CHAPTER I

Introduction to the Study

1.1 Introduction

This thesis deals with the study of the supply chain of petroleum refineries, more specifically, with the supply chain activities such as sourcing of crude oil, its shipping, storage, refining, product storage, blending, and finally dispatch of products from the refinery for distribution, and sale.

Petroleum refining is a material flow intensive industry where supply chain cost amounts to 40% of total refining and distribution cost. Uninterrupted flow of inputs and outputs including byproducts and wastes with minimum facilities are crucial to cost effective and efficient operation of capital intensive, process oriented, tightly coupled system such as a refinery. Mithcelson [1992] has discussed the importance of materials management in capital intensive industries. Raw materials and logistics are very important to refineries as the former constitutes a significant component of the total manufacturing cost and the later seriously affects the output, productivity and profitability of the plant. Supply chain management bottlenecks have long term as well as short term impacts on the economics of a refinery. In order to understand the implications of supply chain in materials and energy intensive refineries in the changing global scenario, it is essential to know the scope, coverage and importance of supply chain in general and supply chain management in particular. Supply chain management focuses on the technical organization of the flow of goods and services in the value chain, from the supplier to the customer. Shell global solution have claimed that supply chain management (SCM) has shown that changes in demand forecasting, feed stock selection and optimization of distribution, supply, and manufacturing have positively impacted their bottom line.

SCM involves in the decision-making activities of inbound logistics, internal logistics, outbound logistics, service logistics, and reverse logistics of any
Offshore exploration

Onshore exploration

Stage I - Identification of Silos
Stage II - Sub Optimization within silos
Stage IIIa - "Test bed" coordination
Stage IIIb - "Inter functional" coordination
Stage IIIc - Integrated supply chain
Stage IV - Full Integrated includes suppliers and customers

Figure 1.1 Supply Chain Integration
industry. In the case of petroleum industry, application of service and reverse logistics is very limited because these two activities are not that common. Inbound logistics deals with all the activities starting from selection of crude oil to receiving of crude oil in the tanks at refinery tank farm. Internal logistics deals with all the operations starting from crude oil tank to the pumping of refined products to the tanks for final products. Outbound logistics deals with the operations like selection of transport mode for distribution of products, making arrangements for delivery of products, and distribution of products through the selected mode of transport. Figure 1.1 shows stages of supply chain integration.

1.2 Supply Chain Management

According to Lambert and Stock [1993], logistics, a widely accepted term by today's professionals, had in the past a variety of names including physical distribution, supply chain management and business logistics. The Council of Logistics Management defines logistics as:

"The process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements"

According to the above definition logistics consists of the following four flows:

Material Flow: Flow of materials from their sources through necessary processes including their storage, retrieval and the delivery of finished products.

Merchandise Flow: Flow of finished goods from finished good's stores in the distribution channels to the customers.

Money Flow: Flow of money including advances from organizations to suppliers of raw materials, energy, services, etc. and into organizations from the wholesalers, distributors, customers, etc.

Information Flow: Flow of required information from and into the organization through various communication channels in the logistics system.
Since, interruptions in any of the above four flows affect an organization's raw materials supply (purchasing), manufacturing (operations) and marketing (distribution) functions. According to Fawcett and Fawcett [1995], there exists a need to integrate these flows through effective management of infrastructure, materials, technology and people. The typical managerial decision problem that one encounters in real life while dealing with the management of above four flows of the logistics system is summarized in Table 1.1. In this thesis, the concern is with the supply chain management of an oil refinery. More specifically, it is concerned with the decisions on infrastructure facilities and transportation of crude oil to the refinery, and the movement of finished products out of the Refinery.

| Table 1.1 A Classification of Logistics Related Managerial Decision Problems |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| **Material Flow** | **Infrastructure Management** | **Materials Management** | **Technology Management** | **People Management** |
| Raw Material, Work-in-process, Finished Goods | Facility Location | Procurement | Equipment Selection | Organization |
| | Facility Design | Transportation | Systems and | Design |
| | Improvement of | Inventory Control | Procedures based | Job Specifications |
| | Existing Facility | Storage | on Technology | Incentive Schemes |
| | | WIP | | |
| | | Finished Goods | | |
| | | dispatch | | |
| **Merchandise Flow** | Selection of supply / distribution channels | Inventory Control | Mode of Transport and Handling | Organization |
| | Contract terms with members of supply / distribution channel | Distribution planning and scheduling | Equipment Selection Systems and Procedures | Design |
| | | | | Job Specifications |
| | | | | Incentive Schemes |
| **Money Flow** | Selection of Banks and credit/ payment arrangements modes | Budgeting | Equipment Selection Systems and | Organization |
| | | Accounting and cash flow management | Procedures based on Technology and regulations | Design |
| | | | | Job Specifications |
| | | | | Incentive Schemes |
| **Information Flow** | Selection of modes of communication | How often who will communicate what information to whom for taking what decisions? | In this case it acts through infrastructure and systems | Organization |
| | Design of logistic information system | | | Design |
| | | | | Job Specifications |
| | | | | Incentive Schemes |
1.3 Supply Chain Management Practices

In India approximately 13 percent of the GDP is spent on logistics (Planning Commission report-2002), whereas this Figure is only 10 percent for developed countries. Supply chain management and logistics are still in the embryonic stage in India. The current lull in the economy is forcing many industries to examine their costs, and cut it down in size. Today excellent logistics management has become essential for success of companies. Logistics function includes the total flow of material, from the acquisition of raw materials to delivery of finished products to the ultimate users. As such, it includes the activities of sourcing and purchasing, conversion including capacity planning, technology selection, operations management, production scheduling, materials planning, distribution planning and management of industry warehouse operations, inventory management, inbound, internal, and outbound transportation; linkage with customer service, sales, reverse logistics, promotion and marketing activities.

Successful supply chain management is extremely complex because of large number of players with varying interest or objectives are involved. Though the supply chain of each company has its own unique features, the following general principles help in management of supply chains.

- Begin with the customer
- Manage logistic assets
- Organize customer management
- Integrate sales and operations planning
- Leverage manufacturing and sourcing
- Focus on strategic alliances and relationship management
- Develop customer driven performance measures

A significant new trend has been evolving in logistics management in the last decade - one that involves the collaboration of all participants in the supply chain in order to reduce the cost of total logistics system. It has been referred to as “Supply Chain Management”, "Logistics Partnership" or "Inter-Corporate
Logistics Management. In traditional Logistics "total cost concepts" model, companies worked to manage logistics as an entity and to lower the total logistics costs to the organization. The model evolved balancing trade-off among production run lengths, inventory, transportation, and warehousing and customer service. Later an increasing number of companies realized that though the total cost concepts might be useful, it is tainted because it does not consider the efficiency of the entire supply chain. The supply chain management on the other hand involves the active collaboration of two or more participants in the supply channel (Supplier, manufacturer, distributor, and/or customer) to manage all the logistics resources in the most efficient manner possible.

The concept of "quick response" gained broad favour as companies in all parts of supply chain developed an appreciation of its potent benefits. Quick response involves the integration of the supply chain, effectively linking retailers, suppliers (manufacturers/ distributors) and carriers in close communication and integrated decision making. Key elements of quick response includes:

- Point-of-usage data capture
- Hem - level management
- Rapid Communication
- Partnerships
- Discipline and commitment

Effective quick - response systems' benefits include lowering inventories by as much as 40 percent, improving in-stock availability significantly, cutting transaction and administrative costs in to half, reducing replenishment lead to a third or less of their former levels, identifying slow-selling items sooner, and reducing operating costs for all players in the supply chain.

Supply chain management strategy involves determination of what performance criteria the logistics system must maintain - more specifically, the service levels and cost objectives the logistics system must meet. Because cost and service normally involve a trade-off, a company must consciously consider that trade-off and determine the desired supply chain performance. This process
involves consideration of the company's strategic objectives, its specific marketing strategy and customer service requirements and its competitors' cost-service position.

Supply chain planning involves the development and management of all logistics resources in order to attain the desired cost-service performance consideration, it might include number and location of warehouses, type of warehouses, mode and carrier selection, inventory position, inventory levels, order entry technologies and information system, and so forth.

Opportunities for differentiation - based on operational, logistics, or customer services excellence - are more likely to be exploited. Supply chain management tends to have a more visible and more important role in the Company. Investments in the supply chain function or infrastructure are more likely to be approved.

Just - in - time (JIT) Logistics: It is useful to classify JIT programs into two categories, JIT production and JIT logistics. These programs typically focus on the reduction of set up funds for key operations, the reduction of lot size, and the enhancement of quality - all leading to lower work - in - progress inventories. JIT logistics programs, on the other hand, apply JIT principles to the management of raw materials, inventories and beyond supplies. For JIT logistics plans to work, four 'Pillars' must be in place. They are:

- Stable production schedules
- Efficient Communication
- Co-ordinated transportation
- Quality control

These four principles are critical to the integrated management of suppliers.

The 1990s have been called the "decade of customer service". All industry sectors are placing a premium on quality, including quality customer service. Serving customers as they want to be served and "making company easy to do
business with" is competitive objective for the next millennium. At the same time
the meaning of effective customer service is changing, and companies must meet
an increasingly higher standard. Customer Service Pyramid is an effective
framework for formulating a customer service strategy in a fluid marketing
environment.

1.3.1 Logistics as a Process

According to Prof. Bernard La Londe of Ohio State University[1998],
logistics is not a focused functional activity but one that enables the integration of
activities across functions. An effective way to promote this expanded role for
logistics is to position logistics as a process, not as an activity or function. These
are three important sub-processes as part of the logistic process. They are:

- Integrated Production and distribution strategy development
- The replenishment process
- The order management process

A well-designed forecasting system can contribute significantly to logistic
performance. Many consumer products companies are trying to operate with a
25 to 60 per cent forecast error (on the stock-keeping unit level) in their one-
month- out forecasts. This error range wreaks havoc with inventory levels and
customer service performance. "Best Practice" companies, on the other hand,
consistently are able to achieve 15 to 20 percent forecast error rates. Companies
that perform poorly in their forecasting typically commit two or more of the "Six
of forecasting" given below:

- Letting finances drive forecasts
- Having no forecast "owner"
- Having insufficient analytical support
- Using a single forecasting approach for every thing
- Having no sales and operations planning meeting
- Failing to track forecast error.
Many companies are discovering that distribution resource planning (DRP) systems can reduce costs, improve customer service, and better their inventory management. DRP systems provide a full view into the warehouse network by first examining demand at the end of the channel and accumulating requirements back through the warehouse network. This approach allows for full visibility of needs and better management of inventories. DRP involves both inventory management and distribution planning. A module of distribution requirement planning (DRP) extends the concepts of materials requirements planning in to a multi-echelon-warehouse inventory environment. The results are time-phased replenishment schedules for moving inventories across the warehousing network. DRP offers an accurate simulation of distribution operations with extended planning visibility, allowing logistics departments to manage all resources better.

1.4 Literature on Importance of Supply Chain

The last decade of this century has seen many significant changes. The important ones are: the end of cold war, breaking up of the former USSR, formation of trade blocks (EU, ASEAN, NAFTA, etc.), emergence of World Trade Organization, and globalization of World Economy. Feasibility of global sourcing and marketing of quality products and services at competitive prices in the world market have called for serious re-look into the logistics functions in such industries as steel, cement, fertilizer, chemicals, petroleum, etc., where logistics cost forms a significant component of the cost of goods sold. Gyula et. al.[1994] and Scully and Fawcett[1993] gives details on global manufacturing.

Based on a survey of 1000 major European companies, Kearney[1995] observes that logistics function is becoming more demanding and complex as the business environment itself is becoming complex and demanding. The critical factors responsible for demanding logistics management are: (1) Escalating customer expectations and demand, (2) Cycle time compression, (3) Global sourcing, (4) Global market, (5) Corporate restructuring, (6) Supply chain partnership, (7) Productivity pressures and (8) Environment awareness. In-spite of the above challenges, revolutions in communication and information
Figure 1.2 Three important flows in a supply chain

Though supply chains have existence since the beginning of civilization, this name and associated approach to looking at the issue is new. The focus so far in the area has been to look at different aspects of the supply chain such as procurement, storage, production, distribution etc, separately and there are different specialists for each. An integrated view of the links as parts of a supply chain is of quite recent origin. Therefore, when one changes the focus from different functional areas to the supply chain concept, some fundamental issues arise that need to be addressed.

The entities of the chain or the departments of the supply chain become dominant and try to form sub-goals and achieve them at the expense of the total supply chain goal. Different entities in the supply chain have different strength. This leads to a condition that the chain is only as strong as the weakest link. The extra money spent in making some areas of the supply chain very strong is wasted because this extra strength does not in practice contribute to the operation of the total supply chain significantly. In a chain if two adjacent rings are not connected the chain is not one but two. The same is the case with the case of a supply chain where strong connections between adjacent links are vital for its existence and functioning. These are called supply chain disconnects. The presence of a loop or a cross-link in the supply chain creates multiple paths to choose from one end of the chain to another. At each such loop or cross-link the conditions under which each path should be taken should be spelt out clearly.
Looping and cross linking of supply chains create many information flow problems, information about the same thing coming from different links might not be at agreement. It has been found that in most supply chains there are people to study and look at the individual departments, because of the organizational structure followed, but almost no one looks at the supply chain as such in total. It is the performance of this complete chain that ultimately matters.

1.6 This study and its objectives

This study was started in September 1998, at the time of dismantling of Administered Price Mechanism (APM) in India. The objectives of this study are:

1. Model development for selection of location for refinery in India and identification of characteristics to be looked into when configuring it.
2. To develop models for integrated supply chain planning for a refinery.
3. Overall design of a logistic information system for a refinery.
4. To make a detailed study of the supply chain management in an Indian refinery and make suggestions for improvement.

1.7 Scheme of the Study

This thesis is organized under seven chapters. In the second chapter presents a survey of literature relevant to the study. The third Chapter discusses world petroleum industry and Indian petroleum industry along with the model to find out the location for a refinery and the importance of maintaining flexibility in refinery. The fourth chapter deals with models for supply chain planning for a refinery. The fifth chapter is dedicated to the information flow in inbound logistics, internal logistics, and external logistics. Kochi Refineries Ltd. and strategies for its long-term supply chain improvement form the ground of the sixth chapter. The findings from the data collected and recommendations related to this area are presented in this chapter. In the last chapter presents the summary of findings and recommendations, and discuss scope for further related work.
CHAPTER II

Review of Literature

2.1 Introduction

In this chapter, a review of literature is carried out. Theoretical concepts in the area of SCM are reviewed. SCM being a practice-dominated area, SCM practices in industry, reported in the literature is reviewed. Since this work focuses on petroleum oil refinery, logistics literature in this area is also presented. Since supply chain management is broad area, for clarity of presentation, we have divided the literature in to nine section covering areas such as location, flexibility, planning, etc. Application of Information Technology and its advantages are investigated.

Theoretical literature is reviewed first to get a strong foundation on concepts. Application of those theories in industrial environment is analyzed next. Industrial applications are divided in to service and manufacturing sector. Literature on manufacturing is again sub-divided in to discrete and continuous. Refining of petroleum products literature is reviewed towards the end in all the sections discussed in this chapter.

2.2 Concept of Supply Chain Management

Supply chain management literature offers many variations on the same theme when defining a supply chain. The most common definitions [See for example, Jones and Riley [1984], Houlihan [1985], Stevens [1989], Scott and Westbrook [1991], Lee and Billington [1993], and Lamming [1996]] are a system of suppliers, manufacturers, distributors, retailers and customers where materials flow down stream from suppliers to customers and information flows to in both directions. Main definition of a supply chain is from Stevens [1989] who defines it as:

"A connected series of activities which is concerned with planning, coordinating, and controlling material, parts, and finished goods from supplier to
customer. It is concerned with two distinct flows (material and information through the organization)"

Oliver and Webber [1192] state that the supply chain should be viewed as a single entity that is "guided by strategic decision making". Gentry [1996] included the carriers in supply chain. O'Brien and Head [1995] included governments as part of the chain. Managing the supply chain would include all the issues associated with the government regulations and customs. Towill [1997] argues that the definition needs to be flexible. Houlihan[1985] is credited with coining of the term supply chain. Cooper, Ellram, Gardner, and Hanks [1997] suggest that the span of management control should be determined by the added value of any relationship to the firm. Houlihan [1985] makes it clear that the differentiating factor between the integrated logistics and supply chain management is the strategic decision making as part of supply chain management.

2.3 Evolution of Supply Chain Management

The literature suggests that SCM has its roots in the evolutionary path followed through materials management and physical distribution after the Second World War, functional logistics (different managers for each functions) and integrated logistics (one manager for all functions). Forrester [1958] justifies the first step beyond functional logistics by using a systems analysis approach. Bowersox [1969] discussed the evolution of integrated logistics. Theoretically development of SCM has different stages. Langley [1992] suggests four stages of development. (1) Cost control, (2) profit centers orientation recognizing the positive impact on sales, (3) view of supply chain as key to product differentiation, and (4) as a principal strategic advantage. Masters and Pohlen [1994] describe the evolution of supply chain in to three phases. (1) Functional Management [1960-1970]-functions such as purchasing, shipping, and distribution, each managed separately. (2) Internal integration [1980s]- the management of such supply chain functions of a single facility is identified and becomes the responsibility of a single individual, and (3) external integration [1990s]-the management of supply chain functions throughout the chain. La
Londe [1994] describes the evolution of integrated supply chain in three phases. (1) Physical distribution – distribution of goods is all that needs to be managed by a logistics manager. (2) Internal linkages it is important for the logistics manager to control both internal supply functions and physical distribution. (3) External linkages logistics management requires co-operation in the management with upstream and downstream entities in order to maximize the benefits of the total logistic system.

Industrial application of supply chain pioneered the concept of (1) integrated logistics that eventually came to be called SCM (Bowersox [1969], Slater [1976]), and (2) partnership lending and management [Slater [1976], Gentry [1996], and Walton [1996]]. Forrester [1958] predicated that the introduction of computer and the adoption of many mathematical models and other optimization tools had a great impact upon the development on supply chain. In 1960’s, Bowersox [1969] notes that computers emerged from their infancy and formed application in physical distribution. Slater [1976] argues that a total systems approach to the logistics channel will reduce total cost and considerably improve the overall quality of the operations. Fuller [1993] states “logistics has the potential to become the next governing element of strategy as an inventive way of creating value for customers, an immediate source of savings, a discipline on marketing, and a critical extension of production flexibility”.

In the last two decades, logistics slowly evolved in to SCM. Houlihan [1988], Copanino and Rosefield [1992], Lee and Billington [1993], Fuller [1993], Thomas and Griffin [1996], Gattorna [1998] and Mitra and chatterjee [2001] have tried to account for the increasing awareness and implementation of SCM. To have maximum benefit, the supply chain must be managed as a single entity.
Firms must avoid sub-optimization through self-interest at any link in the chain by managing the entire chain as a single entity while simultaneously dealing with the power relationship that are inherent in the chains. Baganha and Cohen [1998] point out that application of the variability of demand in the supply chain has been recognized and described. Bhaskaran [1996] notes that manufactures have recognized the need to optimize the performance of the supply chain connecting raw material to the finished product. Gavirneni, Kapuscinski, and Tayur [1998] note that the focus of managing the supply chain has led to radical changes in thinking about supplier/customer relations.

Stevens [1998] suggested that integrating the chain elements has to be done for the improvement in SCM performance. Stock and Lambert [1992] observed that to become a world-class company, a company must focus on logistic integration. Bowersox and Daugherty [1995] identified that logistic integration will be possible by the development in information technology. Cooper, et al. [1997] made it clear that SCM is not the integration of logistics alone, it is the total integration from vendor to customer. Kopicki [1999] identified that developing countries are investing in supply chain to compete in the world-class marketing. Sahay [2001] suggests that managing supply chain is the only way to meet the global challenges. Paul, et al. [1998] identify the changes in definition, growth and approaches. It is noted that integration using information technology and strategic planning are areas of focus now. Gilmour [1999] made some efforts to benchmark supply chain operations. Bench marking SC operations is useful in performance improvement.

From the above literature review it is clear that SCM focus in refinery is a pertinent research problem. It is also clear that an integrated supply chain approach and use of information technology should be taken in SCM studies.

2.4 Location for a New Refinery

Planning the size and location of facilities are traditional problems. It has been established theoretically the importance of location for industry in the SCM context. Weber [1922], Beckman [1968], and Drezner [1995] have addressed the problem by applying the methods of operations research. Hall [1987], and
Daganzo [1996] have tried to solve the location of transportation terminals as an optimization problem. Campbell [1990] developed a continuous approximation model for relocating terminals to serve expanding demand. Noritake and Kimura [1990] developed models to be identified with the optimal size and location of a seaport using separable programming technique. Eichi Taniguehi et al. [1999] suggests a mathematical model for determining the optimal size and location of a logistics terminal. Ganeshan and Terry [2001] suggest that there are four decision areas in SCM (1) Location (2) Production (3) Inventory (4) Transportation. Ioannis et al. [2000] make an analysis on supporting decision makers in land use planning around chemical sites. Min and Melachrinoudis [1999] analyze the relocation problems of a distribution facility and Papazolon et al. [1999] discuss the risk involved in decision making in land use planning. Kuehn, et al. [1963] have used a heuristic programme for locating a warehouse. Geoffroin & Arthur [1976] predict the scope of computer application in selection of location. Hamel, et al. [1985] point out the importance of location when a company is planning for global marketing. Khumawala, et al. [1971] made a comparison of some warehouse location techniques. Klassen, et al. [1994] have identified the barriers in international operations. They have identified location of the plant as one of the major bottlenecks in global marketing. Fordows & Kasra [1997] suggest to find the location correctly for foreign companies. Agostino Villa [2001] introduces some SCM problems. Importance of location is stressed in this article. Mac Cormek, et al. [1994] note the new dynamics of Global manufacturing site location. Porter [1990] suggests the competitive advantage of nations in the location selection especially for continuous manufacturing. Nation must be selected on the basis of target market. Lee & Larry [2002] note that the term globalization describes business deployment of facilities and operations around the world. Globalization results in more exports and imports. East Asia has become the fastest growing and foremost trading regions in the world. They have identified six groups of factors, which dominate location decision for a new plant. Location selection is a very vital decision, which has long-term implication. This strategic decision is not easy to solve because (1) uncertainty of future (2) complexity and conflicting factors associated with the
site selection problem, and (3) constraints and limitation of resources to produce site. Pair wise compassion of factors gives fairly good results for site selection.

Literature shows that the location for refinery must be first selected on a global basis due to the global competition. When looking on the global basis, it will come to a country to setup a refinery. The selection of country can be solved as a non numeric problem. Selection of the country can be followed by state selection and location selection. This can be solved with composite method. Final site selection can be made with the help of numerical solution. So the selection of locations for a new refinery is possible with the integration of both quantitative and qualitative techniques. Selection of site for production setup is complex when compared to the selection of location for a warehouse. Warehouse problems can be solved with operations research or techniques. But manufacturing location selection can not be solved with the help of techniques alone. Composite techniques are ideal for finding out suitable location for a process industry like refinery.

2.5 Flexibility of Resources

Theoretically flexibility is more important for industry with continuous production. Lee and Larry [2002] say that manufacturing process that can be changed easily to handle various products is flexibility. The ability to reprogramme process is useful for high customization. Nemetz and Fry [1998] describe the characteristics of a flexible manufacturing organization. Eric and Amitabh [2002] discuss the sources of volume flexibility and their impact on performance. The inventory will be minimum if the organization can control the volume at sources itself. Cox Jt. [1989] suggests methods for measuring flexibility in manufacturing. This method will give an idea how flexible is the organization. George [1994] and De Toni and Tonchia [1998] discuss the advantages of flexibility in production process and the organizations with flexibility in the competitive market environment. Fiegenbaum & Karnani [1991] studied the competitive advantage for an organization with flexibility in output. Product range can be maximum so it will satisfy more customers. Savoie [1998] describes flexibility as the last word on supply chain improvement. He suggests
that only flexibility can improve a well performing organization. Huchzermeier and Cohen [1998] prove that exchange rate value change risk can be minimized by operational flexibility. This is more useful for organizations, which are operating in the export marketing. Eric and Amitabh [2002] establish the drivers and sources of volume flexibility. They argue that short and long-term sources of volume flexibility have a positive, albeit differential impact on a firm’s performance. A refinery has less resources flexibility because it is a process industry. Identifying flexibility resources will give performance gain for a refinery also.

Flexibility is needed for projects with long life. Short life projects need not have flexibility because the project will be completed before any significant change in technology occurs in market or resources. Projects with longer life are prone to undergo changes in all areas, so there must be provision for adoption of changes. Flexibility must be incorporated at the time of design and implementation itself. A process industry like refinery exists for quite a long period and a lot of changes will take place in the field of refining. So a refinery must identify the areas where they have to be flexible to remain competitive in the market.

2.6 Supply Chain Planning

Planning for all organizations includes both long term and short term to have better performance. Planning can be divided into strategic and short term. Literature on both the types is sufficient to have good idea on planning. Kogut [1985] gives an idea how to design a global strategy to have a comparative and competitive value added chains. Tyndall [2000] discusses the global challenges in supply chain. Lambert, et al. [1998] have discussed on the issues on implementation of SCM. Bnges [1998] & Evans, et al. [1995] suggest steps to avoid failures in SCM. Ganeshan & Terry [2001] and Beth [2000] suggest the importance of strategic planning. They also observed that if the margins are going down, look at the performance of supply chain. Bridleman, et al. [1997] note that the situation in process industry and make-to order industry are different. Scope for SCM is more in process industry such as petroleum refinery.
Eliram, et al. [1990] noticed that the relationship with shipper is important in process industry. Partnership is the most efficient method in the third party logistics. Johnson, et al. [1995] observed that SCM is the best method to gain an edge over the competitors. Inventory reduction and flexibility are the main reasons. Lee, et al. [1992] discuss the problems and opportunities associated with supply chain inventory. He has developed a mathematical model for the reduction in inventory. Production, planning and control using fitter theory is done by Towill and Del Vecchio [1994] for supply chain dynamics. The performance measurement procedure is developed by Beaman [1999]. As per Jones and Riley [1985] inventory must be used for the competitive advantage through SCM. Lee and Billington [1993] suggest that material management will be complex in decentralized supply chain. Mathematical model is also developed for the decentralized supply chain. Lee and Billington [1995] highlights the evolution of supply chain management models and practices in the industry. Bowersox [1997] observed that world class leaders in industry have better control over their supply chain. Cavinato [1999] developed a cost/value model for supply chain competitiveness. Cooper and Eliram [1993], and La Londe [1997] identified characteristics of SCM and its implications on purchasing and supply chain strategy.

2.6.1 Strategic Planning

The importance of long term purchasing planning is emphasized by Carter [1996]. Chan & Huff [1997] suggest that the strategy for purchasing must be focused on customer requirement. Zahra and Covin [1993] have suggested that purchase strategy must be in tune with the policy and performance of the organization. The importance of knowledge management for developing strategy for an organization is discussed by Morten [1999]. Procedure for checking the performance of strategy is developed by Robert, et al. [2000]. Literature shows the development and importance of strategic planning in process industries. Peter and Richard [1976] give guidelines for designing strategic planning. The importance of control of production on the basis of strategic planning is discussed by Burbidge [1984]. Jones and Riley [1985] suggest the use of raw material inventory for the competitive advantage through SCM. They suggest
that the long term planning will have a better control on the raw material inventory and they add procedures for systematic planning. Ballint Jin [1993] recommends method for optimizing the level of inventory in a refinery. A mathematical model was developed for finding the solution. Mac Berth and Ferguson [1991] have identified the strategic aspects of SCM. They have suggested that having a strategy for the purchase as well production and marketing will improve competitiveness. Porter [1996] clearly defines strategy as the long term planning for an organization. The length of plan period must be divided depending on the nature of business. Andrew & Alexander [1997] suggest the precautions to be taken in strategy. If proper planning is not there for short period, then the strategy will fail. Hierarchical planning is important for the best performance of the organization, Pagh and Cooper [1998] discuss the supply chain postponement and speculation management. They are suggesting that the final decision on the product must be delayed as much as possible to have better customer satisfaction. Tyndall, et al. [1998] suggest methods for increasing the value through global operation. Miller [1998] suggested methods for making strategy and structure. Fredric [1986] suggests methods for strategic decision for developing organization structure. He suggests the need for a designed infrastructure for the development of an organization with strategic planning. Morash, et al. [1996] suggest that long term planning in logistics capabilities is essential for competitive advantage and success of the organization. Sahay, et al. [2001] also suggests that to meet global challenges long term planning is essential through out the chain. Harwick and Tom [1997] thought on optimum decision making for the supply chain. Optimum decision in logistics planning is essential for the global competition. Porter [1980] developed a competitive strategy for analyzing the performance of an industry. Oral and Dominique [1989] make an analytical approach to competitive strategy formulation for an industry. Young [1991] suggested that manufacturing must be given more importance in developing strategy.

[1995] developed a framework for logistics framework. Integration of logistics with strategic planning is the objective. Theodure, et al. [1998] suggest that logistic strategy is at a cross road now. Integration must be considered for strategic planning. La Londe and Masters [1994] suggest that strategic planning for logistics is the blue print for success in the next century. Process industries like refinery need long-term planning for the existence in the competitive global market. Strategic planning is essential to maintain the correct sequence of information flow for decision taking in a refinery.

2.6.2 Hierarchical Planning

Theoretically hierarchical planning is required for a process industry. Some of the decisions must be strategic where as some other decisions must be daily. The planning procedure also must be different. Hans and Wolfgang [1992] suggest the importance of strategic planning. They are claiming that to have competitive advantage an organization must plan for developing edge over others. Managers do short term planning. Importance of supply chain planning model development is discussed by Fisher [1997]. He suggests that each industry must have its own unique model. Raghuram [1999] suggests that there must be specially designed long term planning procedure for each organization. Focus required in purchase is discussed by Murray [1998]. Miller [2001] stresses the importance of hierarchical planning in supply chain management. Hartveld [1996] discusses the hierarchical planning importance for a chemical industry. Haulilan [1985] also suggests the importance of hierarchical planning importance for international marketing. Bechtel [1993] gives the use process industry modeling system for the efficiency improvement of planning department. Pinto, et al. [2000] have developed a planning and scheduling model for a refinery.

Firstly, the development of a non-linear planning model for refinery production is presented. The model is able to represent a general refinery topology and allows the implementation of non-linear process models as well as blending relations. Considering the market limitations for each oil derivative usually supplied by the refinery, the optimization model is able to define new operating points, thus increasing the production of more valuable products while
satisfying all specification constraints. Real-world applications are developed for the planning of diesel production in refinery in Brazil. The second part of the work addresses scheduling problem in oil refineries with mixed integer optimization models and rely both continuous and discrete events representations. The paper also discusses the development and selection of optimization models for short-term scheduling of a set of operations that includes, product receiving from process units, storage and inventory management in intermediate tanks, blending in order to attain oil specifications and demands, and transport sequencing in oil pipelines.

2.7 Integration of Operations

Optimization at different levels is common in all industries. In production a lot of researches have been taking place. Some literature is available on inbound logistics and more work has been carried out in outbound logistics. Stevens [1986] presents the importance of integrating supply chain. He suggests that total integration alone will improve the performance. Lambert, et al. [1979] notes the appraisal of the integrated physical distribution. Total integration is not covered in this paper but importance of physical distribution is discussed. Towill [1991] discusses the dynamics of supply chain. In his paper the importance of inbound logistics is discussed. Stevens [1989] and Stevens, et al. [1989] suggest integrating from supplier to the end customer. Use of decision models are also discussed in this paper. Dieasli [1984] discusses the importance and application of functional integration. Back, et al. [1996] compared the performance and procedure of reengineering with SCM. Bell & Stukhast [1986] studied and identified the attributes of material management.

identified the importance of resource identification to have competitive advantage in the market. Bowersox [1997] states the importance of integrating the operations of an organization. Integration, to the customer side and supplier side is discussed. Amundson [1998] suggests the importance of theory driven researches in the field of SCM. In his paper it is noted that the application of research can be made only by integrating the results. Patterson [1999] discusses decision integration between manufacturing and marketing/sales and Scott, et al. [2002] compare that with original performance to establish the benefits of decision integration. Lenz [1981] identified integration as one of the determinants of organizational performance for a refinery. Stevens [1989] also suggested that integration is the only way for improvement of supply chain. Narasimhan and Carter [1998] stress the importance of linking business organization within material sourcing strategies. Wisner and Stanley [1999] developed an integration model for internal relationships and activities associated with high level of purchasing service quality. Narasimhan & Kim [2002] studied the effect of supply chain integration on the relationship between diversification and performance. Diversification is easy in an integrated organization. The performance will be improved by integration Mohan, et al. [2000] suggest that E-commerce can be used for integrating the customer and organization. Sahay, et al. [2001] suggest a framework for developing customer relationship. Eliram and Cooper [1990] make the point that developing partnership with shipper will make the scheduling and movement of materials more efficient. Lewis and Talalayevsky [1997] add the application of integration of logistics operations using information technology. Lewis, et al. [1997] suggested an integrated approach to reengineer material and supply chain control in a process industry.

2.8 Information Technology

Operations of SCM are widespread. Supplier may be at one place, operations in another place, and market can be in the third place. For a company which is doing international marketing, the market will be at different continents. So the integration of operation is really complex. Blois [1980] identified the need
of information for orientation of manufacturing. The focus is on information from market. Balcer and Lipman [1984] suggest the need for technology adoption in information gathering. Broinarezyk & Alba [1994] notice the role of collection of information from consumers for process planning. Deveport and Short [1990] identify the need for redesigning the business process to make use of the development in information technology. Jones and Clarke [1990] made the point that effectiveness of SCM can be made only through integration of information.

performance and predicted that it will reduce the inventory. Lin & Shaw [1998] suggest methods for re-engineering the order fulfillment process in supply chain network. Srinivasan, et al. [1995] identify that the increased speed of data flow can be achieved using information technology. Gustin, et al. [1995] suggested that the integration of logistic is achievable with the development in information flow. Mason Joues and Towill [1998] note that time compression in the supply chain information management is the vital action required for benefiting SCM performance.

Many organizations have recently recognized that sharing of information with other members in their supply chain can lead to significant reduction in the total cost. Gairneni [2002] suggests that information flow can be used for reducing fixed ordering cost. Cochran & Fisher [2002] note that inventory management will be efficient by information sharing. Many recent papers study the direct effect of supply chain information sharing. This line of research includes Cachon & Fisher [2000], Xiande, et al. [2002], Mehmet. et al. [2002]. Decter [1997] identified the importance of data acquisition and team building. In that paper the importance of team is discussed for the development of information sharing. Thouemann [2002] identifies the improvement in supply chain performance by sharing demand information from the market. Kefeng, et al. [2001] suggest that information technology can better co-ordinate the supply chain activities. Lode-Li [2002] writes on the importance of information sharing in a supply chain with horizontal competition.

Literature shows that increasing use of Information Technology is the main reason for the success of SCM. Application of information technology is inevitable for any industry to implement SCM. Information sharing is the essence of speed of material flow. Literature shows that the sharing of information must go up to the supplier. So that they can also plan their production and delivery of goods. A model for information flow is essential to have efficient functioning. Efficiency of the information flow depends on the selection of technology and the appropriateness of information flow model used.
2.9 Tools Used in Supply Chain Management

SCM integration has to take place after optimizing all the elements of SCM operations. Optimization can be achieved only by the use of tools. Many tools are available in literature and a series of studies are taking place for developing new tools. Mohauty & Desutch [2001] emphasize the application of Decision Support Systems (DSS), and Linear Programming for the successful implementation of supply chain management.

2.9.1 Decision Support Systems (DSS)


Simulation in earlier stages were done using programme written using Fortran or other general-purpose computer languages. Developing logic and coding was very complex and time consuming and naturally the quality was also not very good. Expertise was essential for doing simulation. Packages like GPSS, SIMAN, SIMFACTORY, EXTEND, etc. came to help in the next stage. Developing simulation with package was much faster and simple. Still it could not be used as a general-purpose tool. The development of Object Oriented Languages made the use of simulation more popular. Speed of developing
simulation programme reduced drastically because of splitting of operations to objects. Finally the development of Agent Based Simulation made the use of simulation simpler. Agents are developed for doing the simulation.

2.9.2 Optimization Tools.

Jansen warns about the usage of changes. If not carefully done, the variations in results will not have any use. Variable selection must be in line with actual variation in the organization. Vehicle scheduling problem was formulated and solved by Foster and Ryan [1976]. They have used integer-programming approach. Li-Hsing Shih [1997] used mixed integer programming method for planning coal imports. Efficiency of supply chain vehicle scheduling problem was formulated and solved by Foster & Ryan [1976]. They have used integer-programming approach.

2.9.3 Demand Forecasting Methods

Demand forecasting has history of long standing. All types of industry needs demand forecasting for the material flow as well cash flow control. Forecasting demand for the products of a refinery is a similar problem when compared with other industries. Li-Hsing Slil [1997] used mixed integer programming method for planning coal imports that has a bearing on the correctness of demand forecasting. Battachargee [1998] noticed the importance of demand forecasting and claims that it is the major bottleneck in world class marketing. Laugly & Halcomb [1992] suggest that the customer value of the product decides the demand. Mass customization is discussed in the paper. Mentzer [1993] identified the importance of outbound channel management for better demand forecasting. Min & Mentzer [2000] emphasis the role of marketing in supply chain performance. Marien [2000] identifies demand forecasting as one of the major supply chain enablers. Muller [1991] discusses on competitive advantage through customer satisfaction for SCM. Lee, et al. [1997] suggests that the distortion in information as it passes up the supply chain is the reason for bullwhip effect in the demand forecasting. Melters [1997] has quantified the bullwhip effect in supply chain. It is also mentioned that it can be reduced by proper data collection. Federgruen and Zipkin [1989] introduced an inventory model, with limited production capacity. Lee, et al. [1997] studied the bullwhip effect in supply chain and found that bullwhip effect is the most important limiting factor in the performance of supply chain. Clen, et al. [2000] have quantified the bullwhip effect in a supply chain. The impact on forecasting, lead-time, and information are discussed in the paper.
Models are established with the help of case studies. Case studies provide data for checking the models developed. Eisenhurt [1989] did in the other way also. He was establishing that theories could be build from case studies. Stuart, et al. [1998] make point that case studies leverage the understanding. Meredith [1998] also suggested that theory with case study makes better understanding of the theory. Thomas & Yunsook [2002] developed the structure of supply network. It was established with the case of Honda. They compared these cases to establish the importance of supply network [outbound logistics]. Lamming, et al. [2002] did an initial classification of supply chain in to, inbound, internal, and outbound logistics. It was established in a case study.

Forecasting is the first major activity in the planning. It involves careful study of past data and present scenario. The main purpose of forecasting is to estimate the occurrence, timing or magnitude of future event. If the required level of accuracy for the forecast is less, then prediction is on the basis of past data and experience. It is not based on any analysis. To know the future demand on the basis of the demand in the past, extrapolation method can be used. The demand is forecast on the basis of data collected in the past. Volume of data is depended on the policy of forecasting. Morphological analysis can be done for finding out the consumption of petrol or diesel per head in a state or district. Literature shows that forecasting methods must be used for demand forecasting. Trend analysis is one of the commonly used methods for demand forecasting in a process industry.

2.10 Conclusion

Some of the major contributions to the existing vast literature in SCM are briefly reviewed. The literature survey was started with review of literature on concepts, definition and evolution of SCM. From the above literature survey it was seen that as time passed, researches have been widening the scope of SCM to the present status where it covers planning, coordination, controlling, materials, parts, and finished goods from original supplier to final customer focussing on material and information flows, guided by strategic decision making. The literature review brought out the importance of study of integrated SCM using IT.
The literature review on sub problem related to supply chain such as location selection, operational flexibility, strategic planning, hierarchical planning has established their importance in the case of petroleum refinery SCM. The importance of integration of operations and use of information technology to do the same was also seen in literature. SCM integration has to take place by integrating the optimum performing sub elements. Optimization and decision support systems tools used were reviewed. It was seen that mathematical programming tools are more popular in structured small size problems. Fussy logic methods are also popular; simulation models are increasingly being used in supply chain systems. Demand forecasting methods were reviewed and the problem caused by bullwhip effect in supply chains was found to be an important limiting factor for forecasting systems. Morphological analysis was seen to be another approach that could be used for product demand forecasting for a refinery for long term.

It was seen that different aspects of SCM in general and certain SCM functions of petroleum refinery in particular have been studied by researchers. A vide verity of tools have been used to solve the problems. The studies focussed on optimizing sub processes of the supply chain. Integration of the complete supply chain was not to be found. This presents opportunity for work on developing integrated supply chain for refinery.