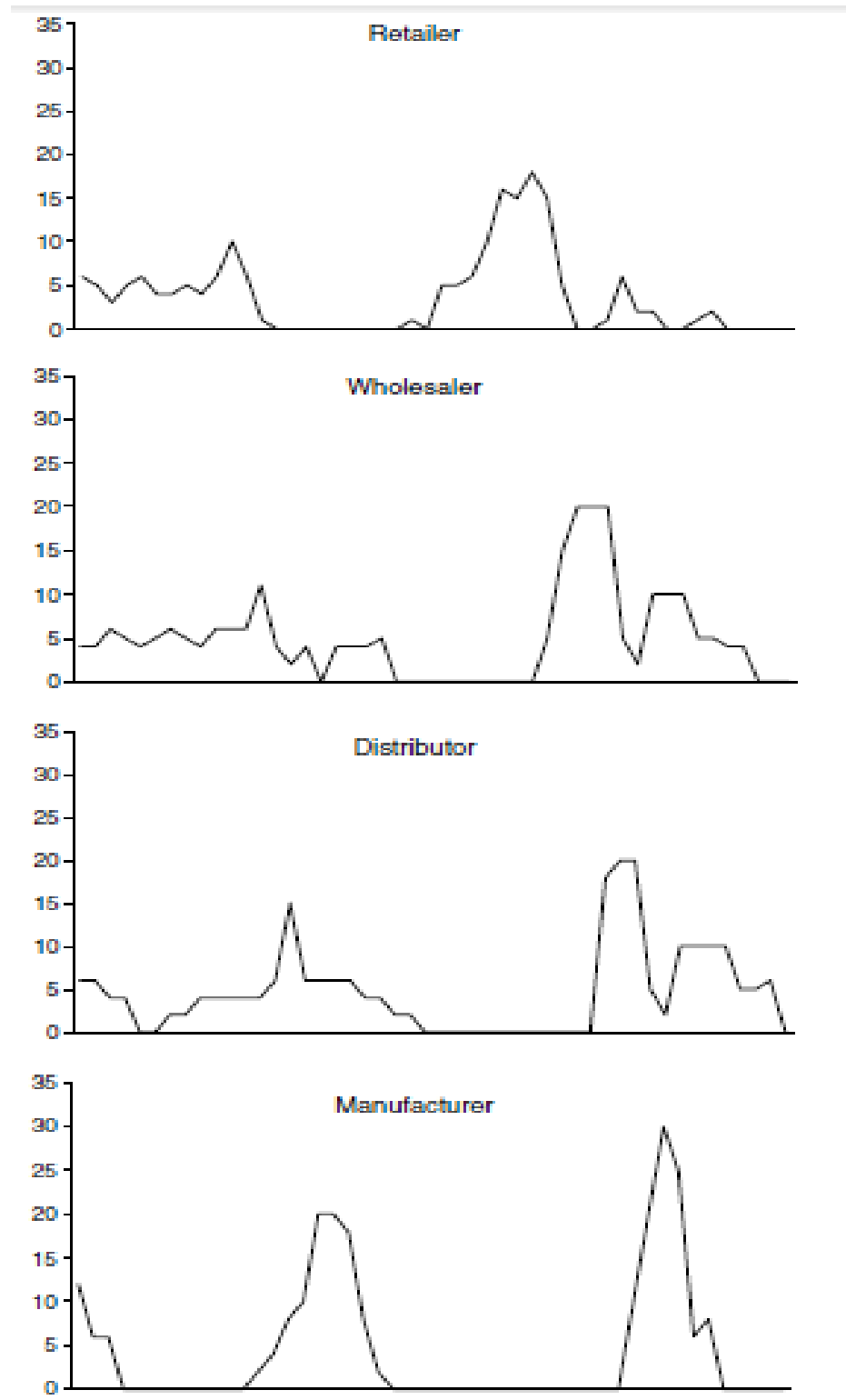


Fig 1.6 Effects of Distortion of Information in the Beer Game [29]



## 1.4. Quantifying the Bull-Whip Effect

The literature analysis was majorly done from the technical presentations [27, 29, 30, and 32]

Supply Chain has a numerous explanations amongst various authors. The term Supply Chain is been predominantly in various organizations at various levels. One of the Authors, La Londe and Masters proposed that a supply chain is a set of firms that pass materials forward. Normally, several independent firms are involved in manufacturing a product and placing it in the hands of the end user in a supply chain – raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies are all members of a supply chain [21]. In this the author does not mention about customers as a component in the Supply Chain. But in this another definition notes a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer [29] ,Here it clearly mentions the involvement of the customer.

In this technical paper, it focusses more on how the customer plays a major role in organizational Supply Chains and how they have a dramatic effect on the whole supply chain majorly the suppliers of the company. This effect of customers is called as the “Bull-Whip Effect”. One of the authors mentions that the Bull-Whip effect refers to the tendency of orders to increase in variation as one moves up a supply chain [31]. The effect of the customer can also be when one moves down the supply chain as well. In the case a customer orders go down for a particular point of time it is clear that the demand on the market of the producers and the suppliers of the producers are influenced greatly.

In an inventory management organizational context text performed by [37] it a “Beer Distribution Game”. This was where each player was asked to vary his inventory level and to order as their only form of communication. Under the linear the cost structure the experiment shows the variances of orders amplify as one moves up in the supply chain confirming the Bull-Whip effect.

In the survey that was conducted by a company which manufactures and sells fast moving products for consumers. It was clear that the shipment of the product was the most fluctuating one in the company.

Calculation of Inventory to curb the Bullwhip effect,

$$Mt = \frac{d}{1-\rho} \left\{ (L + 1) - \frac{\rho(1-\rho^{L+1})}{1+\rho} \right\} + \frac{\rho(1-\rho^{L+1})}{1+\rho} Y_t, \quad (1.1)$$

$$V = \frac{1}{(1-\rho)^2} \left\{ (1 + \rho^{L+2})^2 + \sum_{i=1}^L (1 - \rho^{L+L+3-i})^2 \right. \\ \left. + \frac{\rho^2 (1 - \rho^{L+1})^2 (1 - \rho^{L+1})^2}{(1-\rho)^2} \right\} \quad (1.2)$$

$M_t$ - Mean time

$d$ - Mean

$\rho$ - Sensitivity of Fluctuation.

$L$ - Lead time

$Y_t$ - Retailers Order Quantity

$V$ - Variance in the market

## 1.5. Analysis of Software for Supply Chain Management

There are many software that are just for specific Supply Chain functions and sometimes that can be integrated to the entire Supply Chain. The list below shows the list of companies in the market.

Comparison of Different Software's

Table 1.1

<b>No</b>	<b>Software</b>	<b>Cost</b>	<b>References (customers)</b>	<b>Languages</b>	<b>Input Style</b>
1.	Seram	8500€/Year/ user	Novartis, Swissotel, Raffles, Fairmont, FHRI hotels	English, Deutsch, Italian	Webbased
2.	SAP	3000€/Year/ user/ Module	Southern California Edison MMG Taminco Woongjin Group	All languages	Text
3.	Credit360	2000€ for the first year and beyond 25000€ and more	Phillips, Nestle, Heineken, London Stock Exchange	English, German, Spanish, Brazilian, Chinese	Webbased
4.	Enviance		Alliant Energy AECOM, American Electric Power	English	Text

5.	Clarity Systems	Depending on the number of users	Enigma, Positive, Octink, Orchard, Red Dog Imaging, Samurai Signs and Graphics	English	Text
6.	Oracle	Depends on the type of module	DOW, Lenovo, Saint Gobain.	Customer designed	Webbased
7.	BroadVantage.inc	22488€/Year basic	Canada Post, Del Monte, TVA, Hyatt Hotels, International Paper, Qwest, Duke Foundation, Northwest Airlines, Suncor Energy, TransCanada.	English, Chinese, Japanese, German and language as required by the customer.	Database, Keyboard, Question
8.	Tofuture	25000€ for all Functionality	Wartsila, Ahlstorm, Tamro	English, German, Finish	
9.	360report	2000€ per user	Etventure, FAI, E-On, Greenpeace Energy	English, German, Dutch	Webbased

## 2. INVESTIGATION OF SUPPLY CHAIN IN COMPANY X

Company X has approximately over 128 000 employees in 315 manufacturing units and 82 product development sectors.

In the year 2012 they were the largest automobile parts manufacturing unit in North America. They have been the largest company in Canada. This unit that the candidate has analysed was one of its branches in Chennai, India.

They are located in over 29 countries and they are potential suppliers for leading car manufacturers like Lamborghini, Benz, Toyota, Nissan and similar companies. They also supply raw materials to many other companies like Hyundai.

The strategy in which they operate are based on the equality to all. They treat all their customers irrespective of the type of order the place. They have a very strong Supply Chain and they are aware of the Bull-Whip effect.

The general view of manufacturing department is presented in Figure 2.1, schematic diagram of supply chain in company – in Figure 2.2.



Fig. 2.1 manufacturing department in company X [29]

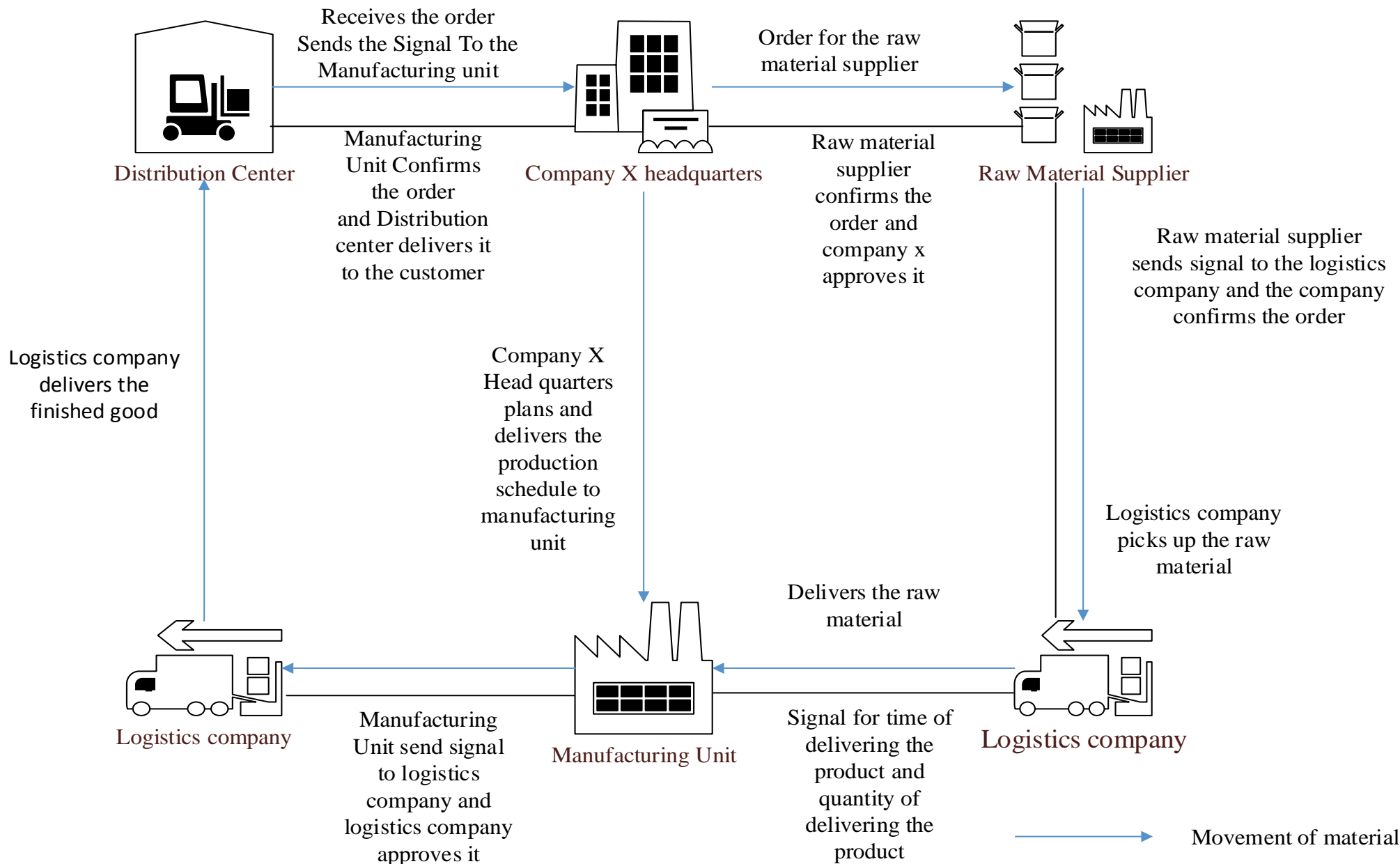


Fig 2.2. Supply Chain of Company X

## 2.1. Supply Chain Optimization strategies used to curb the Bull-Whip Effect

The supply chain of Company X is very strong and they use a large variety of unique strategies for curbing the Bull-Whip effect. Investigation of Supply Chain situation in company X reveals the four main strategies, necessary to apply to curb the Bull-Whip effect (Figure 2.3). The safety of the working personnel is the top priority in Company X. All working personal have to wear necessary protective equipment like goggles, safety shoes and helmets when they are entering the production area.

This knowledge of the company X automotive private limited, clearly was tuned towards the problem. The problem was that the inventory was available throughout the Supply Chain. The entire Supply Chain was clearly aware of what they were having in stock. The supply chain had the knowledge and whereabouts of their inventories.

When there was a procurement order early in the morning, the company was able to deliver the product in time and inventory did not store in the company for more than 7 days.

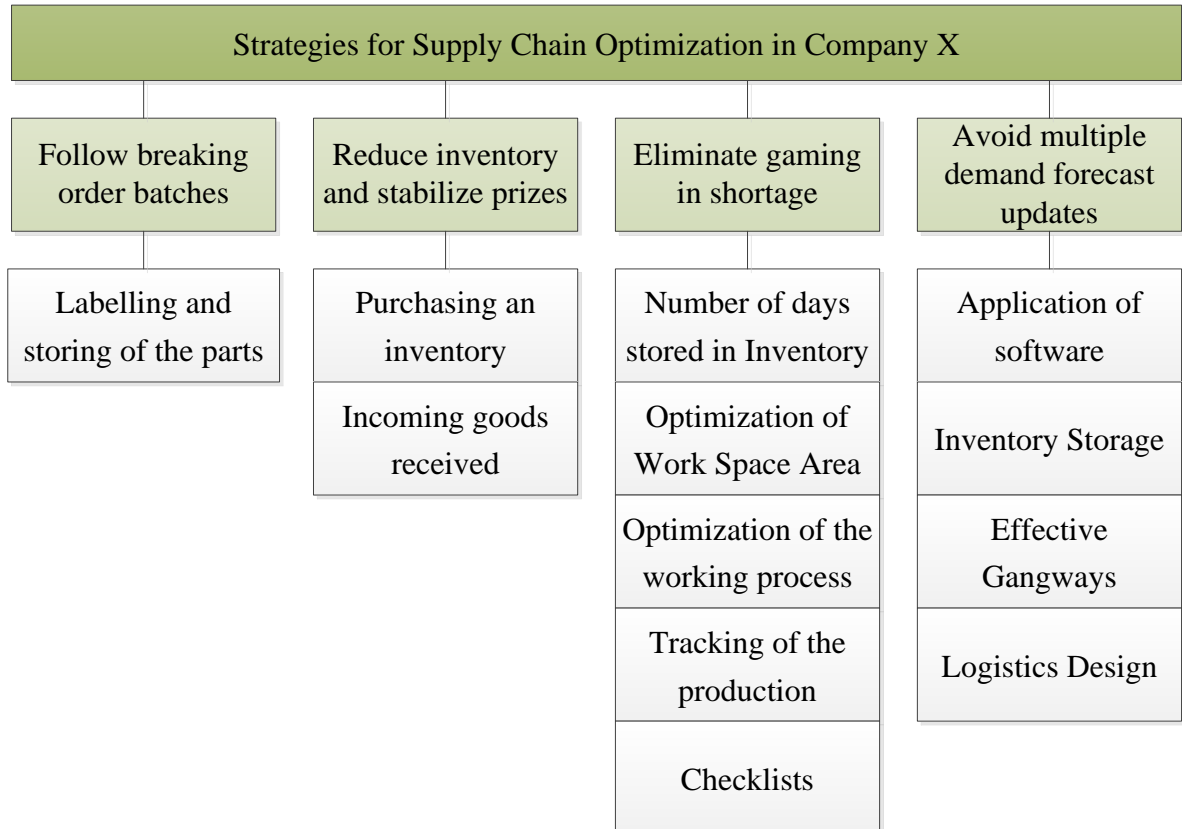


Fig. 2.3. Strategies for supply chain optimization in company X

### **2.1.1. Strategy to follow Breaking Order Batches**

#### **Labelling and storing of the parts**

The first technique Company X follows is the labelling of parts and storing them appropriately at the right place. This technique gives the order to be stored and used.

An automatic weighing machine has been implemented in the system. The product when it reaches the warehouse is checked if the right part and right quantity is available and is put on a weighing machine which automatically provides a label which is stuck on the part. This avoids complications while numbering or weighing and labelling the part. This is one of the effective measures that also helps in keeping track of the parts even after 3-4 years.

This is vital not just for the storing ease but also to know exactly the type of product that is available and also the type of product is available where.

### **2.1.2. Strategy to Reduce Inventory and Stabilize Prizes**

#### **The idea of Purchasing an Inventory**

If the inventory is being purchased with three parts A, B, C where A is the highest pricing inventory B is the second and C third.

The items when they are stored in the inventory they always are stored in the ratio of

A- 10%

B- 60%

C- 30%

This is reduce the cost of the product. However this system is changing from company to another company.

$$\begin{aligned} \text{Safety Stock Storage} = & \text{Required Material Cost} + & (2.2) \\ & \text{Production costly} + \\ & \text{Overhead Production cost} \end{aligned}$$

They consistently reduced the inventory cost by the use of long term agreements. When the long term agreements were used, it is called as bargaining.



### **Incoming Goods Received**

The incoming goods may sometime arrive during odd timings especially goods which are imported. To avoid any complications when the goods arrive and there is one person present in the plant, all working personal in the inventory plant and production unit are trained with data entry and specification measurement techniques. This improves the time in which the goods can reach the factory giving them more time to reach the goods.

### **2.1.3. Strategy to Eliminate Gaming in Shortage**

#### **Number of days it is stored in the Inventory**

The number of days that a part is placed in the inventory after the part has been completed in it is presented in Table 2.1.

Table 2.1

Number of days in inventory

Location	Number of days in inventory	Reasons
Local	3	Depletion in storage space
within the country	5	Depletion of product
International	7	Freight rate problems

The average storage of inventory is also informed to the suppliers and the customers. This gives a clear picture about the amount of product that is being produced.

Companies that would want to buy products from them can be sure about the current inventory hold of the company.

#### **Optimization of Work Space Area**

In Company X they follow a particular system where there are specialized section for each operations. In order to avoid unnecessary disturbances in the work place, the people who are working in the particular section are displayed with their photos. This helps in organizing the work in the work place. A person is appointed to check if the process is happening in order and the work place is in place.

### **Optimization of the working process**

In order to avoid irregular or bad working processes the working processes are displayed in the work area. All working personal follow a particular process of reading and checking what work has to be done and how to operate it. They follow this procedure during two times one during the start of the shift and other during any breakdown is happening.

### **Tracking of the production**

A display systems are being used in Company X to display the number of parts that are being produced in each shift and each line. This helps keeping track of the number of materials that are being sent out. If there are any form of lag in the required and the current running rate, the person in charge has to give a written note stating the reason.

### **Checklists**

They maintain particular check list for all the safety items. They have a set of checklist for cleaning, removing, lubrication and information. There is also a checklist for environment checking.

## **2.1.4. Strategy to Avoid Multiple Demand Forecast Updates**

The company follows many steps to avoid multiple demand forecast and few are described below.

### **Application of software in their supply chain**

The process of using a software to manage orders from one component with the help of an integrated software. It helps in:

1. General Management
2. Inventory Management
3. Logistics Management.
4. Reporting System.

Inventory is managed efficiently with the usage of the SAP software, it helps in warehouse management. It is also an effective software that can be easily updated and changed. It is used in order to store data and retain them even after years. The SAP software functions is given in figure 2.4.

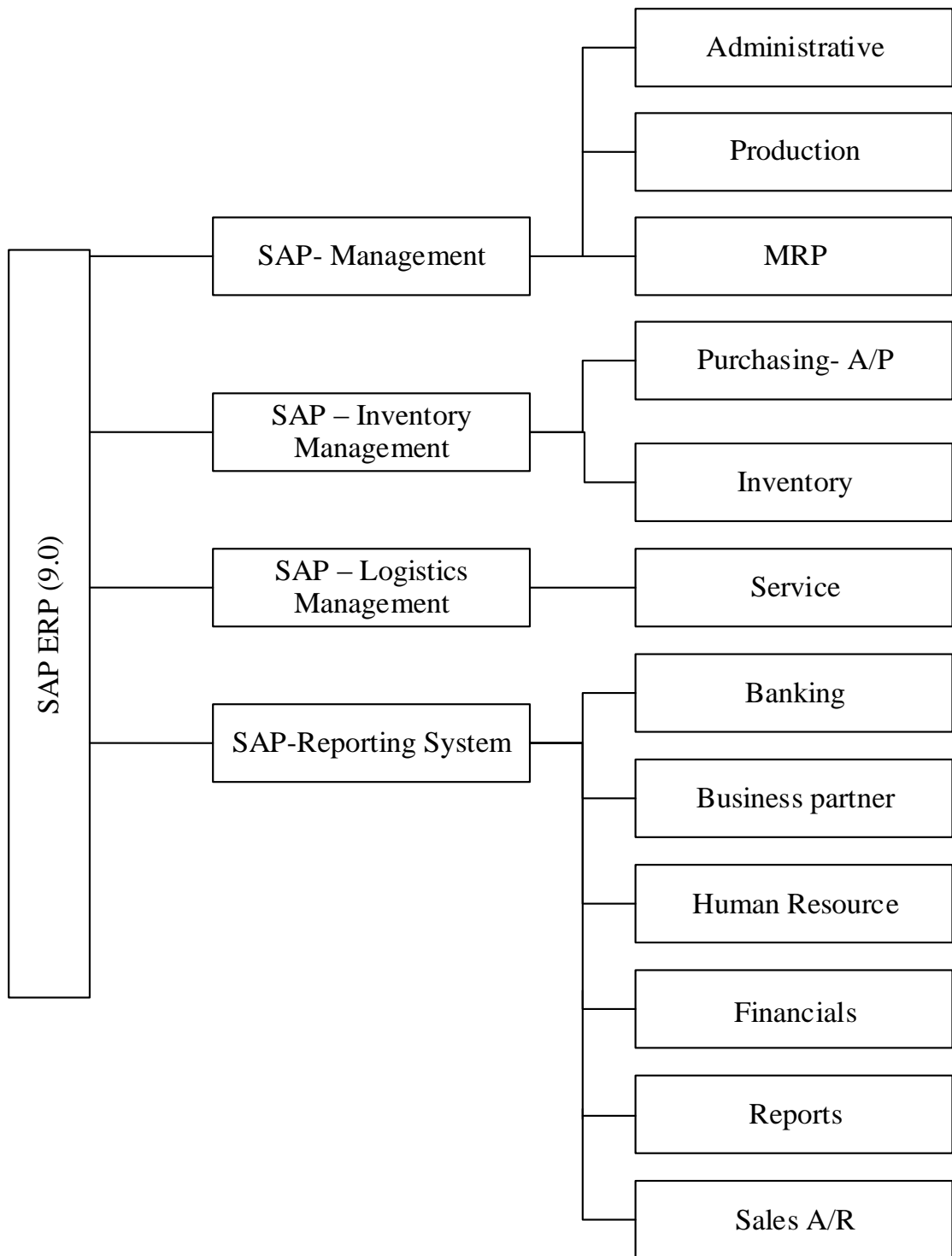


Fig. 2.4 Functionality of Software that is being used in company X

The modularity of SAP can be divided into four main categories

*1. SAP- Management*

The management system consists of administration, production and materials requirements planning. In the module of administration, drop downs like, choose company, Set up, Approval Procedures, License and Add On is present

In the case of production unit, Bill of material, Production Reports, Bill of material reports, MMOG, RM coverage full, FG coverage, FG old coverage, RM coverage minimum days coverage days is present.

In the material, the drop down are as follows, Forecasts, MRP wizard, Order Recommendation

*2. SAP – Inventory Management*

The SAP system has a specific storage space for managing ware house. In the SAP system each storage facility is part of an organizational structure created in the system. For inventory management there are two organizational levels which are required to be created; the plant, and the storage location [8].

There are a lot of moment of goods in the SAP system, they can be broadly divided as Inbound and Outbound. The procedures of inbound logistics, received goods, goods issues and internal movement are:

- **Inbound Logistics:** They are the products that come from the customer. Depending on the type of the logistics, they can be further segregated into smaller fields such as Internal Inbound Logistics and External Inbound logistics.
- **Received Goods:** This process can be either in the form of an inbound supplier or it can also be from the production process of the company. A goods receipt can be created such that the materials that arrive can be used immediately, or if a quality inspection is required they can be performed some form of tests to ensure that they are in stipulated quality. They may also be placed in a blocked stock state where the company cannot accept financial liability for the materials as they were not ordered, or incorrect. This refers to the unavailability of the material for use.

- **Goods Issue:** The ware house can be either uses or the production process or it can be sold to a customer as well. In either case the process that are issued to an order production or sales order which causes the stock level at the plant to be reduced. In some cases the material is also used to scrap and it can be deemed as a usable product by the quality department, even if it's after the shelf time.
- **Internal Movements:** Material in the plant may be changed from once place to another, this process is called as an Internal Movement. There is a movement of goods, so that the material is moved from the main storage area to a production area or a quality inspection area. There may arise times when the material is moved to another plant, in the case the material requirement is close. In such cases the plant is used to transfer material from one point to another. One other internal movement is the transfer posting, where a material is logically changed within the system. For example, a material that has been received as material requiring quality inspection can be changed to material that is available for use, by performing a transfer posting.

The SAP system is used to manage the inventory of the company. All goods, either finished or processed ones are stored in the company by using SAP system. The inventory system that is being used is the First in First out system (FIFO). It is much efficient and works well with the company. They use this system for 209 materials that are currently the different types of inventory that are available. Its can effectively manage all the functions of 22 suppliers and contractors.

In the case of the inventory management system the company follows the centralized inventory management system

### *3. SAP – Logistics Management*

A logistics management information system is a system of records and reports – whether paper based or electronic – used to aggregate, analyse, validate, and display data (from all levels of the logistics system) that can be used to make logistics decisions and manage the supply chain. A well-functioning Logistic Management information system (LMIS) provides decision-makers throughout a supply chain with accurate, timely, and appropriate data, such as stock on hand, losses and adjustments, consumption, demand, issues, shipment status, and information about the cost of commodities managed in the system [4, 5].

#### *4. SAP – Reporting System*

The reporting software of the Company was consistently reporting the type of inventory, the amount of inventory, the quality of inventory, throughout the Supply Chain. This gave access for companies to modify, edit and change their requirements as per the varying demand from the market. This gave the company a strong hold of managing inventory and developing a software.

#### **Inventory Storage**

The inventory of the company raised since new contracts had implemented. The storage of finished goods was optimized efficiently by “Vertical Stacking of the Inventory Products” Now they are accommodating 2 more stacks in the row to have more items in the inventory.

#### **Effective Gangways**

Effective gangway system has been implemented in the premises to allow free movement of people and load carrying machineries. This helps in easy transportation of parts within the assembly.

#### **Logistics Design**

Company X is a company that basically follows Exworks idea. It is a company that manufactures and is responsible for the product only till the time it is in its premises. The company which offers the contract is the one that supplies and takes back the material. This is a process that is effective and does not allow any unwanted responsibilities.

## 2.2. Advantages of the Supply Chain in Company X

The advantages of the Supply Chain of Company X are many, discussed below are the advantages of Company X.

1. **Software Functionality:** The software they used was SAP, this is one of the leading software in the field of managing the functionalities of the company. SAP had nearly 12 modules that were used in the company. These functional modularity was used from receiving inventory to the completed product sent to the storage unit after completion. The management of the Supply chain using SAP is given in figure 2.6.
2. **Computerized Production Planning:** They had a very effective production planning strategy by using SAP. Their operations had a strong back up and they were well experienced in their field. People who worked in the company were experienced for at least 3-5 years. It was almost impossible for them to hire someone who was not a professional. This gives them an effective calibre of human force to operate. Their production planning strategy using SAP is shown in Figure 2.5.

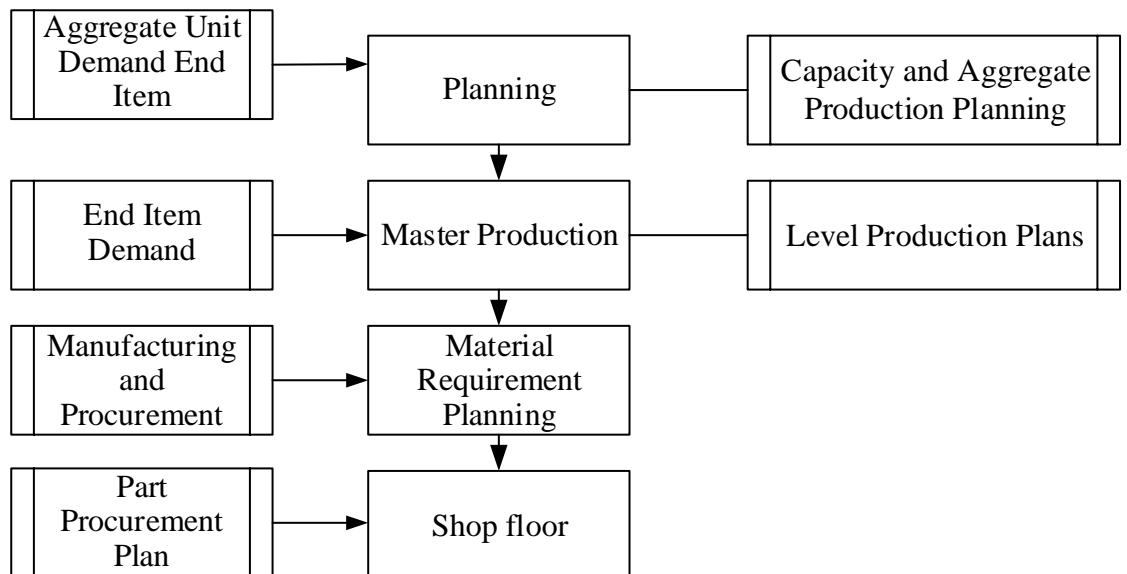


Fig. 2.5 Production strategy of Company X using SAP

3. **Customer Relationship:** They had good relations with their customers. The customers they had were well versed in their field. Their customers were Hyundai Nissan and many other big players in the market they expect a particular calibre for operation. These companies were already well established and have been under operation for the past 20 years in India. This gives them a vast source of experience.

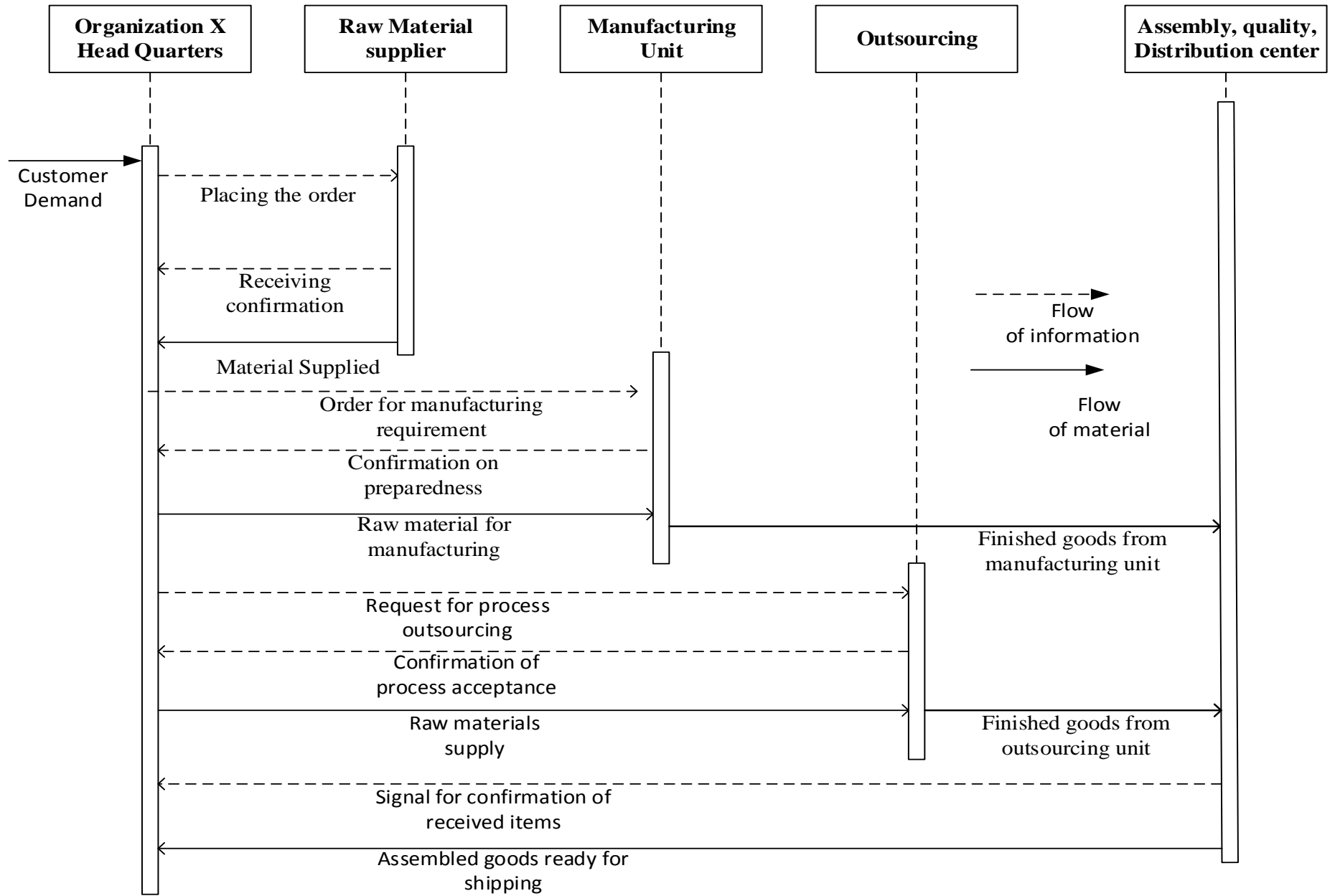


Fig. 2.6 Information Management system of company X using SAP



### **2.3. Challenges of Supply Chain Computerisation**

Challenges implementing software for the supply chain management of company X are:

1. They are very expensive, it becomes almost impossible for a company that is just begun or for a company that is being established just for the past 5 years to have such an expensive software.
2. Not all functions of SAP are required by all the companies. Some companies might not require some functionality. Example a tyre manufacturing company in a small scale might not require the software for administration.
3. Some companies already have existing software, this software cannot be changed immediately. The software that are being integrated might require data base management. The data base management cannot be set immediately. This will take time to set it up.
4. Major companies that are in the area of Small and medium enterprises might not have the knowledge force to handle complex software such as Oracle database management. Cloud computing software have to be simple for them. The functionalities are so wide, that it requires a special person to handle the software.
5. They cannot have reporting directly from a software. They also need to have an auditor and someone who has to check the issues externally before they could produce a report to the stakeholders.

Considering the disadvantages in advance, the next company that the research candidate analysed was a company, which integrated a sustainability software into a system.

### **2.4. Market Need for a Software to Contribute to Supply Chain Optimization**

1. A market requirements for a software that can be used to optimize a supply chain.
2. Should have a few functions similar to that SAP.
3. Should be as efficient as SAP, some functions should be better.
4. The product should be cost effective.
5. The product should contribute to curbing the Bull-Whip effect by eliminating gaming in shortage.
6. The functions should be easy to use.
7. Majority of the customers should benefit from it.

### **3. SUPPLY CHAIN OPTIMIZATION IN COMPANY Y**

#### **3.1. Computerisation of Supply Chain Management of Company Y**

Company Y is a leading packaging company, they manufacture carton packaging worldwide. They develop software that are for reporting in the Supply Chain. They are located in over 6 different countries like France, Germany, Austria, Warsaw Lithuania and Russia.

Their major area of customers were food service, Tobacco, Confectionery and similar industries. They offer packaging such as airbox, cups, multipacks, tobacco packaging and similar functions. They also do premium packaging, food service packaging and similar functions. They are certified with ISO 9001: 2008.

They used a software called as 360report, which specialized in sustainability reporting, energy auditing and carbon discharge emission. The software was specialized in delivering optimal reports within stipulated time. The reports could be directly certified by GRI standards. There were no prior knowledge were needed by the company to implement this software. The software was from a company from Berlin. Delivering professional reports with just a key stroke, were their disadvantage. The software was used to provide reports for stake-holders, employees and other companies. The software costs about 2000 Euros per user. It is affordable and the customers were satisfied with it functionality. The software was used by each unit in the component of the Supply Chain. That is a production unit had this software, a distribution centre had this software and the main office had this software. Each unit was connected individually to the software and hence the data were not able to transmit from one part to another.

One of the key functions of Supply Chain is Reporting (information to customers and suppliers) to Stake Holders, Company Y developing a software that specifies in these functions. The software had a single user interface. Only one computer could access the software at a particular time. In the later stages, this software was able to be integrated into the entire Supply Chain.

The company was ready for updating into its latest software. The software is designed for Sustainability reporting and Energy Audits. Companies that generally use them are Small and Medium Organization.

### **3.2. About existing software**

The existing software had three main functionalities. They are Company Sustainability Reporting (CSR), Energy Audits, and CO<sub>2</sub> Reporting. Company sustainability reporting is essential for companies to show their companies record in not causing any damage for the environment. Any company in the 28 European Union with over 500 employees had to report annually about their sustainability standard. Companies can report on the following data

1. Environmental Matters
2. Social Matters
3. Employee-Related Matters
4. Respect for Human Rights
5. Anti-Corruption Matters
6. Bribery Matters
7. Diversity Policy

It was essential for the company to report to their stake holders, suppliers and investors the sustainability of the company. They had to provide their output to state that they were causing any damage to the external environment. The companies however had problems in collecting data, sorting the data according to requirements and selecting the best solution. A typical example would be the emission of CO<sub>2</sub> from refrigeration system. The refrigeration system in the company could be an old one and the users might not know the output of the system. With this software, the user has to implement only the input the type of refrigeration and coolant that is being used. The CO<sub>2</sub> emission is automatically generated, this is the biggest advantage of this software. This is shown in figure 3.1. This software could generate reports automatically by just inputting the data and the output was generated, which could be directly printed in the form of PDF or Word file.

The main advantage of the software was that no prior experience is required in the case of software handling. The software was user friendly and all employees can access the software and use the functions in it.

The outputs of software were professional and they could easily generate the output without any hassle. The software was in the market for the past 2.5 years and they were mostly used by customers from the small and medium sized enterprises. The cost of the software was phenomenally affordable comparing to its functions. This software could store data in it in the form of a word file. Customers who wanted make notes or store some data that they wanted to remember had the feature of storing upto 5000 words.

3. Please show information relating to the air conditioners used by your organization. The information is required for each individual air conditioner.

Emissions from the air conditioners are calculated as recommended by the Greenhouse Gas Protocol and are part of G4-Scope 1. Please enter under the column "Designation of air conditioner" for example "Production", "Administration", etc.

Add more air conditioners with the Plus button.

**Input**

Designation of air conditioner	Refrigerant type	Capacity (kg)	CO <sub>2</sub> e (t)
<input type="text" value="Production"/>	R-116 ▼	<input type="text" value="5.00"/>	4.88
<input type="text" value="Administration"/>	R-125 ▼	<input type="text" value="10.00"/>	2.80
<input type="text" value="Office"/>	R-1234yf ▼	<input type="text" value="5.00"/>	0.00
<b>Total</b>			7.68

**Automatically generated output**

+ Add row

4. Enter the CO<sub>2</sub> emissions of your air conditioners in metric ton (t).

Fig 3.1. Automatic CO<sub>2</sub> emission calculation

### 3.3. Necessary upgrade needed on the new software in the Supply Chain

The company needed a software that could be integrated into the entire Supply Chain. The functions of the software had to be somehow similar to the old style. The system of operating had to be consistent, but one software for the entire unit. The functions of the new software needed to be constituted were as follows:

1. **Integration of the software into the Supply chain:** the requirement of company Y was that the software had to be used throughout the supply chain. All the areas had to be accessible. The software had to be made into all the supply chain components.
2. **User friendly:** If the software was integrated into the system, the entire Supply Chain cannot have complex functions. The example of it would be, the production unit cannot handle complex software such as the design unit. Practical problems occurred previously, especially with the Warehouse department. The data were not updated as it should be, this led to the inventory of warehouse as sometimes not up to date.
3. **Software upgrade had to be simple:** This software was a cloud based software, the company wanted the system to be upgraded and ready to go within a few days. It was impossible for the company to wait for the upgrade and for days together, without the system running.
4. **Cloud computing reliability:** This software was a cloud based software, the data that is stored had to be reliable. It would be a problem, if this data is leaked or is misused. So the database of the system had to be upgraded as well. The upgrade of database had to be changed from 3000 words- 7000 word. The users needed more space to operate their system.
5. **Integrated for entire supply chain:** All units, like the productions, the warehouse, and the head office had to be connected virtually by this system. No loss of data and it automatically had to calibrate the output.
6. **Pricing:** The software had to have almost the similar pricing the company was paying at the moment. There should not be much of improvisation of pricing of the system. They had to also experience some form of a profit from the new software.
7. **Smart application:** The new software had to have a facility to input tables and charts into the system. The tables and charts had to be clear, concise and also needed to be easy to be made.

3. Please provide information about the raw materials used.

### Single user inputs

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method	
Plastic	11.00	t	internal	renewable	measured value	
Rubber	10.00	kg	external	renewable	measured value	
Wood	12.00	t	external	renewable	measured value	

+ Add row

Fig 3.2 Single User Entry

### Input from the researcher

1. **Curbing the Bull-Whip effect:** The system needed an inventory management system where the inventory was automatically generated. The automatic generation and addition of the numbers, could help in getting a clear picture of the available inventory in all the units.

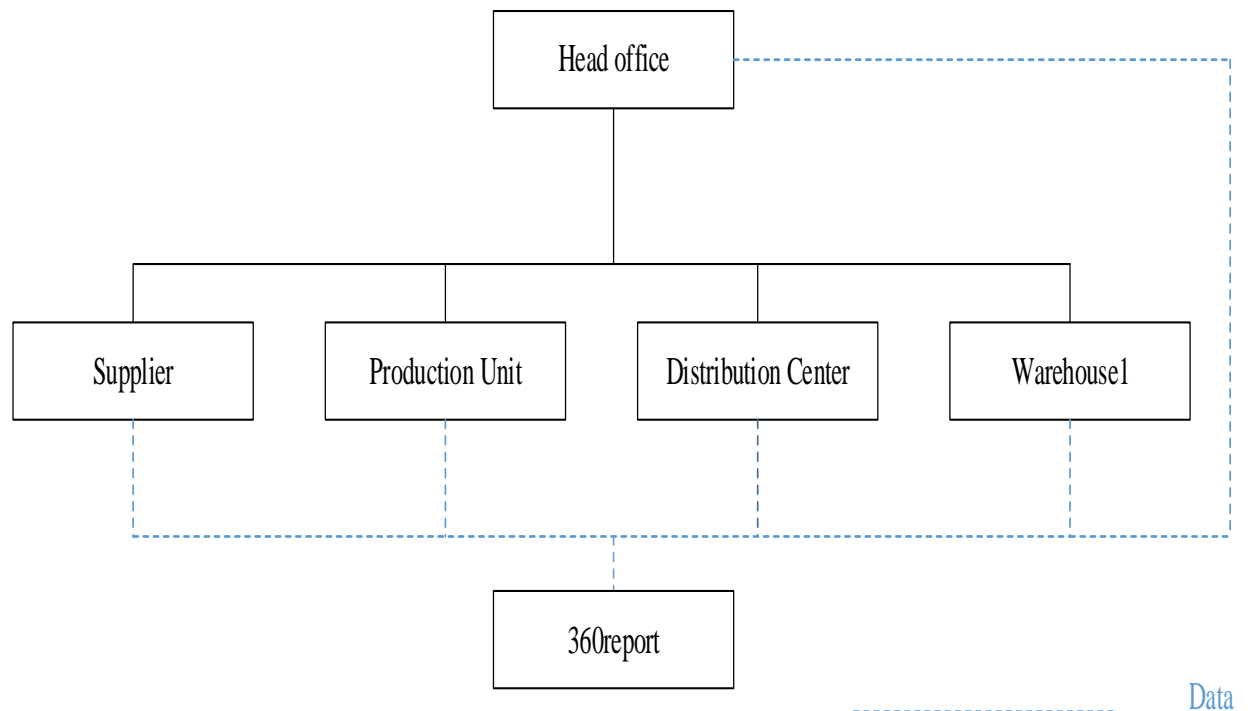


Fig 3.3 Researcher's suggestion for Inventory Management system of company Y

2. **Similarities to SAP:** The warehouse management of SAP as investigated in section 2.1.4 was one of the biggest advantages of Company X. If this system is existing and run by Company Y, then companies would experience a difference in their Supply Chain.
3. **Data allocation:** Each area of the Supply Chain can manually be selected by head organization to avoid hassles while uploading data. All functions are not necessarily needed by all areas of the Supply Chain. Example the organizational data is not needed for Warehouse. The existing system had the trouble where people had to manually change every time. In the new system, the head organizations can just select a few functions to edit the data and store it for one side of the Supply Chain.

### 3.4. Product Development of the new software

The steps for the product development of the new software are shown in the Figure 3.4.

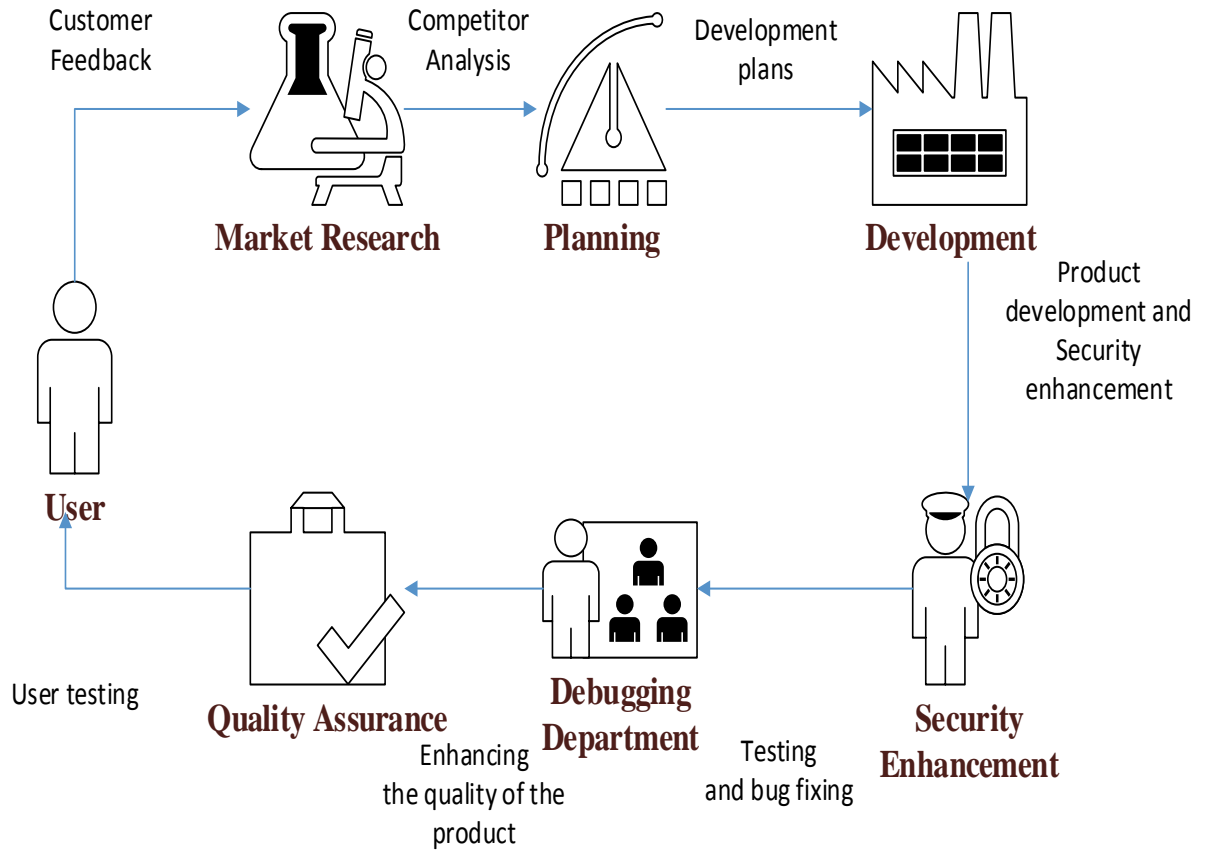


Fig 3.4 Suggested Inventory Management system for company Y

**Customer Feedback:** The Company Y gave 360 report the functionality and what they wanted out of the new software. A strong communication was established between them to facilitate details to be shared amongst them.

**Market research:** The market research was performed by the researcher and the data was clearly presented to the company regarding the functionality of the big players such as SAP, Oracle and similar companies. This provided the outline of how the product should look like. In the case of the company, the company was also able to analyse what segment of competitor they had to face and what type of market they had to reach.



**Development plans:** a proper instruction had to be given and the bigger tasks had to be broken down into smaller tasks. This facilitates the company to develop plans about the front end designing, back end designing, content arrangements, translations, platform help texts and similar arrangements for Dutch platform had to be done in advance.

**Security enhancement:** the software was not just used to single unit but to the entire Supply Chain. This relates to the data storage being enhanced in the system. The security was enhanced by using customized servers and similarly the data could now be secured. This means that each company has its own server base in Berlin.

**Debugging department:** Debugging department had to be vigorous in checking for errors and fixing it. From the company side we also did user based bug fixing. This gives us the idea of how this software runs and how it has to be updated.

**Quality Assurance:** The Company followed an advanced product quality planning to check the company the steps for quality assurance are shown in figure 3.5.

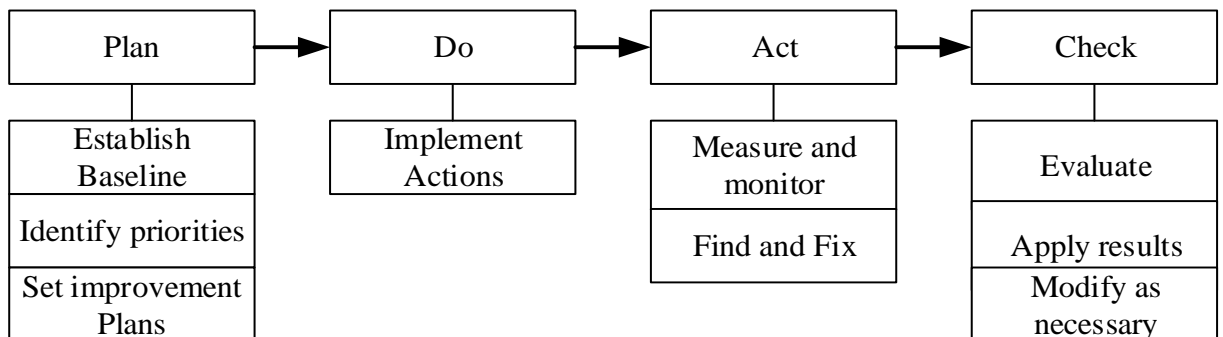


Fig. 3.5 Advanced Product Quality Planning of software integration

**User testing:** the final testing is done by company Y and the researcher was able to be a part of the user testing. The main aspects of the user testing are as follows,

1. To test the language that is being used in the software.
2. To test the operation of the software, the usability,
3. To report errors to the company in case of defaults.

### 3.5. New Software for Sustainable Supply Chain Management

The new software was upgraded on 16.04.2015. The functionality of the new software is shown in the form of a figure 3.6.

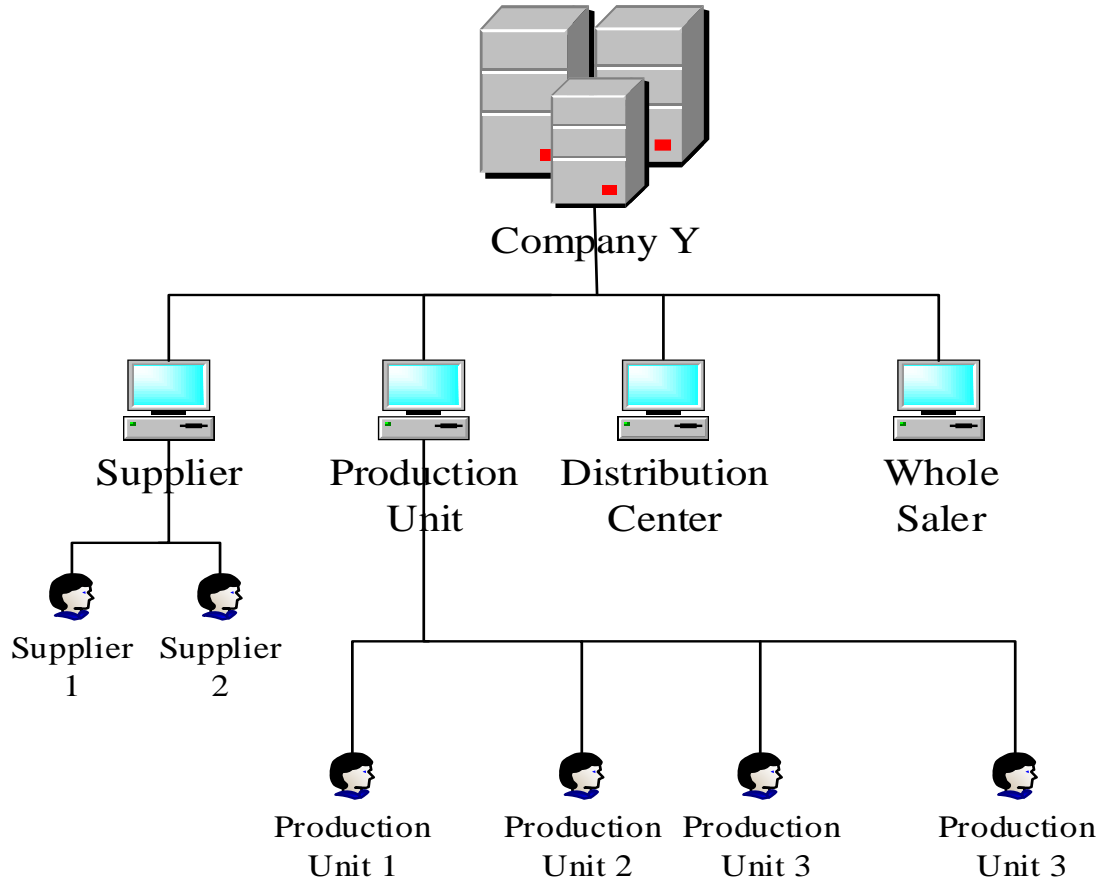


Fig. 3.6 Schematic diagram of the latest software

The upgrades of the software are given below

1. **Integrating it with the entire Supply Chain:** The new software has the functionality of integrating the software into the supply chain. All areas of the supply chain are now available with the facility to use this software. Now the users can automatically update data in any area of their supply chain. Throughout the company the data can be changed, edited and modified according to the requirements of the user.

The advantage of this function is that inventory data can be visible throughout the entire supply chain. The figure 3.7. Shows how the system is integrated for the entire supply chain.

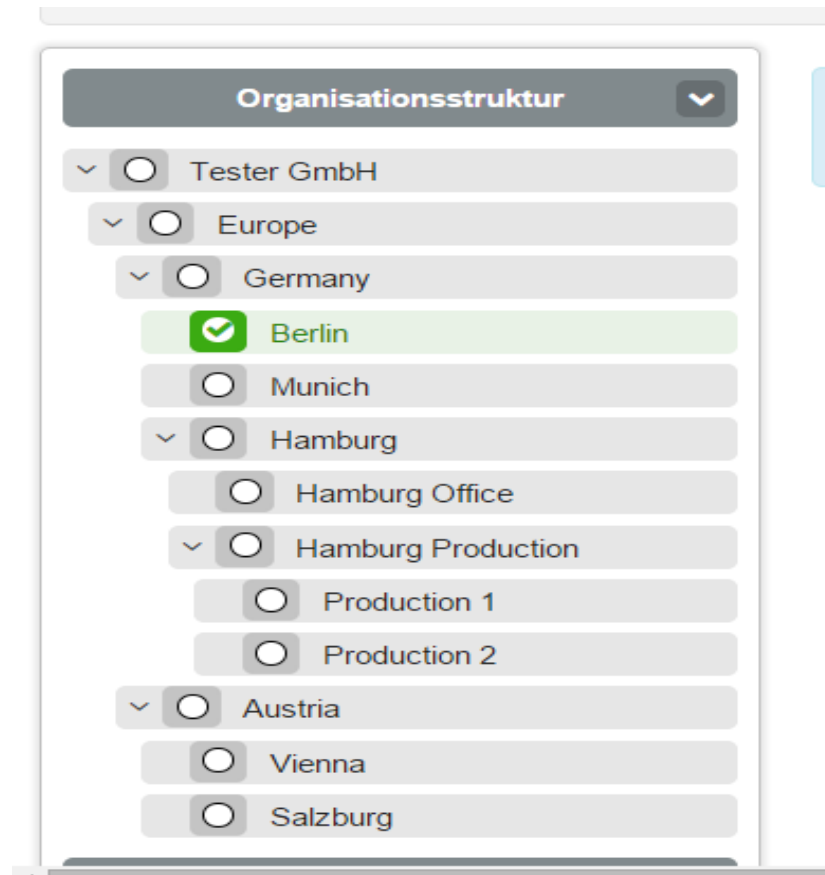


Fig. 3.7 Integration to the entire supply chain.

2. **Simple usability:** Since they are integrated with the entire supply chain, some unit such as warehouse, production in company Y are not so competent with handling computer based technologies such as the head office. Hence the simpler functions and the ability to operate the function for the organization was set up. The selection option helps in resolving issues, such as complex operations, missing of data and similar functions. The functionality is simpler in many areas and the data can be easily loaded even by the ordinary working staffs who do not have prior experience in programming language.

It is shown in Figure 3.8.

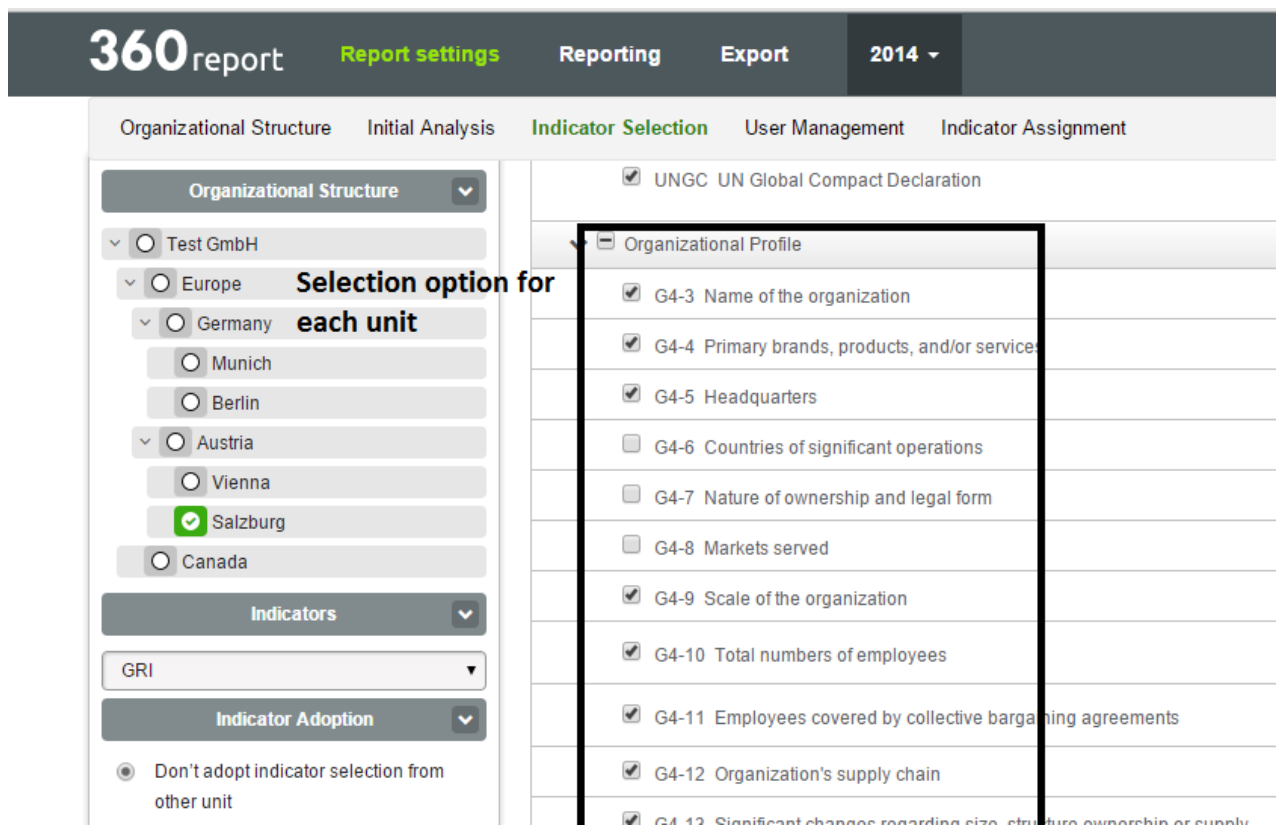


Fig 3.8. Selection option for each unit

3. **Reliability:** 360 report set up a special server for company Y, to host their data. Since they could not compensate on loss of data or any form of leakage in data they had to set up a reliable means to store and process data.

4. **Curbing the Bull-Whip effect by the latest software:** the added advantage in the software is the ability to curb Bull-Whip effect. It is made possible by elimination gaming in shortage as discussed in section 1.3.3. One of the ways to eliminate the Bull-Whip effect would be to make the inventory visible to the entire unit. When the inventory is clearly visible to entire unit, it becomes clear about how much stock is there in store and how much is needed. This gives the company a clear idea about the inventory management system and curbing the Bull-Whip effect, **Demand forecasting** is possible as the inventory is available throughout the Supply Chain, this gives access for the different segments to forecast the demand. **Eliminating Gaming in shortage** is created by the inventory system available.

Customers had experienced the advantage in the system by reducing their inventory levels, since the company displayed the inventory system. The working of it is shown in figure 3.9. and 3.10.

### 3. Please provide information about the raw materials used.

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	254.00	kg ▼	External ▼	Renewable ▼	Measured value ▼
Rubber	135.00	t ▼	External ▼	Renewable ▼	Measured value ▼
Plastic	12.00	kg ▼	External ▼	Renewable ▼	Measured value ▼

Fig. 3.9 Interface for input of information

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	1,266.00	kg	External	Renewable	Measured value
Rubber	135.00	t	External	Renewable	Measured value
<b>Number Value Aggregation</b>		30.00	A	External	
		11.00	t		
✓ Europe	1,266.00	5.00	kg		
✓ Germany	1,266.00	4.00	Other unit		
Berlin	266.00	4.00			
Munich	1,000.00	3.00			
✓ Hamburg	-	2.00			
Hamburg Office	-	11.00			
✓ Hamburg Production	-				
Production 1	-				

Fig. 3.10 Inventory data (fragment)

5. **Graphs and Charts:** Users can also include graphs and charts to their current software .Figure 3.11 shows how they are included in the software.

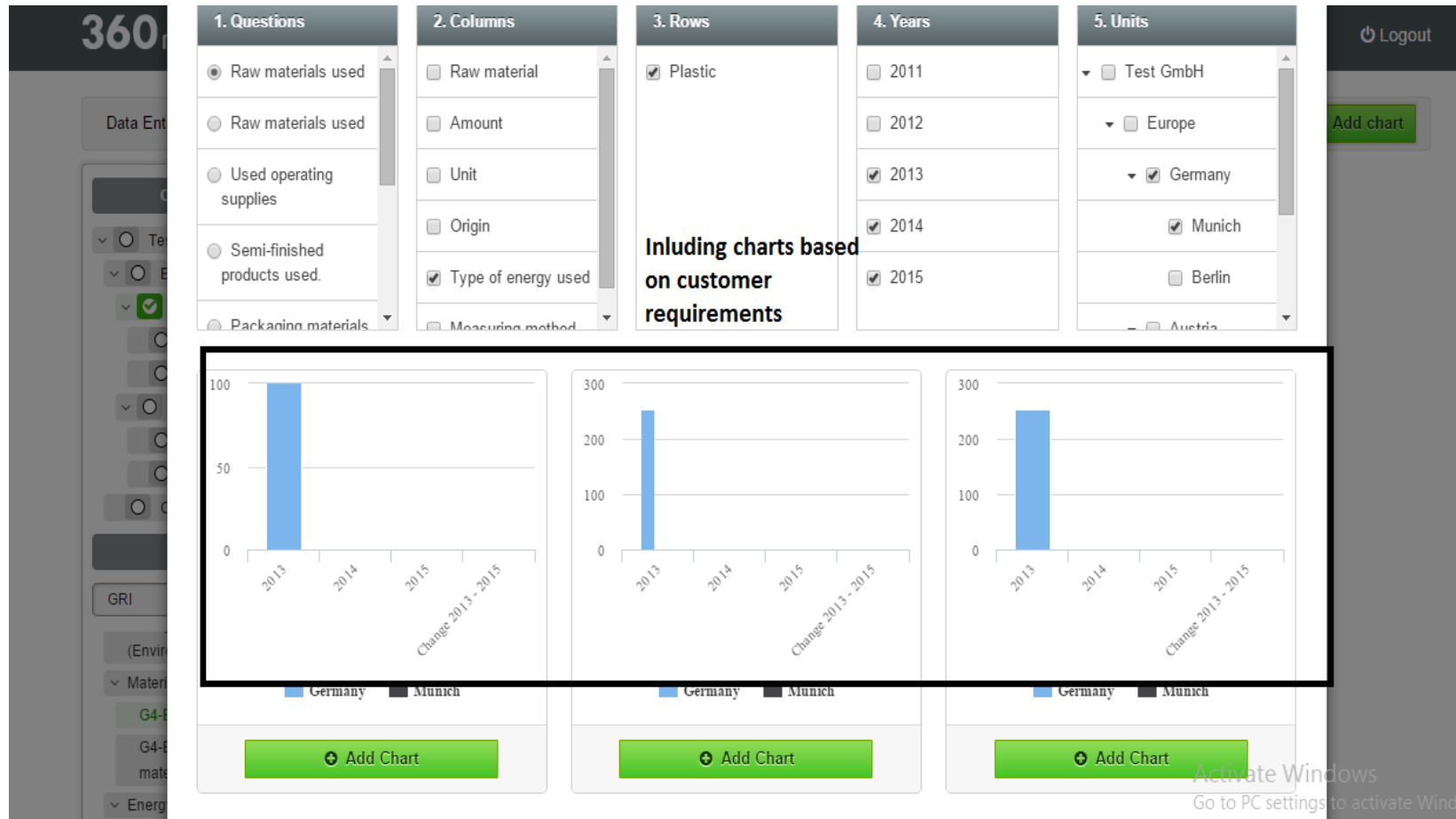


Fig 3.11. Charts and graphs in the new software

### 3.4. Disadvantages of 360report in company Y

The disadvantages of 360report in Company Y are as follows,

1. **Cloud based software reliability:** The software is a cloud based software and reliable information is not suggestible to be stored in it by Company Y. The company cannot use this to store large data. If the internet is down then the warehouse data of the entire supply chain is lost.
2. **Not so efficient:** Software does not curb effects such as breaking order batching, the software does not functions like SAP to automatically plan and evaluate the system for MRP and MRP-II. They cannot process many functions that are there in the SAP. In the case of reporting software they have an added advantage of automated generation of the software.
3. **Lacks Predictability:** The software does not have the ability to stabilize prices, to analyse the price level and make changes if there is a necessity. The software cannot have a data base for storing anything. In the case of 360report they cannot anticipate or make changes in the pricing levels.
4. **Not customized for Bull-Whip:** The Company cannot use this software just for the use to curbing the Bull-Whip effect. This software is used primarily for reporting. It may be used to make the inventory visible to the entire supply chain. It is not a software that is meant only for curbing the Bull-Whip effect.
5. **Customer service:** This Company is located in Berlin and it becomes almost impossible to provide customer service directly to a sector which located somewhere else. It could also be a problem if the customer is not in Europe.
6. **Feedbacks acceptance:** This Company is a start-up and the preference of the company at the moment is the increase their customers and increase their business. However, if they have feedbacks from existing customers to improvise the product on certain areas which are not critical but an added advantage, this company does not accept it immediately.



## 4. COMPARISON OF SOFTWARE'S APPLICATION PECULIARITIES

Table 4.1

Comparison of software application peculiarities

<i>Description</i>	<i>Software in company X</i>	<i>Software in company Y</i>
<b>Functions</b>		
Does it cover all the standards functionality?	+	-
Does it have functions according to requirements of customer?	+	-
Does it cover standards like GRI, EMAS?	+	-
Is it a cloud based software?	-	+
Does it have administrative functionality	+	-
Does it have production functionality	+	-
Does it have materials requirement planning functionality?	+	-
Does it have acceptance and rejects order functionality?	+	-
Does it have financial functionality?	+	+
Does it have inventory functionality?	+	+
Can it be uploaded to another system with similar software?	+	-
<b>Curbing Bull-Whip effect</b>		
Does it avoid multiple demand forecasting?	+	+
Breaking order batches	+	-
Does it stabilize prizes	+	-
Eliminate shortage of gaming	+	+
Are there functionality to just for Bull-Whip	+	-
<b>Usability</b>		
Can a person without prior knowledge about software use it?	-	+
Is there special guidelines for operating?	+	+
Is it updated for easier use often	+	-
Do all employees use it?	+	-

Are the functions simple to use?	-	+
<b>Customer Satisfaction</b>		
Are all the customers satisfied with price?	-	+
Does customer demands over time fulfilled always?	+	-
Do they conduct user training functions often?	+	-
Is the customer feedback effective?	+	-
Do they have repeated customers?	+	+
Are the feedbacks of customers valued the most?	+	-
Does it fulfil all types of customer?	+	-
Does they interact with customers face to face to know what they really want?	+	-
<b>Safety</b>		
Are they prone to malicious viruses?	+	-
Do they have effective system to stop them?	+	+
Are there effective data storage systems?	+	-
Do they provide a virus free guarantee from the software?	+	-
Do they provide security affirmation to their data?	+	-
<b>Output</b>		
Do they guarantee reports professionally?	-	+
Do they need a professional for using it to generate the outputs effectively?	+	-
Do they stake holders always have access to the outputs?	+	+
Can they generate a report by a key stroke?	-	+
Do they need a setup a database for outputs?	+	-
<b>Professionalism</b>		
Can this software be used to develop professional financial reports?	+	+
Can this software be used to develop professional sustainability reports?	+	+
Can this software be used to develop professional CO <sub>2</sub> emission reports?	+	+
Can this software be used to develop reports based on standards such GRI, ISO etc.?	+	+
Can this software be displayed to the customer?	+	-

**Functions:** 360report unlike SAP does not have 12 functionalities, they just have three different functionalities. SAP has more functional advantage over 360report. The software 360report cannot cover all the functional requirements of the customer. Both the software cover standards like GRI, EMAS and so on. Only 360report is a cloud based software. The data base of SAP is within the company only. SAP has got additional functionalities such as administrative, production, material requirements planning, acceptance and rejection of order. Both the software can be used to derive financial statements. All though only SAP can manage financial functions. Inventory can be managed by both the software. 360report unlike SAP cannot be loaded into another system with similar software.

**Curbing the Bull-Whip effect:** Both the software can be used to solve multiple demand forecasting. Breaking order batching can only be done by SAP. This is because it requires database and storage management. 360report does not have the ability to stabilize prices. Both the companies have the inventory visible throughout the supply chain. This gives the company to act on eliminating gaming shortage. However, 360report does not have any functional modularity for just curbing the Bull-Whip effect.

**Usability:** SAP requires prior knowledge about the functional module of the software before one can operate it. Customer demands over time are always fulfilled in SAP because they are aligned only according to the requirements of the customer. It is also updating very often. This gives the latest software for customers to use. Not all employees use 360report in the company Y. In the case of company X all employees use SAP. All the functions are not simple to use in SAP unlike 360report.

**Customer satisfaction:** Many of customer initially think that SAP is not worth the price they pay. However the top management and people who use the product on a regular basis tend to have a positive opinion about the product. In the case of 360report customers are always happy to buy the product for its pricing. Customer demands are always not fulfilled by 360report. In the case of SAP they always try to fulfil the demands of customer. The feedback is effective in the case of SAP and hence they have repeated customers buying more of module. SAP fulfils all its customers but in the case 360report, they focus on fulfilling customers of small and medium sized organizations.

**Safety:** Unlike 360report SAP have effective protection system for their data. They have virus guarantee for free in their system. They provide confirmation that no data would be lost from their end even in case of a computer crash.

**Output:** SAP promises a professional output to their customers. 360 report does not promise this to the customers. 360report do not need a professional to generate the report, but in SAP they need one. SAP cannot generate a report by just a key stroke, it needs authorization, validation but 360report it is possible. They both have their stake holders always in the loop for their data. In the case SAP they need to have a data base for outputs, in the case of 360report they automatically provide the output.

**Professionalism:** Both the software can develop reports, which can be used as financial reports. The two software develop professional sustainability reports. There are a lot similarities in the CO<sub>2</sub> reporting and both the reports are professional. Both SAP and 360report follow standards such as GRI, EMAS, ISO and such standards. However 360report cannot be displayed to customers as the software might not have a professional approach as that of SAP.

### **Results of comparisons**

Company X has a well-organized and a stabilized Supply Chain. They have a wide knowledge domain and many people who are long term customers. This system of SAP is useful for them and enhances their Supply Chain as a whole. It gives them a platform of standard and operating system for uniform results. SAP is a domain, which is preferred by companies which are in terms big sized enterprises. It is not advisable for a company to invest so much of money into a management software when it comes to small or some medium sized enterprises.

Company Y is a medium sized enterprise, the software they use is not expensive. They do not use the best software in the market but they have a frugal innovation. This is one of the best moves in Company Y. Investing in a system that is used to manage their entire operations is a good investment but not at the moment. They have to learn how to optimize their existing system, make slight modification, see how it could be used and later maybe shift to another system with bigger functions. It is better to ration the resources and know how to use them, master the current resources and see what best can come out of it. If everything works out well, it is undoubtedly the best for the company to shift a bigger and major producer.

## CONCLUSIONS

Supply Chain is one of a vast and an expanding topic in a company. Any company that is prone to exist to market for more than 5 years need to have a strong Supply Chain. A company ceases to exist if the Supply Chain has some form of loop holes in it. However effective the Supply Chain, so effective is the productivity of the company.

1. Analysis of Supply Chain Management constituents enclosed the critical factors such as location, inventory, production, logistics and information. Possible ways of optimizing them – effective management of the components using particular software.
2. Investigation of the working strategy of company X revealed the common problem that all companies experience – the Bull-Whip effect. Theoretical solutions, derived to curb the problem – breaking order batches, stabilizing prices, eliminating gaming in shortage and avoiding multiple demand forecasting.
3. Analysis of the need for computer aided systems for supply chain management and the software that is being used by particular companies’ revealed urgent need for efficient software for managing the operations and various components of the company supply chain. Main requirements for the software – inexpensive, simple, user friendly and efficient to prepare the reports for auditing and internal uses.
4. After comprehensive analysis of the application peculiarities of existing software in the company X, the advantages and disadvantages, the suggestions for improvement was implemented in the software used in company Y. The developed software, implemented in company Y, will increase sustainability of supply chain by reducing of inventory and effective information management.

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29. [www.magna.com /financial](http://www.magna.com/financial) update [Checked 28.05.2015]

# APPENDIXES

360report [Report settings](#) [Reporting](#) [Export](#) 2015 [FAQ](#) [Glossary](#) [User settings](#) [Logout](#)

[Organizational Structure](#) [Initial Analysis](#) [Indicator Selection](#) [User Management](#) [Indicator Assignment](#) [Add unit](#) [Add year](#) [Info](#)

INTERN 360 ENGLISH Organizational Structure		Actions
▼ Tester GmbH		<a href="#">Edit</a> <a href="#">Delete</a>
▼ Europe		<a href="#">Edit</a> <a href="#">Delete</a>
▼ Germany		<a href="#">Edit</a> <a href="#">Delete</a>
Berlin		<a href="#">Edit</a> <a href="#">Delete</a>
Munich		<a href="#">Edit</a> <a href="#">Delete</a>
▼ Hamburg		<a href="#">Edit</a> <a href="#">Delete</a>
Hamburg Office		<a href="#">Edit</a> <a href="#">Delete</a>
▼ Hamburg Production		<a href="#">Edit</a> <a href="#">Delete</a>
Production 1		<a href="#">Edit</a> <a href="#">Delete</a>
Production 2		<a href="#">Edit</a> <a href="#">Delete</a>
▼ Austria		<a href="#">Edit</a> <a href="#">Delete</a>
Vienna		<a href="#">Edit</a> <a href="#">Delete</a>
Salzburg		<a href="#">Edit</a> <a href="#">Delete</a>

**Selection for the Entire Supply Chain.**

Fig A.1 Latest advancements in the software



Data Entry Tables Charts Save i

**Organizational Structure** ▼

- Tester GmbH
- ▼  Europe
  - Germany
    - Berlin
    - Munich
  - ▼  Hamburg
    - Hamburg Office
    - ▼  Hamburg Production
      - Production 1
      - Production 2
  - ▼  Austria
    - Vienna
    - Salzburg

**Indicators** ▼

GRI ▼

- ▼ Standard Disclosures
- ▼ Strategy and Analysis

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	254.00	kg ▼	External ▼	Renewable ▼	Measured val ▼
Rubber	135.00	t ▼	External ▼	Renewable ▼	Measured val ▼

◀ Add row ▶

**4. Please provide information about the auxiliary materials used.**

Use the plus button to add more auxiliary materials.

Auxiliary material	Amount	Unit	Origin	Type of energy used	Measuring method
Gasoline	979.00	t ▼	External ▼	Renewable ▼	Measured val ▼
Textile	456.00	l ▼	Internal ▼	Non-renewabl ▼	Estimate ▼

◀ Add row ▶

Fig A.2 Integrating it for the entire Supply Chain

**360report** Report settings Reporting Export 2015 ▼ FAQ Glossary User settings Logout

Data Entry Tables Charts Save ⓘ

**Organizational Structure** ▼

- Tester GmbH
- Europe
  - Germany
    - Berlin
    - Munich
    - ✓ Hamburg
      - Hamburg Office
      - Hamburg Production
        - Production 1
        - Production 2
  - Austria
    - Vienna
    - Salzburg

**Indicators** ▼

GRI ▼

- G4-EN4 Energy consumption outside of the organization ●
- G4-EN5 Energy intensity ●

**3. Please provide information about the raw materials used.**

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	1,000.00	t	Internal	Non-renewabl	Measured val

◀ ▶

+ Add row

**4. Please provide information about the auxiliary materials used.**

Use the plus button to add more auxiliary materials.

Auxiliary material	Amount	Unit	Origin	Type of energy used	Measuring method
Gasoline	258.00	t	External	Renewable	Measured val

◀ ▶

+ Add row

**5. Please provide information about the operating supplies used.**

Use the plus button to add more operating supplies.

Fig A.3 Input text

360report Report settings Reporting Export 2015 - FAQ Glossary User settings Logout

Data Entry Tables Charts Save

**Organizational Structure**

- Tester GmbH
  - Europe
    - Germany
      - Berlin
      - Munich
      - Hamburg
        - Hamburg Office
        - Hamburg Production
          - Production 1
          - Production 2
      - Austria
        - Vienna
        - Salzburg

**Indicators**

GRI

- (Environment)\*
- Materials
  - G4-EN1 Materials

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	254.00	kg	External	Renewable	Measured value
Rubber	135.00	t	External	Renewable	Measured value
Plastic	2,000.00	t	External	Renewable	Measured value
Rubber	1,000.00	kg	Internal	Renewable	Measured value
Rubber 1	1,000.00	t	External	Renewable	Measured value

4. Please provide information about the auxiliary materials used.

Use the plus button to add more auxiliary materials.

Auxiliary material	Amount	Unit	Origin	Type of energy used	Measuring method
Gasoline	979.00	t	External	Renewable	Measured value
Textile	456.00	l	Internal	Non-renewable	Estimate

5. Please provide information about the operating supplies used.

Use the plus button to add more operating supplies.

Operating supplies	Amount	Unit	Origin	Type of energy used	Measuring method

Fig A.4 Output Texts

**Organizational Structure** ▼

- Tester GmbH
- ▼ ○ Europe
  - ▼ **Germany**
    - Berlin
    - Munich
    - ▼ ○ Hamburg
      - Hamburg Office
      - ▼ ○ Hamburg Production
        - Production 1
        - Production 2
  - Austria
    - Vienna
    - Salzburg

**Indicators** ▼

GRI ▼

(Environment)\* ▲

▼ Materials

Use the plus button to add more raw materials.

Raw material	Amount	Unit	Origin	Type of energy used	Measuring method
Plastic	254.00	kg	External	Renewable	Measured value
Rubber	135.00	t	External	Renewable	Measured value
	0.00	t	External	Renewable	Measured value
	0.00	kg	Internal	Renewable	Measured value
	0.00	t	External	Renewable	Measured value

**Number Value Aggregation**

- ▼ Germany 254.00
  - Berlin 254.00
  - Munich -
  - ▼ Hamburg -
    - Hamburg Office -
    - ▼ Hamburg Production -
      - Production 1 -
      - Production 2 -

the auxiliary materials used.

materials.

	Amount	Unit	Origin	Type of energy used	Measuring method
Gasoline	979.00	t	External	Renewable	Measured value
Textile	456.00	l	Internal	Non-renewable	Estimate

5. Please provide information about the operating supplies used.

Use the plus button to add more operating supplies.

Operating supplies	Amount	Unit	Origin	Type of energy used	Measuring method
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Fig A.5 Output texts 2