MAJOR PROJECT

RISK POOLING THROUGH LATERAL TRANSSHIPMENT IN MULTI RETAILER SUPPLY CHAIN INVENTORY SYSTEM

Submitted in partial fulfillment
of the requirement for the award of the degree of

Master of Engineering
In
Mechanical Engineering
(Production and Industrial Engineering)

Submitted By
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01/ME/02

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CERTIFICATE

This is to certify that the dissertation entitled **"RISK POOLING THROUGH LATERAL TRANSSHIPMENT IN MULTI RETAILER SUPPLY CHAIN INVENTORY SYSTEM"** being submitted by Atul Sidola, Roll No. 3301, in partial fulfillment of the requirements for the award of degree of "Master of Engineering" in "Production and Industrial Engineering", has been carried out under my supervision and guidance.

The matter embodied in this thesis has not been submitted, in part or in full, to any other University or Institute for the award of any degree, diploma or certificate.

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ACKNOWLEDGEMENT

*I wish to express my deep sense of gratitude to my erudite project guide **"Dr. O.P Sharma"**, Professor & Head, Deptt. of Training & Placement, Delhi College of Engineering, Delhi. I owe his overwhelming debt for helping me to plan the content of this project and discussing important points of this project. His ideas, stimulating comments, interpretations and suggestions increased my cognitive awareness and helped considerably in the fruition of my objective. I remain obliged to him for his help and able guidance through all stages of this project. His constant inspiration and encouragement to my efforts shall always be acknowledged. His observation and comments were highly enlightening. I am also grateful to Dr. Ravi Shankar for his help and guidance in my project.*

I also sincerely acknowledge the help of all the people, who directly or indirectly helped me in my project work and constantly encouraged me.

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ABSTRACT

Lateral Transshipment is very an effective means of reducing total cost of the system, as well as improving the service level. The objective of this study is, to explore the implication of pooling on multi-Retailer supply chain inventory system, with one central ware house, with varying demand and varying lead time at each retail outlet. The product is either sold out or remains as a surplus. This surplus is transshipped to the other retailer having shortage. This way, both the holding costs and shortage costs of the total system are reduced and improvement in the service level. Here as an illustrative case with one central warehouse and three retail outlets have been considered. The demand and lead-time are randomly generated. The study is for perishable goods such as fruits and vegetables.

This work demonstrates the benefits of lateral transshipment in terms of reduced total system cost and improve in customer service level or overcoming the uncertainty of demand and lead-time. This study also shows that risk pooling through lateral transshipment is effective, when unit lateral transshipment cost is low. One more conclusion we can drive from this study is that all members participating in pooling should be located near to each other.

NOTATIONS USED IN THE MODEL

$E(CH)$	Expected Cost of Holding
$E(CO)$	Expected Cost of Stock Out
$E(CT)$	Expected Cost of Lateral Transshipment
C_h	Unit Holding Cost
C_P	Unit Stock Out Cost
C_t	Unit Transshipment Cost
$E_1(C)$	Expected Cost With Lateral Transshipment
$E_2(C)$	Expected Cost Without Lateral Transshipment
H_i	Surplus Quantity for Retailer i
O_i	Stock-Out Quantity for Retailer i
X_{ij}	Transshipment Quantity from Retailer i to j
M	Maximum Level of Inventory
D_i	Demand for Retailer i
D_m	Mean Demand
R_L	Reorder Level Quantity
Q_i	Order Quantity of Retailer i
Q_{ti}	Intransit Inventory for Retailer i
T_i	Total Inventory Available of Retailer i
S_i	Surplus Inventory of Previous Day
Q_{ri}	Inventory Reached That Day to Retailer i
L_i	Lead Time for Retailer i
R	Review Period

l_m	Mean Lead Time
$SL1$	Demand Service Level
$SL\ 2$	Period Service Level
N_O	Total no. of Stock out Periods
N_T	Total no. of Orders Periods
σ	Standard Deviation
WO	Without Transshipment
WT	With Transshipment
i	1,2,3

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3 INTRODUCTION AND LITERATURE REVIEW

3.1
1.1 GENERAL

The supply chain, consists of suppliers, manufacturing centers, warehouses, distribution centers, and retail outlets, as well as raw materials, work-in-process inventory, and finished products that flow between the facilities

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed as the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements.

Supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores; it encompasses the firm's activities at many levels, from the strategic level through the tactical to the operational level.

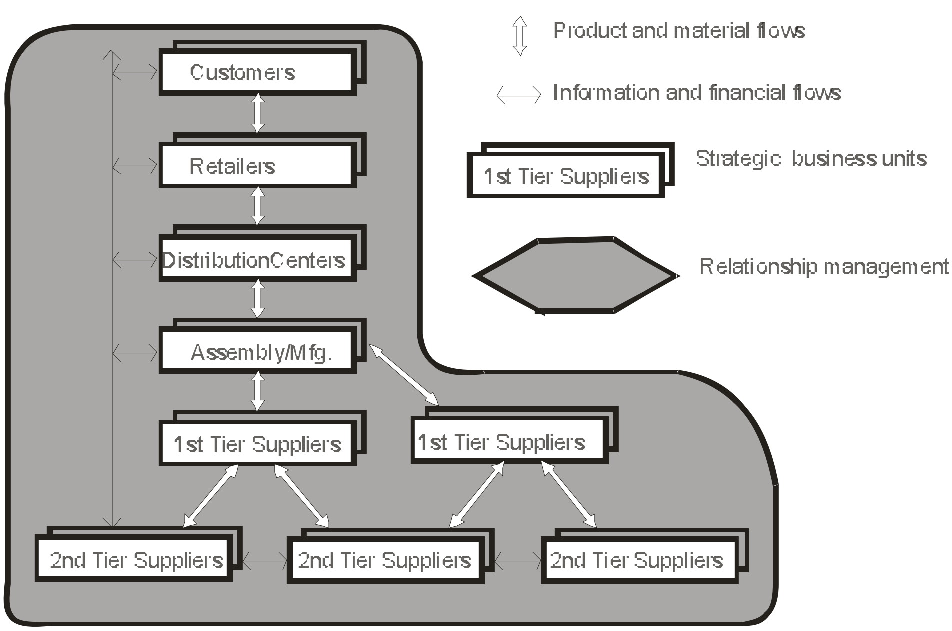

Fig 1.1 Integrated Supply Chain Model

In a typical supply chain, raw materials are procured, items are produced at one or more factories, shipped to warehouses for intermediate storage and then shipped to the retailers or customers. Consequently, to reduce cost and improve service levels, effective supply chain strategies must take into account the interactions at various levels in the supply chain.

Fierce competition in today's global markets, introduction of products with short life cycles, and the heightened expectations of customers, have forced business enterprises to invest in and focus attention on, their supply chains. For the success of supply chain, flow of material and information should be managed properly. Besides these two, one more factor that is equally important is "relationships among supply chain members". We will discuss about all these in detail in following sections.

4 1.2 LITERATURE REVIEW

Research on risk pooling through lateral transshipment can be classified along several dimensions, depending on the distribution network structure and the model characteristics and assumptions, Tagaras. G [17] mentioned that One can think of at least six important features that should be taken into account when trying to present existing work systematically: (1) the number of locations in the pooling group, (2) the replenishment lead time from the central warehouse, (3) the demand process, (4) the timing (before or after demand is observed) and consequent purpose of transshipment (preventive or emergency), (5) the reparability of stocked items, and (6) the measure of performance (cost or service level).

Since this thesis work examines a periodic review system with emergency transshipment per period, non-repairable items, variable demand and variable lead time, expressed by normally distributed random variables, only related, research with similar characteristics will be summarized in the following paragraphs. Gross [8], Das [6], jonsson aid Silver [9] and Diks and de Kok [7], among others, have presented models where preventive transshipment takes place before realization of the entire ordering cycle's demand, with the purpose of achieving a better distribution of available inventory among the stocking locations,' Emergency transshipment models for repairable items and/or low demand, typically assumed to follow a Poisson distribution, include those of Cohen *el aI,* (4], Lee [11], Axsater (2], Dada [5] and Sherbrooke (14], viswanathns [18].

Effective management of the supply chain is nowadays recognized as a key determinant of competitiveness and success for most manufacturing organization [3]. Many quantitative models have been constructed to prove decision support for the management of materials in supply chains and an excellent review of these models is given by Lee and Billington [12]. However, since the network of facilities that constitute the entire supply chain is typically too complex to analyze and optimize globally, it is often desirable to concentrate on smaller parts of the system so as to gain a full understanding of its characteristics, performance and tradeoffs involved. One such part that is attracting growing attention is the local distribution network, consisting of multiple retail outlets (stocking locations), which are supplied by a central warehouse or distribution center. [17].

The earliest contribution to the emergency lateral transshipment problem is due to Krishnan and Rao [10], who derived the optimal order-up-to quantities assuming that the replenishment lead-time is zero and all costs at each location are identical. Tagaras [15] extended the two-location version of Krishnan and Rao's model by allowing different service level constraints. Robinson [13] examined the general case of multiple locations with different cost parameters, maintaining the assumptions of instantaneous replenishment and transshipment, and proved the optimality of the base stock ordering policy. However, the optimal order-up-to points can be found analytically only when there are only two outlets. For the general case Robinson [13] proposed a heuristic solution technique employing Monte Carlo integration. Archibald, Sassen and Thomas [1] considered a modification of the two-location problem, where emergency transshipments can occur at any time during a period, instead of only at the end of the period. Much transshipment may occur during a period and the total demand is not known when any transshipment occurs. An alternative to transshipment is an emergency order from the central warehouse, which also arrives instantaneously but it costs more than a lateral transfer. Archibald, Sassen and Thomas [1] derived the form of the optimal policy for that model. The ordering policy is of the base stock type, while the decision whether to place an emergency order or to use lateral transshipment depends on the costs, the remaining time in the period and the available inventory at the alternative location.

Tagaras and Cohen [6] resorted to simulation in order to study the two-retailer inventory system with non-negligible replenishment lead times and unequal cost parameters. Their main finding is that complete pooling is still superior to partial pooling, i.e. transshipment policies using target and\or reserves stock levels. Tagaras and Cohen [16] also provided approximations for the expected on-hand inventories, backorders and transshipments, as well as a heuristic algorithm for determination of near-optimal order-up-to quantities complete pooling.

Cachon P. (18) Studies the competitive and cooperative selection of inventory policies in a two-echelon supply chain with one supplier and N retailers. Stochastic demand is monitored continuously. Retailers incur inventory holding and backorder penalty costs. The supplier incurs holding costs for its inventory and backorder penalty costs for backorders at the retailers. The latter cost reflects the supplier's desire to maintain adequate availability of its product to consumers.

Cachon G and P. Zipking [19] studied competitive and co-operative inventory policies in two stage supply chain. Lariviere. M, [20] studied supply chain contracting and co-ordination with stochastic demand. George Tagaras [17] studied pooling in multi locations distributions system and get some useful results such as (a) benefit of pooling increases with increase the pooled location (b) the type of transshipment policy in case of shortage does not affect significantly the system performance (c) it is preferable to form a balanced pooling group consisting of location that face similar demand. Now, we will discuss about literature concerning to supply chain.

4.1 1.3 INVENTORY MANAGEMENT ACROSS THE SUPPLY CHAIN

One of the major trends facing organizations today is the demand for ever-higher levels of responsiveness and shorter defined cycle times for deliveries of goods and services. A variety of changes occurring throughout global markets have resulted in an increasingly competitive environment. The rate of change in markets, products, technology, and competitors, occurs at an increasingly rapid pace, leading to a condition in which managers must make decisions on shorter notice, with less information, and with higher penalty costs. At the same time, customers are demanding quicker delivery responsiveness. These same customers require products that incorporate state-of-the-art technology and features. Products are becoming less standardized, and customers are demanding options that are tailored to their unique requirements. In many segments of the marketplace, only those firms that have the ability to mass-customize are successful. This means that such products are becoming more complex, have a greater variety of options and must be tailored to a greater number of shrinking market "niches". In many industries product life cycles are shrinking.

Managers throughout the supply chain are feeling the full effect of these changes. Cutbacks in staffing are forcing managers to handle a greater number of channels with fewer people, while cost pressures require that they do so with fewer inventories. Because of the ever-increasing levels of competition found in many markets, supply chain related mistakes leading to lost sales couldn't be easily dismissed and written off. Furthermore, both customers and suppliers are becoming better at measuring performance. "Perfect orders" are being demanded, requiring a supply chain that is quick, precise, and provides a top-quality product every time.

Despite the imposing challenges of today's competitive environment, some organizations are thriving. These firms have embraced these changes and have integrated quick response and flexibility into their day-to- day culture. They are managing by paying attention to time. For example, the reduction of delivery times both in the marketplace and throughout the supply chain. In entire industry time based competition is a phenomenon that is here to stay because of its direct linkage to profits. The advantages achieved by time-based competitors enable them to grow faster and earn higher profits relative to other firms in their industry; increase market share through early introduction of new products; control overhead and inventory cost.

Establishing integrated supply chains that provide end customers and supply chain member organizations with the material required, in proper quantities in the desired form, with the appropriate documentation at the desired location at the right time and at the lowest possible cost, lies at the very heart of supply chain management. Major part of the cost in supply chain is due to the inventory and its efficient use; hence inventory should be managed properly.

In recent years, few topics have generated more interest. The notion of organization its suppliers, their suppliers, your customers, and their customers, all working together to meet the needs of the ultimate end customer for the mutual benefit of all parties concerned is a very appealing proposition. However, adopting and implementing an SCM strategy requires considerable effort and represents a quantum change in direction for many organizations. Prior to embarking into the promising but largely "uncharted" world of SCM, it is critically important that organizations have a detailed understanding of current supply chains and associated processes. This understanding will serve the organization well in its efforts to determine the relative importance of its various supply chains and to identify those processes most in need of improvement. In this section, we describe several tools and techniques employed by managers to help them fully understand their organizations' supply chains. So, we will discuss the organization of supply chain.

1.3.1 DIVISION OF SUPPLY CHAIN

Most organizations are simultaneously members of multiple supply chains. An organization in each chain typically offers a number of products and services, purchases materials from a wide range of suppliers, and sells to multiple customers. From the perspective of a typical organization, each of its supply chains will have both internal and external "linkages." However, it is unlikely that all of the organization's supply chains will be part of formal inter-organizational SCM initiatives. An organization must, therefore, focus its SCM efforts on those supply chains most critical to the organization's success. By critical, we mean those supply chains related processes, suppliers, and customers that offer the greatest potential for achieving a competitive advantage, and that, therefore, hold the greatest promise for the ongoing success of the organization. In discussing supply chains, we will first differentiate between internal and external supply chains

1. *INTERNAL SUPPLY CHAINS*

The internal supply chain is that portion of a given supply chain that occurs within an individual organization. Internal supply chains can be quite complex. Given the multidivisional international organizational structures found in many businesses. It is not uncommon for the internal part of a supply chain to have multiple "links" that span the globe. Developing an understanding of the organization's internal supply chain is often an appropriate starting point for firms considering an SCM initiative. It is interesting to note that in these multidivisional structures, the employees of one division often view the other divisions in much the same manner as they would external suppliers or customers. In some cases the "turf wars" that exist between divisions make it very difficult to integrate cross-divisional functions and processes.

Development of supply chain process maps (flowcharts) for major supply chains and their related processes is a useful technique for establishing an understanding of the internal supply chain. Process map development is best accomplished through the use of cross-functional teams comprised of personnel from all parts of the organization included in the supply chain under review. Team members must be knowledgeable regarding their part of the supply chain and must also have an understanding of how their part interfaces with the other supply chain members

2. *EXTERNAL SUPPLY CHAINS*

Once an understanding of the internal supply chain is gained, it is necessary to extend the analysis to the external portion of the supply chain (i.e., key suppliers and customers). This is an important step as significant opportunities for improvement often lie at the interfaces between the various supply chain member organizations. This step also adds a greater level of complexity, given that multiple organizations and their representatives are now participating in the analysis. At this point in the analysis, the organization needs to focus its efforts on those supply chains that are most important to the organization's success.

Once the key supply chains have been identified, it is also necessary to identify the supply chain member organizations (suppliers and customers) that are considered most critical to the organization's supply chain management efforts. These key suppliers and customers are likely to provide the greatest benefits to the SCM initiative. Organizations must be important members of the supply chain because the time and effort required for a significant SCM program is not warranted "minor players".

In selecting external members, several issues should be addressed. First, consideration should be taken to identify the competitive situation that exists between prospective SCM members. SCM endeavors are likely to be more productive if participating organizations are not direct competitors. There may be limits to collaborative supply chain efforts when both buyer-supplier and competitor relationships exist between participating organizations (i.e., company A is supplier to company B in one market. but A and B are direct competitors in several other markets). Second, all organizations and their representatives must be pursuing similar goals. This does not mean that each organization should have identical goals, but their respective goals must be compatible with the overall SCM initiative. Third, SCM efforts have limited potential for success unless all organizations feel their involvement is beneficial. In an internal setting, participants may be able to survive situations where individual business units or functional areas may feel like "losers" (in terms of loss of planning authority, responsibility, *re*sources, etc.) as a result of decisions considered optimal for the overall organization. An external SCM initiative is unlikely to be successful unless all members from each organization involved feel they are benefiting from participation.

Once the external participants have been identified, the development of the external supply chain process map is conducted in the same manner as discussed earlier for the internal supply chain. However, the team is now both crosses functional and inter-organizational in its composition. This team should include representatives from all functional areas and all member organizations in the supply chain under consideration. Here again, the inter-organizational workshop sessions have been found to be an effective means to complete the development of the external supply chain process maps. As with the internal supply chain workshops, significant learning takes place during these sessions.

1.4 THE IMPORTANCE OF TIME IN SUPPLY CHAIN

Superior cost, quality, delivery and technological performance do not guarantee success for a supply chain. Increasingly, organizations are finding that they must also be able to compete on the basis of time. This does not mean that cost, quality, delivery, and technology considerations are no longer important they are critically important. However, individual organizations and supply chain organizations must be competitive in these areas and be able to get their products and services to their customers faster than the competition.

Increasingly, organizations are realizing that they are competing on the basis of time. Reducing the time required to provide the end customer with products or services is one of the major forces that is leading organizations to participate in supply chain management initiatives. Adopting an integrated supply chain management approach provides, the means to make significant reductions in the cycle time, required to move materials between supply chain members and to the end customer.

This time-sensitive environment presents new challenges and opportunities for the individual organizations and supply chains. This section introduces the concept of cycle time; presents common causes 01 "long" cycle times discusses an approach for making cycle-time improvements and presents several critical success factors that should be considered as part of the cycle time reduction initiatives.

4.1.1 1.4.1CYCLE-TIME OVERVIEW

Cycle time is the total elapsed time required to complete a business process. All too often only a small of the total elapsed time required to complete a process has anything to do with "real work. The rest of the time is typically devoted to a wide range of counterproductive activities and events all of which take time. Identifying and eliminating these poor uses of time represent one of the major SCM opportunity areas. It should be noted, however, that cycle-time reduction is not just about completing a process quickly (i.e. speed for the sake of speed); it is concerned with completing the given process effectively. By focusing on-key processes supply chain member organizations can make significant improvements in cycle-time performance, improvements that can provide a source of competitive advantage for the supply chain.

1.4.2 CAUSES OF LONG CYCLE TIMES

There are a number of causes of long process cycle times that can be found in a supply chain environment. In examining supply chain processes typically one or more of the following causes will he present. Several common causes of long process cycle times and key issues that should be addressed, when these situations are encountered include, but are not limited to the following.

***Waiting*:** In many multistep processes, significantly more time is devoted to waiting between process steps than is spent in all of the processing steps combined! Where are the longest "waits" occurring in the process? What are the causes of these waits? What actions can be taken to reduce or eliminate the time spent waiting? Does the organization or supply chain need additional capacity in terms of facilities, equipment, or personnel?

***Non- Value-Added Activities*:** The key processes found in many supply chains have been in existence for many years. When examining supply chain processes, it is worth-while to determine the value that is being added by the overall process and individual process activities. It is not uncommon to find processes or activities within a process that were essential at an earlier point in time that add little or no value in the current environment. Is this process necessary? Do all activities in the process add value? Those activities that are not adding value should be eliminated. If the process activity is adding value, is it being conducted in the "best" way possible given current practices?

***Serial versus Parallel Operations*:** Many supply chains have processes where activities are conducted in a serial manner (i.e. first complete activity 1, then complete activity 2, and so on through activity N). Are there opportunities in the process for activities to take place in a parallel (i.e., simultaneous) manner as opposed to the commonly used serial or sequential fashion? For example, within a manufacturing organization in the supply chain, are new products and the processes that will be used to manufacture these products developed concurrently? or is the product designed and then thrown "over the wall" to the manufacturing group? Are the manufacturing organization's key supplier and customer partners in the supply chain involved in the new-product development process?

***Repeating Process Activities*:** A significant cause of poor supply chain cycle-time performance is, having to repeat process steps due to product or service quality issues. There are few situations that can increase product cycle times (in terms of both average cycle times and variability) more than problems of this nature. Are there parts of the process that are repeated due to an inability to "get it right the first time"? What are the causes of these problems'? What actions are necessary to resolve these problems?

***Batching*:** Batching occurs when some quantity of materials, orders and so on is accumulated at one step in the process or organization in the supply chain before it is released to the next process step or supply chain member organization. What is the rationale for batching? If the rationale is economic (rather than "that's how we have always done it"), then it should he implemented. An example of an economic rationale might be taking advantage of lower transportation rates for larger shipment quantities. In such circumstances however the economics of the situation should be periodically revisited to ensure that the savings associated with the "batch approach" are worth the time required.

***Excessive Controls*:** How much lime is spent and potentially wasted following the rules and regulations governing processes within and between supply chain member organizations? A common internal example of this situation is seen in purchase order (PO) processing. How many signatures arc needed for a PO? How many of these signatures are merely being "rubber stamped"? We do not mean to imply that all controls" should be abandoned. However, organizations would be well served to review the control, that are being utilized to govern both internal and external supply chain processes periodically, and determine if the level of control provided is worth the associated cost. A periodic cost/benefit analysis for interorganizational and interorganizational controls as they apply to the supply chain is likely to be time well spent. Many organizations discover that their rules and regulations serve only to increase their response time to internal and external customers, and that many of these control mechanisms are morel of a burden than a benefit.

***Lack of Synchronization in Materials Movement*:** Are materials being moved across the supply chain in the most effective manner? Are product movements across the supply chain managed in such a way to ensure that the right quantity of the right product is getting to the right location at the right time? Or are materials arriving at the customer's location too early, causing additional storage and materials handling activities, or too late, disrupting the customer's operations and in so doing damaging the supplier's reputation?

***Ambiguous Goals and Objectives*:** Do all supply chain member organizations have a clear understanding of the overall supply chain goals and objectives? Do all supply chain members understand what their organization must contribute for the over all supply chain to be successful?

***Poorly Designed Procedures and Forms*:** Do the procedures and forms associated with a specific process lead to the efficient completion of the process? Or do they significantly increase the time required to complete the process by creating more work while adding little value?

Outdated Technology**:** Are the supply chain member organizations making the best use of available technology? How is key information communicated across the supply chain? For example, are purchase orders transmitted from the buying organization to the supplying organization by fax, EDI, or Internet, or are they mailed? Are warehousing operations within the supply chain utilizing a high level of automation or are they primarily manual operations?

Lack of Information**:** The cycle time for supply chain decision-making is often lengthy due to the time needed to gather the information required to make decisions. It should be recognized that the required information may originate within the decision maker's organization or in one or more of the other supply chain member organizations. Do decision makers have the information that they need when they need it and in the desired format? How much time is being spent identifying, collecting, and manipulating the information required to make a decision versus making the actual decision?

Poor Communication**:** Inter-organizational communications is critical to overall supply chain performance. Have the necessary lines of communication been established across the supply chain member organizations? Do managers within supply chain organizations know whom to contact in other functional areas within their own organization, as well as in the other supply chain organizations, If there are problems? A list of key contacts in different organization, across the chain is a very simple but valuable resource in solving problems when they arise.

Limited Coordination**:** Coordination of supply chain processes is another important factor in determining supply chain performance. Do all parties involved in a given process recognize their respective roles and associated responsibilities? Are the inter-organizational processes effectively coordinated? Are there formal "rules of engagement" to ensure that the desired level of coordination is maintained'?

Limited Cooperation**:** Are all supply chain member organizations truly committed to the supply chain management initiative? If not, it is time to reevaluate the membership of those organizations that lack the required level of commitment. Cycle time and overall supply chain performance hinges on the cooperative efforts of the member organizations, Do all organizations have the appropriate cooperative philosophy?

Lack of/Ineffective Training**:** Proper training reduces the time for people to become proficient in their jobs and can also lead to improvements on an ongoing basis. Have all people involved in supply chain processes and activities received adequate training for their specific jobs? Are there ongoing training opportunities for employees that focus on supply chain performance improvement in general and cycle-time reduction in specific?

4.1.2

1.4.3 CRITICAL SUCCESS FACTORS FOR CYCLE - TIME REDUCTION

In conducting research with organizations that have successfully completed cycle-time reduction efforts in a variety of supply chain management areas, several "critical success factors" have been identified that include:

- Top management support;
- A commitment to significant cycle-time reduction goals;
- Use of cross-functional teams with team members that possess thorough process knowledge;
- Application of TQM tools (e.g., process mapping, Pareto analysis fishbone diagrams; etc.):
- Training in cycle-time reduction approaches;

- Establishing monitoring and reporting formal cycle-time performance measures
- Application of information systems and technology; and
- Collaboration with supply chain members.

4.2 1.5 PERFORMANCE OF SUPPLY CHAIN

One component of Supply Chain Management that had until recently been relatively neglected was that of supply chain performance measurement. In inter-organizational systems, such as supply chain, timely and accurate assessment of overall system and individual system component, performance is of paramount importance. An effective performance measurement system (I) provides the basis to understand the system, (II) influences behavior throughout the system and (III) provides information regarding the results of system efforts to supply chain members and outside stakeholders. In fact, performance measurement is the glue that holds the complex value creating system together, directing strategic formulation as well as playing a major role in monitoring the implementation of that strategy. In addition, research findings suggest that measuring supply chain performance itself leads to improvements in overall performance. .

Now there has been considerable concentration regarding the specific performance measure required to manage an integrated supply chain. Organizations recognize that future competition is likely to pit different supply chains against each other in pursuit of the end customer's business. Therefore, it is critical to assess and continuously improve the performance of the entire chain. Recognizing the importance of this issue, a comprehensive group of performance measures for supply chain is made. These measure address four broad performance areas: (I) customer satisfaction /quality, (II) time, (III) costs, (IV) assets. For each these areas, primary and secondary performance measure are identified .The specific measures necessary to manage supply chain performance will vary according to the customer type, product line, industry, or other factors. Here we are giving a generalize table for attribute. Table1.1 shows supply chain performance measures.

Organizations must realize that overall supply chain performance ultimately affects their own individual performance. Furthermore, supply chains are only as strong as the weakest links between organizations in the chain. For example, the linkages between the supply chain manufacturing organization and suppliers may be functioning well. However, if the linkages between the manufacturing organization and the retailing organization are not functioning at a desired level, then the supply chain is not performing well. The critical linkage for the ultimate success of the supply chain is sales to the end customer. It is of little consequence, if the performance at earlier stages of the supply chain is outstanding but the product is not available as needed to support retail sales.

Table1.1 Supply Chain Performance Measures

Performance Area	**Primary Measures**	**Secondary Measures**
Customer Satisfaction/Quality	Perfect order fulfillment Customer satisfaction Product Quality	Delivery-to-commit date Warranty costs, returns, allowances Customer-inquiry response time
Time	Order fulfillment lead time	Source/make cycle time Supply chain response time Production planning achievement
Cost	Total supply chain costs	Value-added productivity

Assets	Cash-to-cash cycle time Inventory days of supply Assets performance	Forecast accuracy Inventory obsolescence Capacity utilization

The overall performance of the distribution network, whether evaluated in economic terms or in terms of customer service, can be substantially improved if the retailers collaborate in the event of unexpectedly high demand, which may result in shortages in one or more outlets.

Organizations that can successfully incorporate the aforementioned areas into their supply chain management initiatives will be well positioned to manage the flow of materials across the supply chain.

4.3 1.6 SHARING THE RISKS IN SUPPLY CHAIN

The concept of collaboration and joint competitiveness is often more appealing than going it alone. However, as demands on supply chains continue to escalate, the relationships between organizations will be tested. In any supply chain structure, a number of risks exist that must somehow be managed between the participating members.

Co-operation should be along the supply chain but here we are discussing the co-operation across the supply chain. All the retailers are selling same product but at the time of shortage they share their product to each other. In this way they overcome the uncertainty or minimize the risk.

Collaboration usually takes the form of lateral inventory transshipment from an outlet with a surplus of on-hand inventory to an outlet that faces a stock out. Since the cost of transshipment is generally lower than both the shortage cost and the cost of an emergency delivery from the central warehouse. Transshipment time is shorter than the regular replenishment lead-time. Lateral transshipment simultaneously reduces the total system cost and increases the service at the retailers. The stocking locations that share their inventory in this manner are said to form a pooling group, since they effectively pool their resources to reduce the risk of shortages and provide better service at lower cost.

Here we are concentrating on periodic review with variable demand and variable lead-time inventory system. This supply chain system is studied for perishable goods such as fruits and vegetables, which are distributed through a central, were house to three distant retail outlet. The retailers have emergency lateral transshipment policy. Emergency lateral transshipment takes place when demand at particular retail outlet exceeds the existing inventory of that retail outlet.

4.4 1.7 CONCLUDING REMARK AND ORGANIZAZTON OF THESIS

Here we have discussed about supply chain and its different aspects, such as material flow, information flow in supply chain. We have also discussed about concerning literature to this topic. Relationship play, very vital role for the success of supply chain. So we will discussed about, relationship in supply chain. Today market is very much competitive, so to compete in the market, right information at right time is very much necessary, hence next chapter "information system and relationships in supply chain", is an extension of this chapter, has been devoted to this.

In third chapter formulation for the simulation model is done. In fourth chapter simulation model is discussed for an illustrative example. In fifth chapter finding are discussed and finally in sixth chapter conclusions of project work, and work for future are discussed.

5 CHAPTER 2

6 INFORMATION SYSTEM AND RELATIONSHIPS IN

7 SUPPLY CHAIN

8

9 2.1 GENERAL

Supply chain management is concerned with the flow of *products* and *information* between the supply chain members. At the limit, it encompasses all of those organizations (i.e., suppliers, producers, service providers and customers) that link together to acquire, purchase, convert/manufacture, assemble, and distribute goods and services, from suppliers to the ultimate end users. These flows are bi-directional. This section addresses the information required for effective supply chain management and introduces a number of technologies that organizations are using to make this information readily available across the supply chain Fig. (1.1).

Recent developments in technology have brought information to the forefront of resources from which forward-thinking firms can cultivate genuine competitive advantage. These technologies provide the means for multiple organizations to coordinate, their activities in an effort to truly manage a supply chain. As the rate of these technological advances increases, the cost associated with this information has decreased. Simultaneously, the speed with which this vital information can be made useful and applicable in a variety of business situations continues to increase.

By 1980, the information revolution was in full swing in the world's advanced economics. During this period many standard business processes and functions such as customer order processing inventory management and purchasing were altered through the use of computer technology. However, only as the variety of available information technologies and capabilities began to grow exponentially mid-decade, did a more expanded *information technology* (IT) paradigm begin to emerge.

With changing scenario of industry, managers need to understand that information technology is more than just computers. Today, information technology must be conceived of broadly to encompass the information that businesses create and use as well as a wide spectrum of increasingly convergent and linked technologies that process the information. In addition to computers, then data recognition equipment, communications technologies, factory automation and other hardware and services are included. We utilize this paradigm in this section description the role of information and technology in the supply chain.

10 2.2 IMPORTANCE OF INFORMATION IN AN INTEGRATED
11 SUPPLY CHAIN MANAGEMENT ENVIRONMENT

Prior to the 1980s a significant portion of the information flows between functional areas within an organization, and between supply chain member organizations, were paper based. In many instances these paper-based transactions and communications were slow, unreliable, and error prone. Conducting business in this manner was costly because it decreased firm’s effectiveness in being unable to design, develop, procure, manufacture, and distribute their product. This approach also impeded efforts to develop and capitalize on successful inter-organizational ventures. During this period, information was often overlooked as a critical competitive resource because its value to supply chain members was not clearly understood. However, firms that are embarking upon supply chain management initiatives now recognize the vital importance of information and the technologies that make this information available.

In a sense, the information systems and the technologies utilized in these systems represent one of the fundamental elements that "link" the organizations of a supply chain into a unified and coordinated system. In the current competitive climate, little doubt remains about the importance of information and information technology to the ultimate success and perhaps even the survival of any supply chain management initiative.
Timely and accurate information is more critical now than at any time in the history of business. Three factors have strongly impacted this change in the importance of information. First, satisfying in fact pleasing customers has become something of a corporate obsession. Serving the customer in the best, most efficient, efficient and effective manner has become critical and information about issues such as order status, product availability, delivery schedules, and invoices has become a necessary part of the total customer service experience. Second, information is a crucial factor in the manager’s abilities to reduce inventory and human resources requirements to a competitive level. Finally information flows play an essential role in the strategic planning for and deployment of resources

A key notion in the essential nature of information systems in the development and maintenance of successful supply chains is the need for virtually seamless bonds within and between organizations. This means creating inter-organizational processes and links to facilitate delivery of seamless information between marketing, sales, purchasing, finance, manufacturing, distribution and transportation internally, as well as inter-organizationally to customers, suppliers, carriers, and retailers across the supply chain. Perhaps more importantly, it means alteration of perspective at the firm's highest levels. Changes in thinking that become necessary include aligning corporate strategies to the IT paradigm, providing incentives for functions to achieve common goals through the sharing of information, and implementing the technologies to redesign the movement of goods to maximize channel value and lower cost. So, we will discuss about dynamics of supply chain organization.

11.1.12.2.1 SUPPLY CHAIN ORGANIZATIONAL DYNAMICS

Several inter-organizational dynamics come into play when addressing information sharing across the supply chain. Two issues in particular are risk and power. All enterprises participating in a supply-chain management initiative accept a specific role to perform. They also share the joint belief that they and all the other supply chain participants will be better off because of this collaborative effort. Each member specializes in the function or area that best aligns with its distinctive competencies. Risk occurs in that rather than prospering or failing on the basis of its own efforts. Each firm must now rely on other supply chain members, as well as in its own efforts in determining the success of the supply chain. Some supply chain members are more dependent than other for the supply chain success. Thus, members with the most at stake may take more active roles and assume greater responsibility for fostering cooperation, including the information sharing efforts, throughout the supply chain.

Power within the supply chain is a central issue, one that in today's marketplace centers on information sharing. Although not universal to all industries, there has been a general shift of power from manufacturers to retailers over the last two decades, which has resulted from a combination of factors. One is the trend toward consolidation at the retail level within the supply chain. Gone are the days of "Mom and Pop" grocery stores in every neighborhood. In the interest of capitalizing on the benefits of economies of scale, giant retail conglomerates operate as part of nationwide supply chains.

Perhaps more importantly, retailers sit in a very important position in terms of information access for the supply chain. For several reasons major retailers have risen to this position of prominence through (1) technologies such as bar codes and scanners, (2) their sheer size and sales volume and most importantly, (3) their position within the supply chain right next to the final consumer. This combination of factors has put retailers in a very powerful position within the supply chain.

11.1.22.2.2 INTER-ORGANIZATIONAL INFORMATION SYSTEM

Recognizing the critical importance of information in an integrated supply chain environment, many organizations are implementing some form of an inter-organizational information system (IOIS). IOISs are "systems based on information technologies that cross organizational boundaries. In fact, at "the ultimate level of integration, all member links in the supply chain are continuously supplied with information in real time". The foundation of this ability to share information is the effective use of IT within the supply chain. Appropriate application of these technologies provides decision makers with timely access to all required information from any location within the supply chain.

IOIS can be described as, an integrated data-processing/data-communication system utilized by two or more separate organizations. These organizations may (buyer-supplier) or may not (credit clearinghouse) have a preexisting business relationship. What must exist is a computer-based electronic link between the two organizations that automates some element of work, such as order processing, order-status checking, inventory-level review, shipment tracking information or, minimally transaction transfer which would previously have been performed manually or through other media, such as the mail.

Among the earliest forms of IOISs were, those developed by time-sharing services and on-line database vendors. The potential impact of such systems on the way business is conducted was recognized as early as the 1960s. Since that time new technologies have been integrated to produce systems of increasing capability. Examples of such implementations include electronic funds transfer (EFT) systems, the Treasury Department's decision support system, a variety of buyer-supplier order-processing systems and on-line professional tool support systems. Existing implementations serve the grocery industry, the drug wholesaling industry, the insurance industry, and the transportation industry, with more systems coming into existence each year.

The development of an IOIS for the supply chain has three distinct advantages: cost reductions, productivity improvements and product/market strategy. Five basic levels of participation for individual firms within the inter-organizational system have been identified:

1. Remote I/O node, in which the member participates from a remote location within the application system supported by one or more higher-level participants.

2. Application processing node, in which the member develops and shares a single application such as an inventory-query or order-processing system.

3. Multiparticipant exchange node, in which the member develops and shares a network interlinking itself and any number of lower-level participants with whom it has an established business relationship.

4. Network control node, in which the member develops and shares a network with diverse applications that may be used by many different types of lower-level participants; and finally

5. Intergrating network node, in which the member literally becomes a data-communication/data-processing utility that integrates any number of lower-level participants and applications in real time.

A sixth level of participation also appears within the context of the supply chain in which the participant shares a network of diverse applications with any number of participants with whom it has an established business relationship. IOIS participants may, in fact, be at a level lower, higher, or equal to the IOIS sharing organizations. We will describe this level of participation as the supply chain partner node.

As organization explores development of IOISs to support their supply chain management efforts, they will be faced with several challenges. One impediment undoubtedly lies in developing a common language in terms of planning, format, and priority across several vastly different constituencies. Information-sharing requirements are well beyond those of a manufacturer and its distributor's need to process orders in a consistent way. All relevant information ultimately must circulate to and among all organizations between the supply chain's point of origin and its point of consumption such as ordering (i.e., orders for component parts, services, and finished products), inbound transportation, manufacturing, warehousing, inventory management, outbound transportation, sales, marketing forecasts and customer-service information. Although organizations recognize the importance of an IOIS for effective supply chain management no one standard approach is being utilized in terms of technology or information.

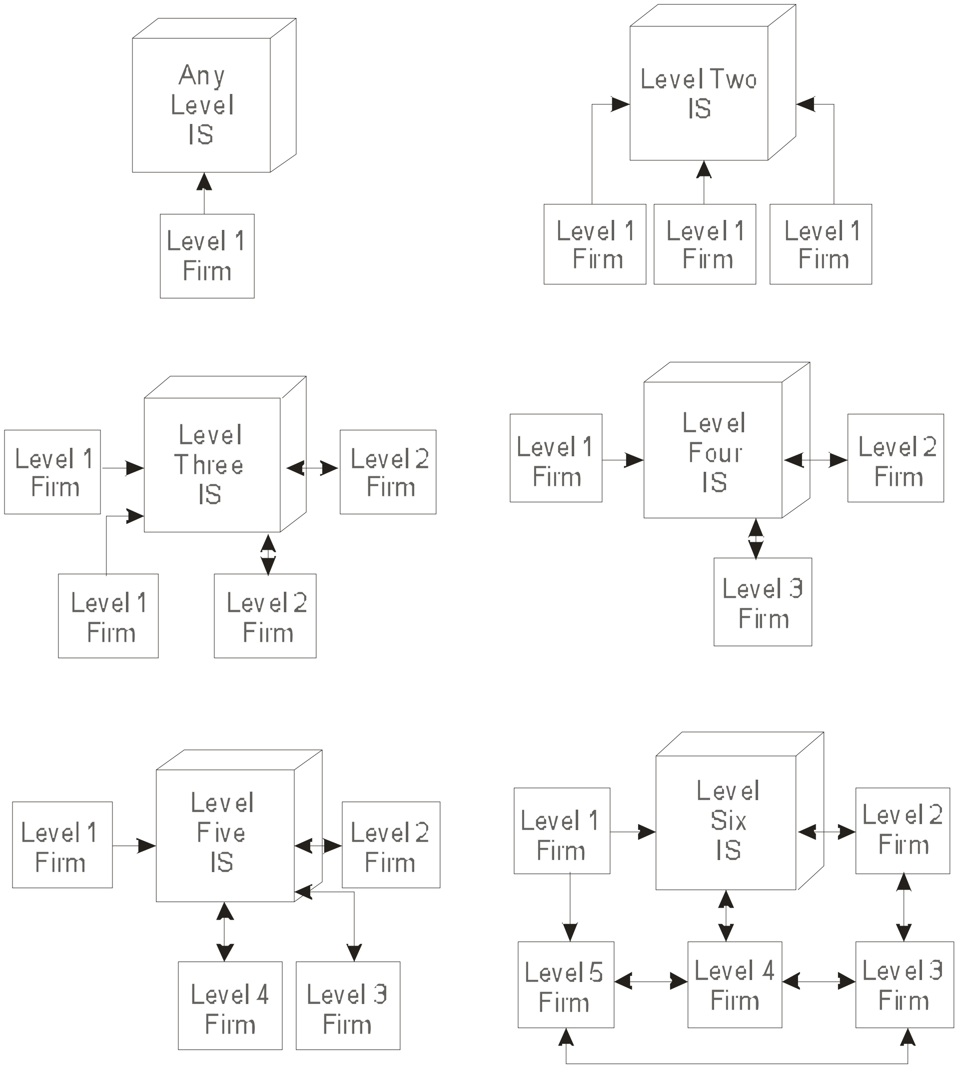

Fig: 2.1 IOIS Configuration Types

11.1.32.2.3 INFORMATION REQUIREMENTS DETERMINATION OVERVIEW

On several levels, free sharing of accurate and timely information across the supply chain is a key factor for success. In addressing the hurdles to be faced in the development and cultivation of successful supply chain management arrangements, it is noted, "By far the largest single element in impeding progress is lack of a common language to describe, analyze, measure, and improve". In other words, the basic tools of communication are essential to the development of successful supply chain relationships. The sharing of information between and among several diverse constituents requires a great deal of care and sophistication. Information coordination requirements are numerous, including strategic objectives, capacity constraints, as well as logistics, manufacturing, and procurement requirements for all of the supply chain members. Information requirement determination is indeed one of the most critical issues to be considered when developing IOIS to support a supply chain._The four fundamental mistakes made when determining information requirements are:

- Viewing systems as functional instead of cross-functional.
- Interviewing managers individually instead of jointly.
- Not allowing for trial and error in the detail design process.
- Asking the wrong questions during the interview.

Viewing systems as functional instead of cross functional is a very narrow and inappropriate perspective to take in the information requirements determination process. Much of the information needed to make decisions within a given function will come from sources outside the function. Therefore, it is necessary to include all of the functions involved in an information system in order to facilitate the development of a system that allows information to flow cross-functionally. When developing information systems to support an integrated supply chain, this cross-functional perspective needs to be extended to be cross-functional and inter-organizational, because the information required to make decisions within one organization may come from another supply chain member.

Interviewing managers individually, although it has been the historical standard approach for conducting information requirements determination has several problems. It places stress on managers, thereby limiting their ability to respond to questions. The most popular method for overcoming the problems associated with individual interviews is to undertake a group interview process known as joint application design (JAD). This allows the group to pool their memories concerning their information requirements by having all of the affected functions represented in the same room at the same time. This overall information requirements perspective is difficult to achieve if each manager is interviewed individually. Building an effective IOIS would be virtually impossible without taking a JAD approach to determining information requirements. Analysts often ask managers the wrong questions. To avoid asking the wrong questions three different information requirements determination methodologies were developed: business systems planning, critical success factors and ends/means analysis.

11.1.42.2.4 INFORMATION AND TECHNOLOGY APPLICATIONS FOR SUPPLY
11.1.5 CHAIN MANAGEMENT
11.1.6

Exciting technology-based approaches emerge almost daily. Many of these innovations are well suited to the enhancement of supply chain management, including Just in Time, Quick Response, Efficient Consumer Response, and Continuous Replenishment. Regardless of the technology-based approach, all are attempts by businesses to manage activities across company boundaries in a coordinated, integrated fashion. Similarly, all rely heavily on the information made available through the latest technological advances.

Although the importance of information, and the supporting technology to supply chain management is evident determining which specific systems and applications can provide a specific supply chain with the greatest benefit is not at all clear. "How to best extract value from information technology resources is a major challenge facing both business and IT managers particularly as they turn their focus to searching for competitive benefits of strategic information systems and striving for benefits beyond process reengineering. This search becomes increasingly complex for those organizations attempting to operate in supply chains with multiple participants.

Several technologies have gained popularity recently, due to their ability to facilitate the flow of information across the supply chain. Many of the technologies fall, in today's language, under the heading of electronic communication. Other relevant technologies include bar coding/scanning and data warehouses. It is interesting to note that several of these technologies have been available for a number of years: however, the application to inter-organizational supply chains is a relatively recent phenomenon.

Electronic commerce is the term used to describe the wide range of tools and techniques utilized to conduct business in a paperless environment. Electronic commerce therefore includes electronic data interchange (EDI). email electronic funds transfers electronic publishing image processing, electronic bulletin boards, shared databases and magnetic/optical data capture (such as bar coding) the Internet, and Web sites. Electronic commerce is having a significant effect on how organizations conduct business. Companies are able to automate the process or moving documents electronically between suppliers and customers in such a manner that the entire process is handled electronically no paperwork is involved. With the rise of the Internet and the ability to transfer information cheaply and effectively over the whole world electronic commerce is becoming major focus for many organizations and represent a significant opportunity for integrated supply chain managements efforts.

11.1.7*1*. ELECTRONIC DATA INTERCHANGE

EDI refers to a computer-to-computer exchange of business documents in a standard format. EDI describes both the capability and practice of communicating information between two organizations electronically instead of the traditional forms of mail, courier, or fax. Capability refers to the ability of the various members of the supply chain to use their computer systems to communicate effectively, whereas the practice refers to the ability of the members of the supply chain to willingly share and effectively utilize the information exchanged. EDI is being utilized to link supply chain members together in terms of order processing, production, inventory, accounting and transportation. "It allows members of the supply chain to reduce paperwork and share information on inventories, orders, payments, inquiries, and scheduling among all channel members. The benefits of EDI are numerous, including:

- Quick access to information.
- Better customer service.
- Reduced paperwork.
- Better communications.
- Increased productivity,

- Improved tracing and expediting.
- Cost efficiency,
- Competitive advantage, and
- Improved billing.

EDI improves productivity through faster information transmission as well as reduced information entry redundancy. Accuracy is improved by reducing the number of times an individual is involved in data entry. The use of EDI results in reduced costs on several levels, including:

- Reduced labor and material cost associated with printing, mailing, and handling paper-based transactions:
- Reduced telephone and fax transmissions: and
- Reduced clerical costs.

Through the use of EDI, supply chain partners can overcome the distortions and exaggerations in supply and demand information by using technology to facilitate real-time sharing of actual demand and supply information.

2. *BAR CODING AND SCANNING*

At its most basic level, bar coding refers to the placement of computer readable codes on items, cartons, containers and even railcars. This particular technology application drastically influenced the flows of product and information within the supply chain. As noted throughout in this section, information exchange is critical to the success of supply chain management. In the past, this exchange was conducted manually with error-prone and time-consuming paper-based procedures. Bar coding and electronic scanning are identification technologies that facilitate information collection and exchange, allowing supply chain members to track and communicate movement details quickly with a greatly reduced probability of error.

Bar code scanners are most visible in the checkout counters of the supermarket. They scan the black-and-white bars of the Universal Product Code (UPC). This code specifics the name of the product and its manufacturer, Bar codes are used in hundreds of situations ranging from airline stickers on luggage to blood samples in laboratories. They are especially useful in high-volume tracking where keyboard entry is too slow and/or inaccurate. Other applications are the tracking of moving items, such as components in PC assembly operations railroad cars at various locations and automobiles in assembly plants.

3. *DATA WAREHOUSE*

Although definitions vary a data warehouse is generally thought of as a decision support tool for collecting information from multiple sources and making that information available to end users in a consolidated, consistent manner. The concept originated in the 1970s, when corporations realized they had many isolated information systems "islands" that could neither share information nor provide an enterprise-wide picture of corporate activities. Recently, there has been a renewed interest in this concept as organizations adopt distributed computing architectures while they leverage their isolated legacy systems. Rather than trying to develop one unified system or linking all systems in terms of processing a data warehouse provides a means to combine the data in one place and make it available to all of the systems.

In most cases a data warehouse is a consolidated database maintained separately from an organization's production system databases. It is significantly different from a design standpoint. Production databases are organized around business functions or processes such as payroll and order processing. Many organization, have multiple databases, often containing duplicate data. A data warehouse, in contrast is organized around informational subjects rather than specific business processes. The data warehouse, then is used to store data fed to it from multiple production databases in a format that is readily accessible by end users.

Combining data from these different systems may yield insights into the effectiveness of coupon sales promotions that would not be immediately evident from the output data of either system alone. Integrated within a data warehouse, however, such information could be easily extracted.

4. *INTERNET*

In terms of advancement in technology and communications capabilities, perhaps the most influential development over the past decade has been the adaptation of the Internet from strictly government and research applications into the areas of commerce and mass communications. At the most basic level, a network of networks, the Internet provides instant and global access to an amazing number of organizations individuals and in formation source. Through systems like the popular World Wide Web (the Web) Internet users are able to conduct organized searches on specific topics as well as browse various Web sites to discover the vast resources available to them through their computer.

The Internet offers tremendous potential for supply chain members to share information in a timely and cost-effective manner, with relative ease. Many organizations are now exploring the numerous opportunities provided by the Internet. For example, the Internet provides opportunities for the development of EDI systems. It also provides an incredible source of information about potential suppliers of products and services.

5. *INTRANET/EXTRANET*

Intranets are networks internal to an organization that use the same technology that is the foundation of the global Internet. Many industry analysts expect such corporate networks to provide most of the revenue for computer hardware and software vendors over the next few years as an increasing number of businesses expand their internal networks to improve efficiency.

By using Web browsers and server software with their own internal systems, organizations can improve internal information systems and link otherwise incompatible groups of computers. Internal networks often start out as ways to link employees to company information, such as lists, product prices, or benefits. Because internal networks use the same language and seamlessly connect to the public Internet, they can easily be extended to include customers and suppliers, forming a supply chain "Extranet" at far less cost than a proprietary network

Supply chain management initiatives are unlikely to succeed without the appropriate information systems and the technology required supporting them. Given this situation, information systems and technology decisions cannot be taken lightly. These important decisions should be made by a cross-functional, inter-organizational management group that has been afforded the time and resources required to develop a supply chain information systems strategy, implement the strategy, and oversee its ongoing performance.

In recent years, few topics have generated more interest. The notion of organization its suppliers, their suppliers, your customers, and their customers, all working together to meet the needs of the ultimate end customer for the mutual benefit of all parties concerned is a very appealing proposition. However, adopting and implementing an SCM strategy requires considerable effort and represents a quantum change in direction for many organizations. Prior to embarking into the promising but largely "uncharted" world of SCM, it is critically important that organizations have a detailed understanding of current supply chains and associated processes. This understanding will serve the organization well in its efforts to determine the relative importance of its various supply chains and to identify those processes most in "need of improvement. In this section, we describe several tools and techniques employed by managers to help them fully understand their organizations' supply chains.

12 2.3 DEVELOPING SUPPLY CHAIN RELATIONSHIPS

In discussing the implementation of a truly integrated supply chain, organizations arc continually faced with the challenge of managing the "people" part of the equation. Relationship management affects all areas of the supply chain and has a dramatic impact on performance. In many cases, the information systems and technology required for the supply chain management effort are readily available and can be implemented within a relatively short time period, barring major technical mishaps. In addition, the inventory and transportation management systems are also quite well understood and can be implemented fairly readily. A number of supply chain initiatives fail. However, due to poor communication of expectations and the resulting behaviors those occur. Managers often assume that managing the personal relationships within and between organizations in a supply chain will automatically "fall into place" once the inventory and information systems arc established. However, the management of interpersonal relationships between the different people in the organizations is often the most difficult part of the SCM initiative. Moreover, the single most important ingredient for successful supply chain management may well be a trusting relationship between partners in the supply chain, where each party in the chain has mutual confidence in the other members' capabilities and actions. Without a good relationship, all of the other systems (important systems inventory, contracts. etc.) cannot function effectively.

In the early stages of supply chain development organizations will often eliminate those suppliers or customers that are clearly not suitable. Because they do not have the capabilities to serve the organization too distant and are not well aligned with the company or are simply not interested in developing a relationship. After these firms are eliminated from consideration organizations may occasionally encounter a supply chain member that is willing to put forth time and effort required to create a strong relationship. In such cases, firms may consider developing a special type of supply chain relationship in which confidential information is shared assets are invested in joint projects and significant joint improvements are pursued. These types of inter organizational relationship are sometimes called strategic alliances. A strategic alliance is a process wherein participants willingly modify basis business practices to reduce duplication and waste while facilitating improved performance. Strategic alliance allows firms to improve efficiency and effectiveness by eliminating waste and duplication in the supply chain.

However, many firms lack the guidelines to develop, implement, and maintain supply chain alliances.

12.1 *2.3.1* A CONCEPTUAL MODEL OF ALLIANCE DEVELOPMENT

Figure 1.3 is a model showing how organizations typically establish and develop supply chain alliances. The general model has a number of vertical and horizontal components. The vertical components arc detailed below:

- ❖ The strategic component examines how strategic expectations and evaluations of alliance effectiveness evolve as an alliance progresses through development stages.
- ❖ The process component outlines the stages of alliance development that show the required steps for formation, implementation, and maintenance of an alliance.
- ❖ The operational component positions the development of search and selection criteria and operating standards for managing an alliance.

Within each of the horizontal stages, we must also consider the vertical stages that occur. At each stage (as we go from top to bottom), managers must consider the strategic and operational issues that coincide with each of the following horizontal stages of development.

- ❖ Level One **- alliance conceptualization** - begins when a firm determines a collaborative arrangement has appeal and provides a potential alternative to the current arrangement. This level involves significant joint planning to determine what the "ideal strategic alliance" would be in an "ideal world," and then project what a more "realistic" type of alliance might be.
- ❖ Level Two **- alliance pursuance -** The decision to form an alliance is finalized, and the firm establishes the strategic and operational considerations that will be used to select the alliance partner
- ❖ Level Three **- alliance confirmation -** focuses on partner selection and confirmation. Managers determine the strategic and operational expectations for

the arrangement through joint meetings with the alliance partner and the relationship is solidified.

- ❖ Level Four - **alliance implementation continuity -** creates a feedback mechanism to administer and assess performance continually to determine whether the alliance will be sustained, modified, or terminated. Should a conflict occur, the firm might need to explore different types of conflict resolution mechanisms?

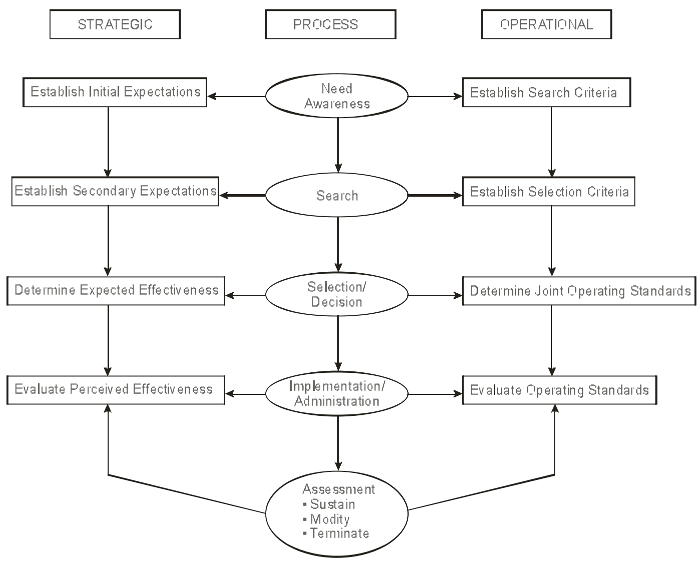

Fig: 2.2 General Alliance Development Model

It is important to note that the first two stages focus primarily on the firm initiating the alliance (the "initiating firm"), whereas the last two stages correspond to both parties, because the alliance partner has now joined the relationship. It is also important to note that such alliances may begin with a single firm, but may then extend to other firms both customers or suppliers in the supply chain. In each case, the same series of stages has to occur, although the situation is now made more complicated by the fact that there are two or more initiating firms performing the process, not one.

12.1.1*2.3.2* DEVELOPING A TRUSTING RELATIONSHIP WITH PARTNERS
12.1.2 IN THE SUPPLY CHAIN

Trust is not something that simply "happens." Especially in the early stages of a supply chain relationship partners must trust not only one another but also other members higher or lower up in the supply chain. Trust can be initiated when a company's performance history and reliability of its supply chain linkages can be demonstrated. If another party does not perceive your supply base or customers as being reliable, then a strong convincing factor is an "open hook" policy of past performance data.

Trust is not something that can be easily measured or identified. For instance, what are the specific criteria that one as an individual use in "trusting" another individual? The elements of trust will typically vary considerably depending on the situation. One may trust someone other out of a sense of loyalty or because he or she has "always come through" for him or simply because one get a "'good" feeling about his or her integrity even though you haven't known the individual very long. In fact, anyone of these types of feelings is important in assessing trust. Once we understand how trust develops, we can then begin to understand the types of actions that can lead to a trusting relationship, resulting in the important benefits achieved through supply chain integration.

In this section, we describe the major types of trust, how they are developed, and illustrate each type with a supply chain example. In other words, we will consider how people can become more "trustworthy" in the eyes *of* their customers and suppliers, and thereby increase confidence that their joint goals and objectives can be achieved.

12.1.2.1 Reliability

This element of trust depends on the prior contact that an individual has experienced with another individual over time. If someone has acted in a consistent and predictable manner over an extended period that person is likely to be considered reliable by the other party. However, reliability is also often based on the integrity or honesty of the other party.

Integrity refers to the extent to which a person repeatedly acts according to a moral code or standard. If a person consistently follows this code, even in unusual situations, he or she is perceived as being reliable, and, therefore, trust in that individual is likely to increase.

12.1.3 Competence

Competence is one person's perception of the ability of another person to meet commitments. This form of trust is somewhat different than reliability. Competence-based trust can be broken down into three key areas. The first area, *specific competence,* is trust in the other person's specific functional area. The second area is *interpersonal competence,* which is the ability of a person to work with people. This often refers to an individual's "people skills." such as the abilities to listen effectively to another person to negotiate effectively to communicate and make a presentation, to reach a consensus with a group and other types of related skills necessary when dealing with others on a day-to-day basis. In managing a supplier or customer, these types of skills are especially important as the majority of communication in the early stages of supply chain integration occur at face-to-face meetings. The third area of competence involves *business sense,* which refers to an individual's experience, wisdom and common sense. This may also occur in specific technological or functional areas.

Affect - Based Trust ("Goodwill"

This dimension of trust is somewhat difficult to define fully because it refers to the emotional investment that develops between individuals that trust one another. The importance of interpersonal relationships is recognized as a vital element in developing trust between organizations. Affect-based trust can be broken down into two elements. The first, *openness with the other party,* describes a situation when each party feels that it can share problems or information with the other party. For instance, a supplier who provides information on internal costs, or a buyer who provides information on future forecasts, may instill greater trust on the behalf of the other party. Second, affect-based trust requires *benevolence,* which refers to the assumption by one party of an acknowledged or accepted duty to protect the rights and interests of the other party. Moreover, this type of trust can best be described as a faith in the moral integrity or goodwill of others, which is produced through repeated personal interactions. Over time, this leads to a certain "bond" between the individuals, defined by common mutual norms, sentiments, and friendship.

12.1.3.1 Vulnerability

It has been said that trust without some kind of vulnerability simply cannot exist and that trust involves adhering to commitments to others or a stated course of action even if the probability of failure is greater than the probability of success. Moreover vulnerability suggests that some form of risk is present in committing to a supply chain partner, which goes beyond the common types of uncertainties that accompany any supply situation. Vulnerability projects a feeling of being unprotected or exposed in addition to uncertainty or risk.

12.1.3.2 Loyalty

This type of trust occurs after a period of reliable performance, when 'one party develops a certain degree of faith in the other party. This leads one party to believe that the other party is not only reliable but will perform well in extraordinary situations and can be relied on when "it really counts. This goes back to the old adage. "You find out who your true friends are when you're really in trouble." One can only be certain that someone really cares when a situation makes it possible for that person not to care. This often occurs through strong interpersonal bonds.

13 2.4 CONCLUDING REMARK

13.1

In this section, we have presented a general framework for managing supply chain relationships. It is clear that the concepts proposed are, by definition very broad and general in nature. There is a very good reason for this: Every supply chain relationship is unique and carries with it a unique set of benefits, challenges, and potential conflicts. Companies who go into a close relationship with supply chain members must be aware of the fact that such relationship requires a great deal of time, effort, and resources to manage.

14 CHAPTER 3

15 THE MODEL FORMULATION

16
17

3.1 INTRODUCTION AND ASSUMPTIONS

We are considering a supply chain inventory system having one central warehouse or distribution center with a very large capacity, and three retail outlets. Each retailer faces normally distributed random demand pattern, demand at every retail outlet is independent of other's demand. Lead-time is also normally distributed and independent of other retailer's lead-time. All retailers are following periodic review policy.

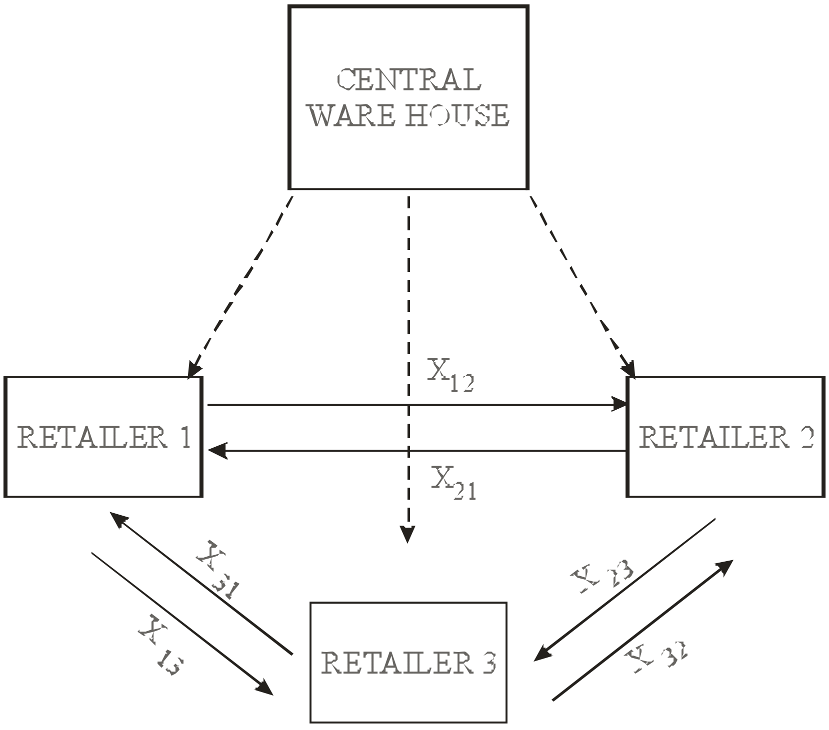

Fig. 3.1: Central Ware House and Retailers

Central warehouse supplies a fixed quantity of units to the retailers and not allowed to transship more quantity, In case of stock-out in a particular period. If surplus quantity is remained after fulfilling the demand, retailer will hold it.

In case of shortage at one retailer and availability of product at any other retailer, lateral transshipment occurs between them. Demand not satisfied after transshipment is considered as shortage. Back orders are not received from central warehouse, and there is not any emergency buying from any agency. Shortage in any period does not affect the demand of any other period. Model allows complete pooling, between retail outlets. The three retailers have identical unit costs of shortage per period, holding and unit transshipment cost between any two retailers. It is assumed that lateral transshipment occurs practically instantaneously. This is possible when retailers are very near to each other; Fig.1 shows the structure of the supply chain inventory system and flow material. Fig.4. 1 shows a central warehouse with three retail outlets.

Unit lateral transshipment cost among retailer is being very low as compared to ordering from central warehouse. If retailer has some surplus inventory after lateral transshipment then he has to pay holding cost for it. Retailers have to pay for lost sale and, loss of goodwill of customer if stock-out is there. We are studying the fruit and vegetable supply chain, but we are not considering here loss due to decaying of goods. Sometimes retailer has to hold the inventory without selling for few periods, hence the mode for selling will be "First Come First Sell" (so that, decaying of goods could be avoided).

We have considered that demand at individual retail outlet is independent of demand at other retail outlet. Hence increase or decrease in demand at any outlet does not affect demand at other outlet. We have assumed that inventory at the start is maximum inventory level for all the retailers. Relationships of different costs and, different inventory policies are given as per following description. Relationships for service level are also discussed to measure the performance.

3.2 RELATIONSHIPS FOR INVENTORY

We are analyzing supply chain-inventory system for perishable goods such as fruits and vegetables. Thus, we have considered periodic review inventory policy. Inventory is checked at the end of every singe period and if inventory is less then or equal to reorder level quantity then an order is placed. All the calculation regarding inventory are as per following relations. Maximum level of inventory is given as

$$M = (Review\ Period + Mean\ Lead\ Time)*Mean\ Demand$$

$$or\ \ M = (R + \iota_m)\ D_m \tag{3.1}$$

Now we will discuss the relation for reorder level. It is amount of inventory such that, if inventory level touches it or fall below this an order is placed. Recorder level of inventory is given as per following relation.

$$R_l = Mean\ Lead\ Time*Mean\ Demand$$

$$or\ \ R_l = \iota_m\ D_m \tag{3.2}$$

When inventory reaches at reorder level or below this level, an order is placed. Here intransit inventory is also included, to calculate the ordered quantity by retailer *i*. It is the inventory, which has, been ordered but yet could reach to retailer. Hence ordered quantity can be calculated as per following relation,

$$Q_i = Maximum\ Level\ of\ Inventory - (Intransit\ Inventory + Surplus\ Inventory)$$

$$or\ Q_i = M - (Q_{ti} + H_i) \tag{3.3}$$

Some quantity of fruits and vegetables are not sold in particular period, hence surplus quantity of previous day is held by retailer. Thus total inventory for sale in particular period is given as,

T_i = *Surplus Inventory of Previous Day + Inventory Reached That Day to Retailer i*

or $T_i = S_i + Q_{ri}$ (3.4)

We have assumed that all retailers have maximum level of inventory at the start, for both the cases with transshipment and without transshipment.

3.3 RELATIONSHIPS FOR COST

Here expected cost is adopted, to measure the performance of the system. In general total cost consist of the transportation cost from the central warehouse, inventory holding cost, shortage cost and cost of emergency lateral transshipment. But transportation cost in long run, will not vary with demanded quantity and ordered quantity. Hence we take transportation cost constant for over all system. This will be independent of base stock and transshipment policy, and can be disregarded [17].

Thus applicable cost function include only holding, shortage and lateral transshipment cost terms, so expected cost for holding is given as,

$$E\,(CH) = \sum_{i=1}^{3} \textit{Unit Holding Cost * Surplus Quantity of Retailer } \mathrm{i}$$

or $$E\,(CH) = \sum_{i=1}^{3} C_h H_i \quad (3.5)$$

Expected cost for shortage is given as,

$$E\,(CO) = \sum_{i=1}^{3} \textit{Unit Penalty Cost * Stock-Out Quantity for Retailer } \mathrm{i}$$

or $$E(CO) = \sum_{i=1}^{3} C_p O_i \quad (3.6)$$

and expected cost for lateral transshipment is given by

$$E(CT) =- \sum_{i=1, j=1, i\neq j}^{i=3, j=3} \textit{Unit Transshipment Cost * Transshipment Quantity from Retailer } \text{i}$$

to j

or $$E(CT) = \sum_{i=1, j=1, i\neq j}^{i=3,\ j=3} C_t X_{ij} \tag{3.7}$$

Now expected cost per period, with transshipment, will be sum of expected holding cost, expected shortage cost, expected lateral transshipment cost. It can be given by following relationship.

$$E_1(C) = \textit{Expected Holding Cost + Expected Shortage Cost + Expected Lateral Transshipment Cost}$$

or $E_1(C) = E(CH) + E(CO) + E(CT)$

or $$E_1(C) = \sum_{i=1}^{3} C_h H_i + \sum_{i=1}^{3} C_p O_i + \sum_{i=1, j=1. i\neq j}^{i=3, j=3} C_t X_{ij} \tag{3.8}$$

In case of, without transshipment expected cost will be, sum of expected holding cost and expected stock out cost. it can be written as following.

$$E_2(C) = \textit{Expected Holding Cost + Expected Stock-Out Cost}$$

or $E_2(C) = E(CH) + E(CO)$

or $$E_2(C) = \sum_{i=1}^{3} C_h H_i + \sum_{i=1}^{3} C_p O_i \tag{3.9}$$

Both cost *E1(C)* and *E2(C)* is to be compared for every period, as well as for the whole system, to measure the performance on the basis of cost.

18 3.4 RELATIONSHIPS FOR SERVICE LEVEL

We measure the performance of system by expected cost and service level. Service level shows, fraction of total demand, which is satisfied. Service level can be shown in two ways. These are, demand service level and period service level. Demand service level (SL_1) gives better idea of satisfied customer. But when previous day's unsatisfied customer demand, does not affect next day's demand, then Period service level (*SL2*) can be used to measure the performance.

Demand service level can be defined as, "it is the ratio of, available quantity (to satisfy the customer) to total demand". Mathematically it can be written as

$$SL1 = 1 - \frac{Total\ Stock\ out\ Quantity}{Total\ Demand}$$

$$or\ SL1 = 1 - \frac{\sum_{i=1}^{3} O_i}{\sum_{i=1}^{3} D_i} \qquad (3.10)$$

Period service level can be defined as, "it is the ratio of number of periods, in which all the customers are satisfied to total number of periods under consideration". Mathematically it can be written as follows,

$$SL2 = 1 - \frac{Total\ No.of\ Stock\ out\ Periods}{Total\ No.of\ Periods}$$

$$or\ \ SL2 = 1 - \frac{N_O}{N_T} \qquad (3.11)$$

One of the above relations can be used to measure the service level of system. We can measure, the service level for total system as well as for individual retailer.

3.5 CONCLUDING REMARK

Different equations are discussed here, for inventory, cost and service level. In the next chapter, an illustrative example is considered for simulation model. All the above-mentioned relations are used to evaluate the model. We will solve the model by, using above written equations of inventory, costs, and service level.

CHAPTER 4

20 DEVELOPMENT OF A SIMULATION MODEL
21

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4.1 INTRODUCTION

Simulation is an effective way to solve stochastic problem. Simulation model is considered here, to study the risk pooling effect, for variable demand and variable lead-time. Because of complexity, the stochastic nature of data, the stochastic relationship between variable and certain problem –specific characteristics not all real-world problems can be modeled and solved with use of mathematical models and /or heuristic methods. The use of mathematical or heuristic method for such complex real problems will often require simplifying assumptions. This may cause the resulting solutions to be much inferior and sometimes infeasible. Simulation is probably the only available form of solution methodology in such cases. In a simulation model the complexities of the problem and relationship between various variable are modeled by means of equations. The inputs to the model are often described by probability distributions. The system is simulated over time to analyze the outputs. Simulation is typically used for analyzing the performance of real-world systems over time under various operating procedure and policies. Before discussing the simulation model for illustrative example, we will discuss about simulation first.

4.2 SIMULATION

Simulation is a widely used quantitative procedure in which a process is described by a model of reality and then a series of organized experiments are conducted to predict the behavior of the model over a period of time. Simulation is thus the laboratory experimentation of reality for determining the effect of a number of alternative policies without disturbing the real system. A laboratory imitation of the reality is at the core of the simulation process. Hence simulation can be defined, as “it is the use of quantitative system model that has the designed characteristics of reality in order to produce the essence of actual operation by developing a series of organized experiments to predict the process over a period of time” (23).

23.1 4.2.1 *PURPOSE OF SIMULATION*

- Many situation are difficult to be modeled into conventional mathematical model such as linear programming, integer programming, etc. sometimes, the approximation of real life parameters may not desirable. In these cases, simulation is an effective way to model and analyze the situations.
- Simulation may be cost effective as compared to real experimentation.
- Sometimes, the observation of real system is impossible, as it is not yet implemented. The analysis of a manufacturing- system design through simulation is widely used before implementing the actual system.
- Simulation provides modeling flexibility may be evaluated.
- Simulation provides the ease in modeling the system.
- Simulation provides the ease in modeling the system.
- Simulation provides a faster mode of evaluating the system. Many computers – based simulation model can evaluate the performance of the system in few hours. For the real life observations, many years needed.
- Simulation may be designed to have graphic capability and on screen display potential.
- Simulation is normally associated with large observations over a period of time. Many inputs to the system may contain a statistical distribution. For example, arrival of parts to machine may be treated as coming from a normal distribution.
- Simulation may have the capabilities to analyze, the result in the statistical terms.
- Simulation is a useful way to draw customer attention about the system performance. It also provides customer support.
- Sometime, the operation and observation of the system in a particular situation may be too dangerous or disruptive. In these cases, simulation is a good way to analyze the system's behavior.

Many times, simulation may be the only way to solve. In such situation, use of mathematical model or real life system is just impossible.

- Simulation is useful to judge the system's behavior in a controlled environment. This is important when effect of changes in few parameters needs to be observed.
- Simulation provides a better understanding of the system.
- Simulation is a useful teaching tool when there is a time limitation for working on a real system for many years and cost of procuring and handling the real system is too high.
- Simulation is helpful in giving new insights of a complex system with facility to undertake wide experimentation in relatively lesser time. Wide experience may be developed in a lab setting.

23.2 4.2.2 *LIMITATIONS OF SIMULATION*

- Generally simulation models are not precise and exact replication of reality. It is, therefore, not an optimizing tool. It is descriptive tool.
- Simulation requires large number of experimentations or runs under a given set of conditions. Any deviation in these conditions may not justify the simulation results. Therefore, each simulation model provides a unique solution.
- With increase in parameters, simulation becomes very complex to the model.
- An effective simulation model is very expensive to develop. For example, if we develop p corporate planning model or selection of an FMS system, it may take years to develop a reasonable model.
- Management has to generate all the options, constraints and, which are mercenary for evaluation. Simulation does not generate any conditions on its own.

4.3 SIMULATION MODEL FOR ILLUSTRATIVE EXAMPLE

Here a simulation model is considered for an illustrative example. The model is applied to fruits and vegetables supply chain. There are three retail outlets, with one central warehouse. Warehouse is far away from retail outlets, but retail outlets are very near to each other. The products considered in this example are perishable. Therefore, strategy related to transshipment of the inventory across different retailers should be effective in minimizing the loss due to passage of time. The order quantity, which comes first, sold first, so that we could reduce loss due to passage of time.

Maximum lead-time is considered less than the life of the product. Thus product will not decay in transportation. There is variable lead time, which is according to normal distribution curve, it is considered that delay may be due to different reasons such as accidents, road blocks etc. Since retail outlets have variable demand and lead time, which are randomly generated, they face shortage or surplus. When there is no transshipment among retailers, the retailers have to pay for surplus or shortage. However with lateral transshipment both holding and shortage quantity decreases simultaneously shortage or surplus at one retail outlet is decreased or removed thereby reducing the total expected cost. If the retail outlets do not consider for lateral transshipment, they have to pay holding cost for surplus inventory that remains after the individual demand is satisfied and have to pay for shortage cost, if stock-out take place at some outlets. Here three outlets are considered to form a complete pooling group. Complete pooling means that outlet with surplus will transship, its entire surplus to fulfill the shortage at the other outlets if the surplus is less than or equal to the shortage. In the following section we will discuss the methodology to solve the illustrative example.

24 4.4 THE METHODOLOGY

The methodology adopted to solve the problem is as follows,

1. We assumed constant holding cost, shortage cost and transshipment cost for each retailer.
2. We have considered randomly generated normally distributed demand and lead-time for the problem.
3. Simulation model are made for lateral transshipment as well as without lateral transshipment. (Total four simulation model have been made)
4. Total transshipment cost with or without transshipment is calculated.
5. Service level is calculated for both the cases.

25 4.5 THE DATA SET

The demand for the three retailers is randomly generated for 150 demand periods of 50 each (retail outlet) cost parameters for all the retailers are assumed to be same for the entire group. Holding cost for each surplus unit is Rs. 3 per unit. Shortage at each retailer is charged with Rs. 2 per unit, and transshipment cost of the group is taken as Rs. 1 per unit. Also different unit transshipment cost is taken as Rs. 1, Rs. 2, and Rs. 3 respectively as per requirement, to see the effect of different transshipment cost. Mean demand is taken as 10 units and its standard deviation is 2, and mean of lead-time is taken 3 and its standard deviation is taken as 1.

Now, all the data are determined, so we will discuss the solution as per following steps.

26 4.6 THE SOLUTION STEPS

Now we will discuss the steps to solve the problem. Above-mentioned problem will be solved as per following steps.

1. Calculate demand variation up to $\pm 3\sigma$ level.
2. Compute randomly generated normally distributed demand for 150 different periods.
3. Also calculate the lead-time variation up to $\pm 3\sigma$ level.
4. Compute the randomly generated normally distributed lead-time for 150 different periods.
5. Solve the simulation model for given demand and lead-time.
6. Find out the surplus and shortage of each retailer for one set demand.
7. Transship the require amount of surplus to the retailer with a shortage.
8. Calculate the holding cost as in Eq.3. 5 Shortage cost as per Eq.3. 6.
9. Calculate the transshipment cost for the group using Eq. 3.7.
10. Calculate the total expected cost for with transshipment and without transshipment using Eq.3.8 and Eq.3.9.
11. Calculate the service level as per Eq.3.10 and Eq. 3.11.

4.7 CONCLUDING REMARK

Here, in this chapter, we have discussed about simulation. We have also discussed about, simulation model for illustrative example, solution methodology of the problem, data set is determined and then solution steps are discussed to solve the model. In the next chapter, we will discuss the finding of solution generated, according to above mentioned solution steps.

// Codes are generated (for simulation) in c++.

27 CHAPTER 5

28 ANALYSIS OF THE FINDING AND DISCUSSION

Risk pooling effect, in considered supply chain is evaluated, as per mentioned relationships and mythology in earlier chapters. This supply chain is studied for inventory and cost. To measure, the performance of supply chain, service level is considered. So, to discuss different aspects, we have plotted the graphs for them. Different aspects of inventory (inventory available per period, order quantity, surplus quantity and stock out quantity) will be considered, for both with transshipment and with out transshipment. We will analyze these aspects for individual retailer as well as for whole system. First, we will discuss about total inventory available per period to the retailers. The following graphs are made for total inventory available per period.

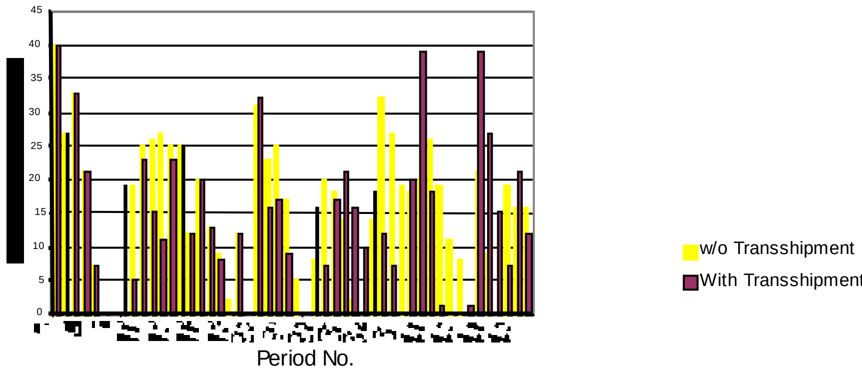

Fig 5.1 Comparison of Total Inventory Available Per Period With and Without Transshipment for Retailer 1

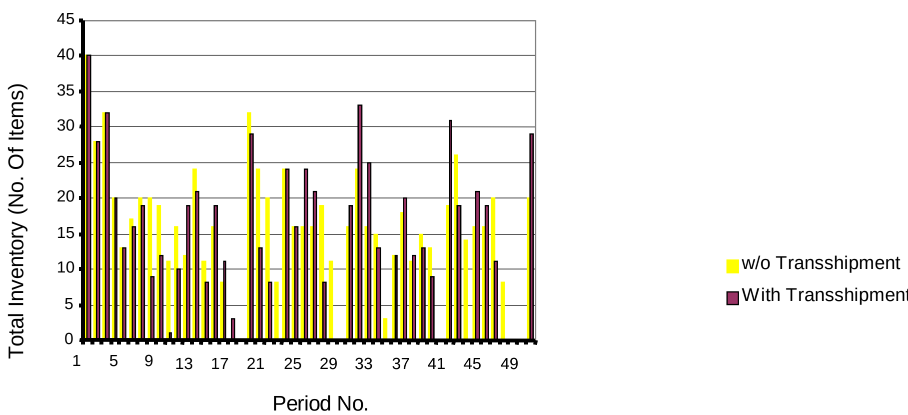

Fig 5.2 Comparison of Total Inventory Available Per Period With and Without Transshipment for Retailer 2

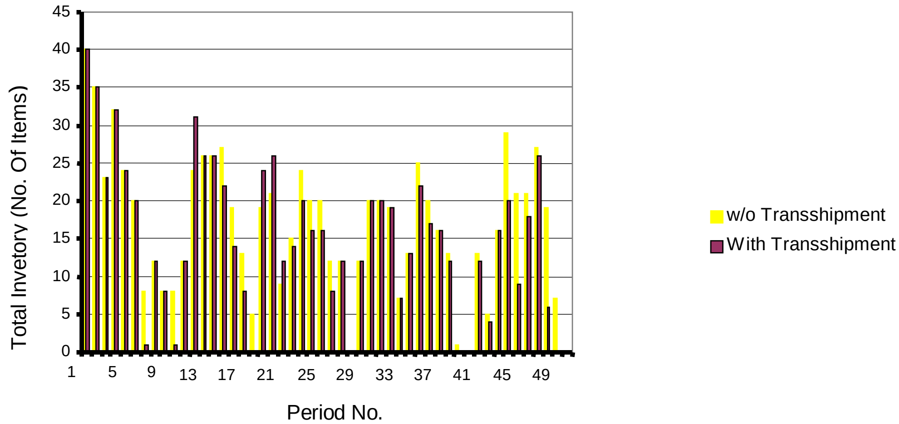

Fig 5.3 Comparision of Total Inventory avialable Per Period With and without Without Transshipment for Retailer 3

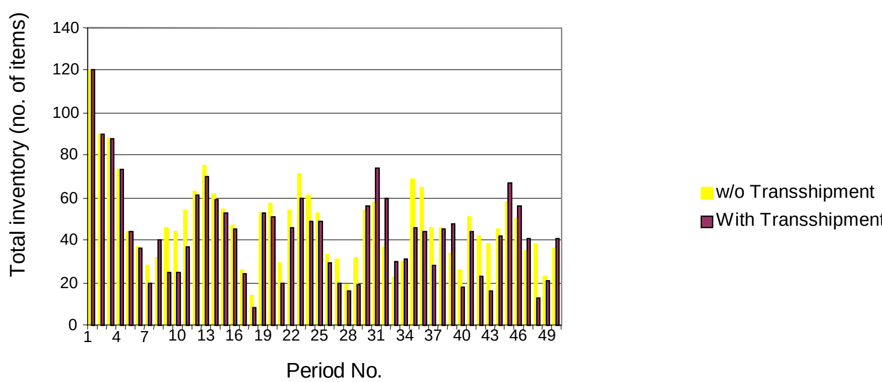

Fig 5.4 Comparison of Total Inventory Available Per Period for All Retailers, With and Without Transshipment

- Fig. (5.1–5.3) shows that, when we compare total inventory available per period for all the fifty periods, we find, in most of the periods, total inventory available is more, in case of without transshipment than with transshipment.

- Fig. 5.4 shows that, in case of comparing total inventory per period without transshipment and with transshipment, there is more difference than comparing for single retailer.
- Few starting periods (Fig. 5.1-5.4) shows that, total inventory available is equal, for both the cases with transshipment and without transshipment (for all three retailers).

Total inventory available per period, for all three retailers is discussed above. This shows different trend exists in fifty periods. Now, we will discuss about order quantity, for individual retailer as well as for whole system.

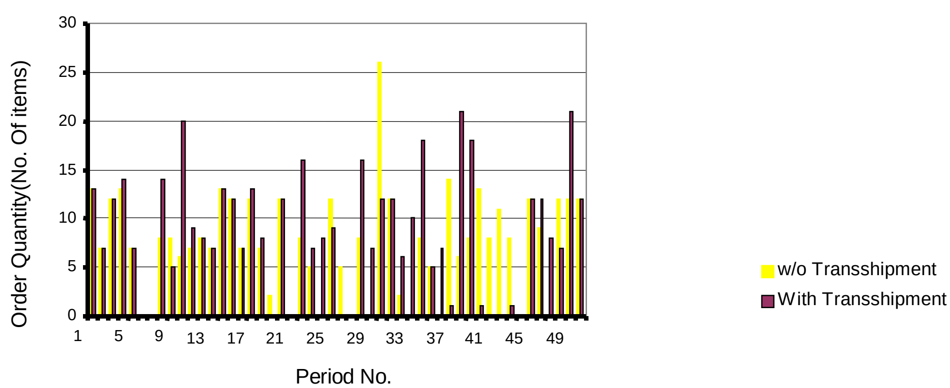

Fig 5.5 Comparision of Order Quantity Per Period With and Without Transshipment for Retailer 1

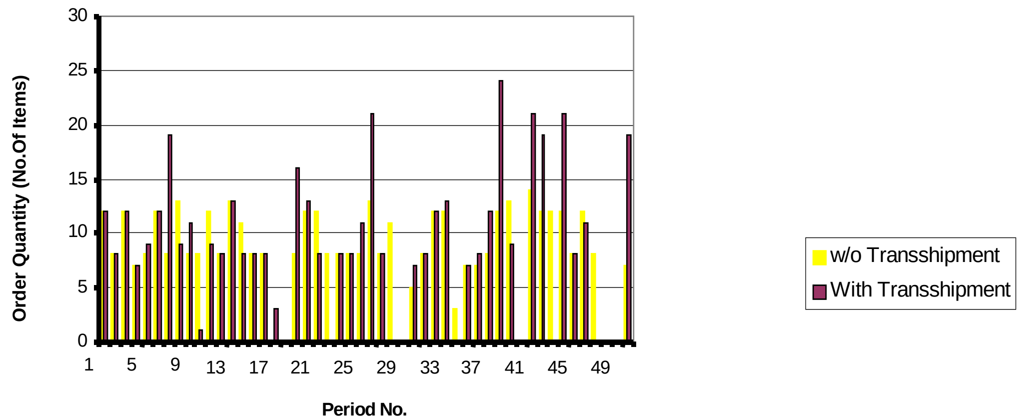

Fig 5.6 Comparision of Order Quantity Per Period With and Without Transshipment for Retailer 2

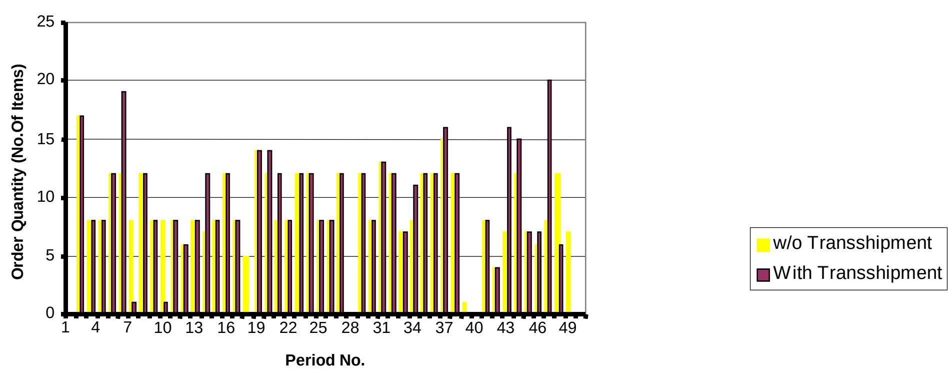

Fig 5.7 Comparision of Order Quantity Per Period With and WIthout Transshipment for Retailer 3

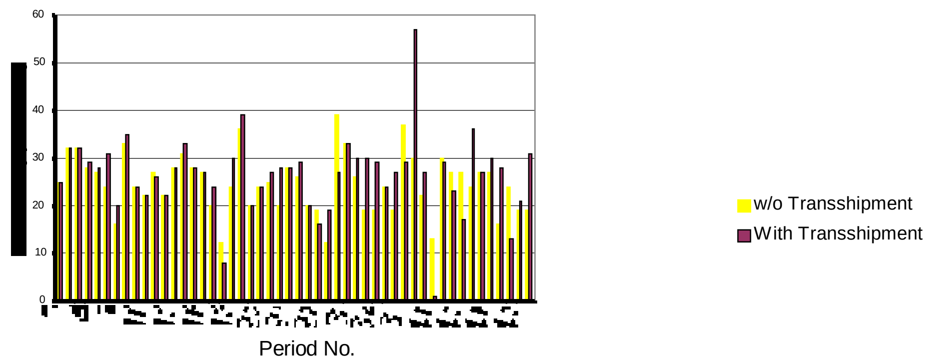

Fig 5.8 Comparision of Order Quantity per Period for All Retailers With and Without Transshipment

- Fig. (5.5–5.8) shows that, when we compare order quantity per period, for all the fifty periods, we find, in most of the periods, order quantity is more, in case of with transshipment than without transshipment.
- Few starting periods (Fig. 5.5-5.8) show that, order quantity is equal, for both the cases with transshipment and without transshipment (for all three retailers).

Order quantity per period, for all three retailers is discussed above. This shows different trend exists in fifty periods. Now, we will discuss about surplus quantity per period, for individual retailer as well as for whole system.

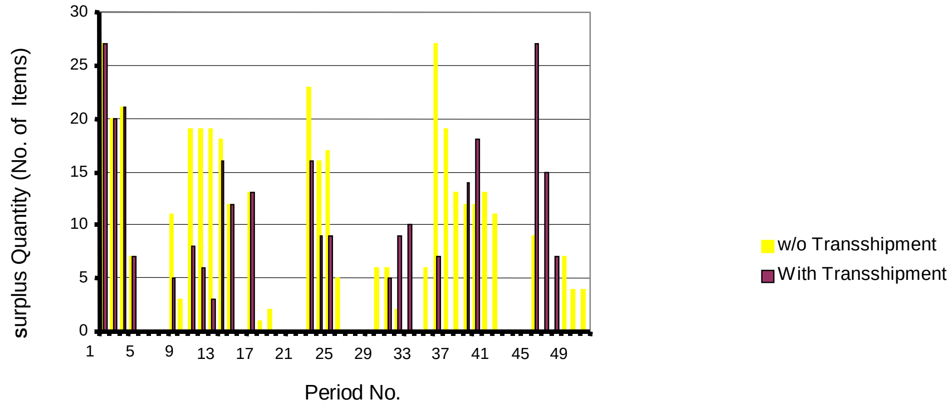

Fig 5.9 Comparision of Surplus Quantity Per Period With and Without Transshipment for Retailer 1

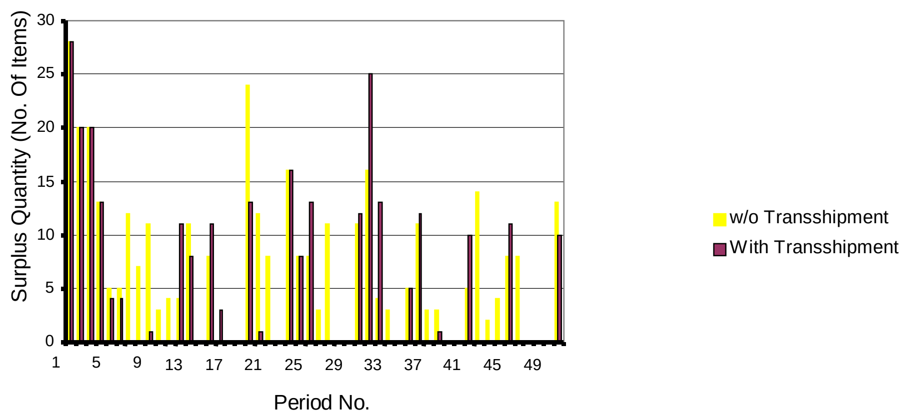

Fig 5.10 Comparison of surplus Quantity Per period with and without Transshipment for Retailer 2

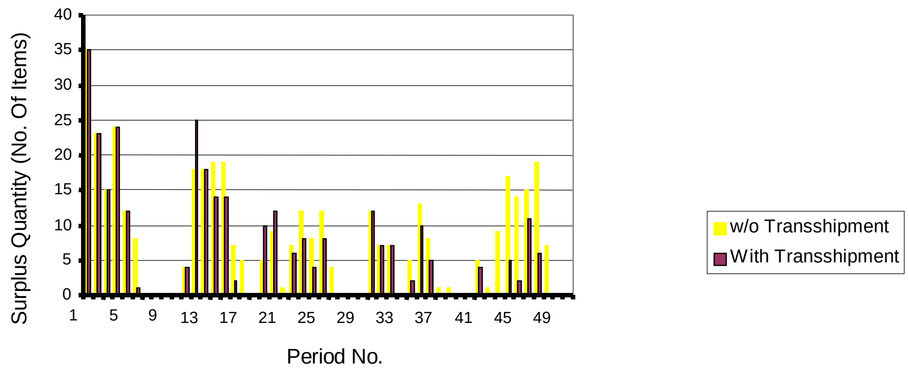

Fig 5.11 Comparision of Surplus Quantity Per Period With and Without Transshipment for Retailer 3

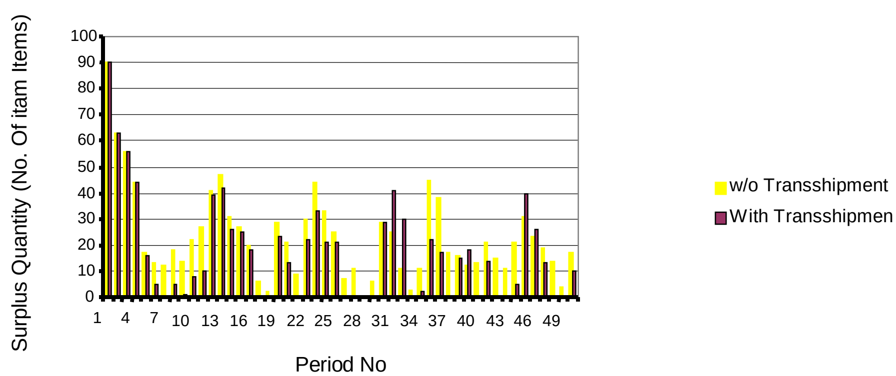

Fig 5.12 Comparision of Surplus Quantity Per Period for All Retailers With and Transshipment

- Fig. (5.9–5.12) shows that, when we compare surplus quantity per period, for all the fifty periods, we find, in most of the periods, surplus quantity is more, in case of with transshipment than without transshipment.

- Few starting periods (Fig. 5.9-5.12) show that, surplus quantity is equal, for both the cases with transshipment and without transshipment (for all three retailers).

Surplus quantity per period, for all three retailers is discussed above. This shows different trend exists in fifty periods for surplus quantity in both cases. Now, we will discuss about stock out quantity, for individual retailer as well as for the whole system.

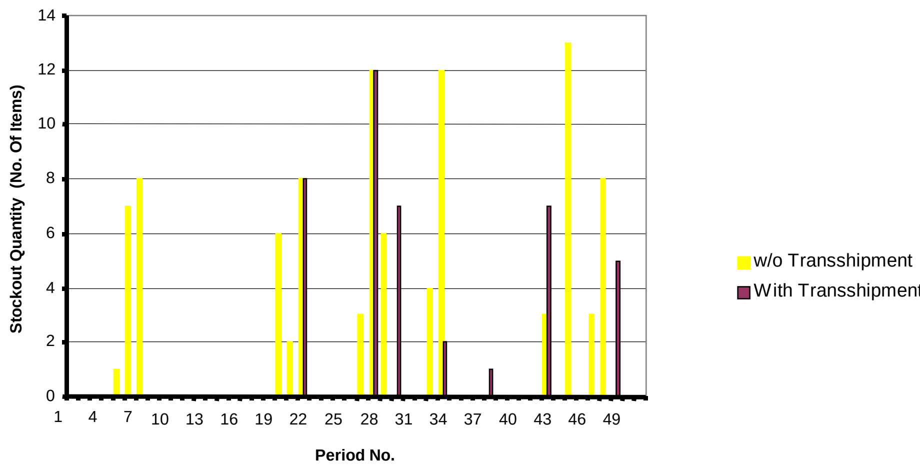

Fig 5.13 Comparision of Stockout Quantity Per Period With and Without Transhipment for Retailer 1

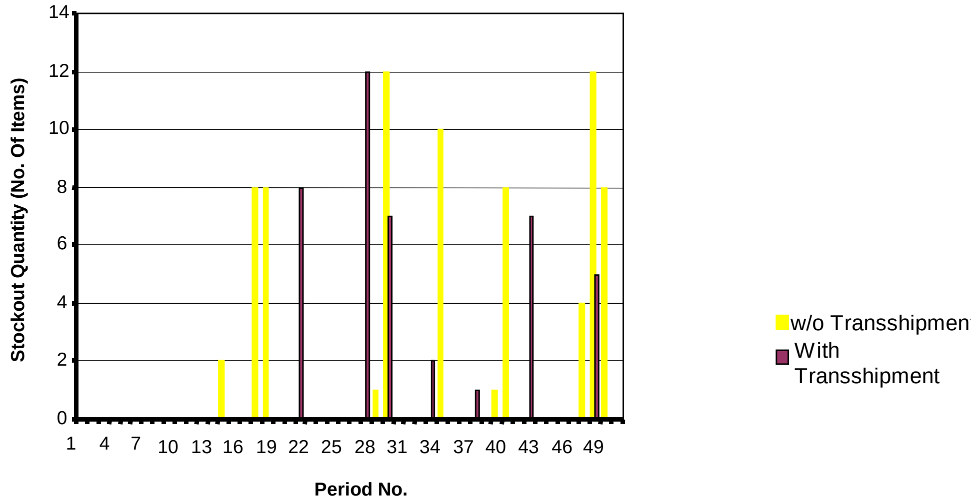

Fig 5.14 Comparision of Stockout Quantity Per Period With and without Transshipment for Retailer2

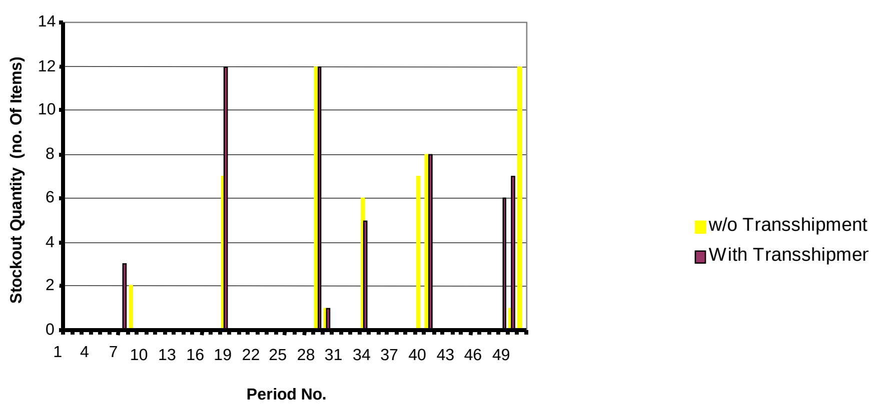

Fig 5.15 Comparision of Stockout Quantity Per period With and Without Transshipment for Retailer 3

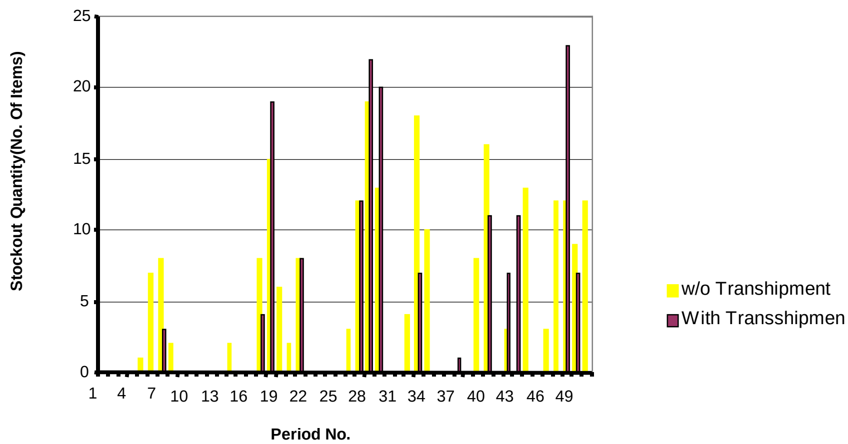

Fig 5.16 Comparision of Stockout Quantity Per Period for All Retailers With and without transshipment

- Fig. (5.13–5.16) shows that, when we compare stock-out quantity per period, for all the fifty periods, we find, in most of the periods, stock-out quantity is more, in case of without transshipment than with transshipment.
- Few starting periods (Fig. 5.13-5.16) show that, stock-out quantity is equal, for both the cases with transshipment and without transshipment (for all three retailers).

Stock out quantity per period, for all three retailers is discussed above. This shows different trend exists, in fifty periods for stock out quantity. Now, we will discuss about cost of inventories for both cases, for individual retailer as well as for whole system.

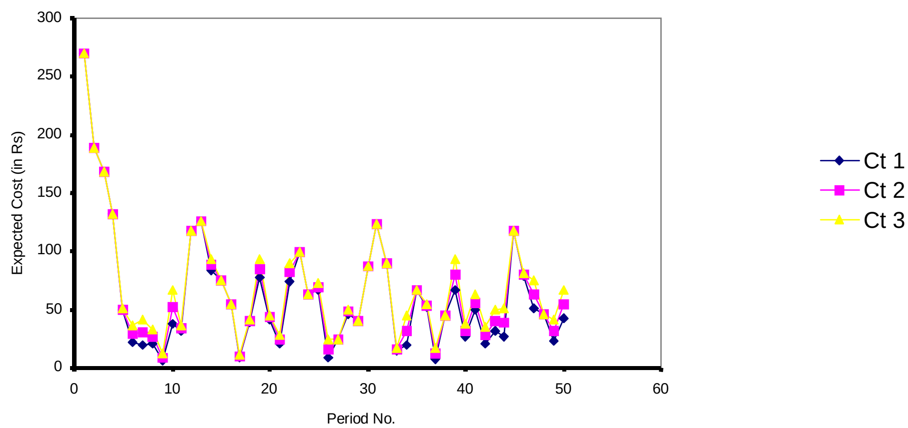

Fig 5.17 Total Expected Cost with Transshipment for Different Transshipment Costs

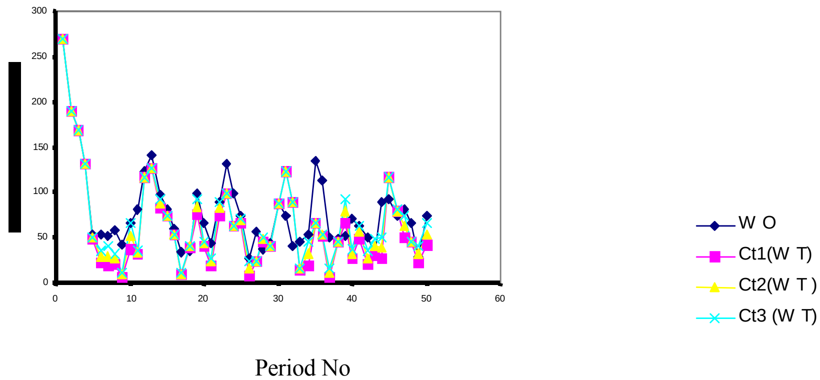

Fig 5.18 Comparison Of Total Expected Cost With and Without Transshipment

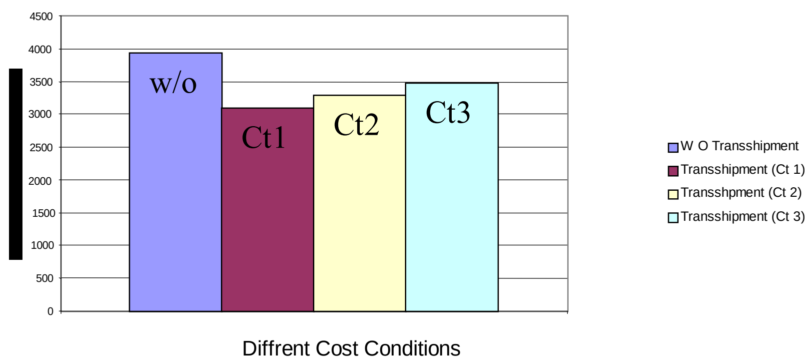

Fig 5.19 Comparision of Total Expected cost with variable Transshipment costs

- Fig 5.17 shows total expected cost with transshipment. In this Fig we find that expected cost increases as we increase unit transshipment cost.

- Fig 5.18 shows expected cost per period with and without transshipment. In most of cases expected cost without transshipment is more than transshipment cost for all considered values of unit transshipment cost.

- Fig. 5.19 shows total expected cost of all three retailers fifty periods of each. This

Fig. Shows that as unit lateral transshipment cost increases total cost also increases. Total cost is also higher for without transshipment.

It also shows that, if we increase unit transshipment cost, than at some of its value total cost with transshipment will be equal to cost without transshipment.

Cost in case of transshipment and without transshipment is discussed above, for all three retailers. Total cost with, different unit transshipment cost is also discussed. Now, we will discuss about service level, for individual retailer as well as for the whole system.

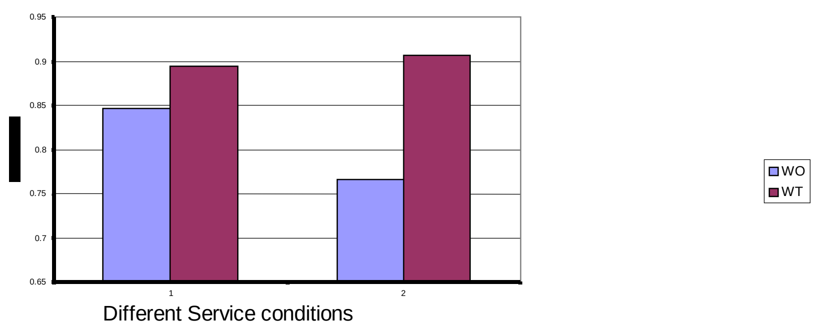

Fig 5.20 Comparison of Service Level With Transshipment and W/o Transshipment

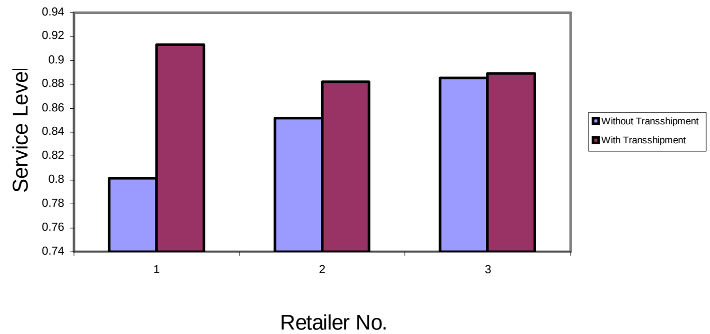

Fig 5.21 Service Level for Different Retailers

- In Fig 5.20, we compare the service level for two cases. We find that service level is high in case of transshipment. It also shows that, demand service level is higher than period service level. In both cases of with transshipment and without transshipment.

- Fig 5.21 shows that, when we compare service level for both cases individually, for all three retailers, we find improvement in service level, in case of with lateral transshipment.

Here, we have discussed the finding of the simulation model. We have discussed about different aspects of inventory, expected costs and service level. Now, in the next chapter, conclusion on the basis of this discussion is made.

28.1 CHAPTER 6

28.2

28.3 CONCLUSIONS AND DIRECTIONS FOR FUTURE WORK

Emergency lateral transshipment in multi retailer system is studied. We compare, different aspects for two cases, with transshipment and with out transshipment. The comparison is made for different aspects of inventory, such as Total Inventory Available, Ordered Quantity, Surplus Inventory and Stock Out Quantity. We have also compared both the cases (with transshipment and with out transshipment) for cost. To measure the performance of system as well as performance of individual retailer, we have studied the service level. This study gives, very useful and beneficial conclusions to manage the supply chain. As per earlier describetion, the most important out comes, can be concluded as follows.

28.3.1.1 Conclusions

1. Surplus quantity is less in case of lateral transshipment, so holding cost is decreased. Thus, lateral transshipment good way, to reduce holding cost in supply chain inventory system (of retailers).

2. Stock-out quantity is less in case of lateral transshipment, so stock-out cost is minimized. Thus, lateral transshipment is also good way to reduce shortage cost in supply chain system (of retailer).

2. The total expected cost is less, in case of lateral transshipment than without transshipment. It is true for individual retailer, as well as group of retailers, participating in sharing of inventory in emergency. Therefore lateral transshipment is an effective tool to reduce the total system cost, as well as individual retailer's inventory cost.

4. In case of lateral transshipment, more customers are satisfied, than without transshipment. It is true, for system of retailer as well individual retailer. Thus it is an effective way to satisfy the customer demand.

5. Lateral transshipment is fruitful, when unit transshipment cost is less.

6. It is ineffective, when all retailers, in every period, showing same pattern (of surplus and stock-out)

.

7. To make risk-pooling (lateral transshipment) strategy effective, there should be good relation among retailers. It is win-win situation to all the retailers.

8. Locations of retailers should be very near to each other, so that transshipment

cost remains low, and they could provide better service to customer.

28.3.1.2 Limitations

This study is done, for specific problem (fruits and vegetables supply chain) under certain assumptions, for variable demand and variable lead-time. Hence, conclusion of above study may be specific and sometime they can't be generalized. There may be lot of variations of this study. Some variations are listed below for the future work. This is practical area of daily life problems, so there may exist lot of specific problem concerning to supply chain inventory system.

28.3.1.3 Work for future

1. Study without complete pooling
2. Study with dependent demand
3. Study of multi warehouse system.
4. Study with different holding costs at different outlets
5. Study of different Lateral transshipment cost for different retailer.
6. Study of optimization of inventory at the start

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Appendix A: Expected Demand and Lead Time for Three Retailers

Pr.No.	D1	L1	D2	L2	D3	L3
1	13	1	12	1	5	2
2	7	5	8	4	12	1
3	12	4	12	2	8	2
4	14	5	7	2	8	4
5	8	5	8	2	12	2
6	7	1	12	2	12	5
7	8	4	8	4	8	2
8	8	1	13	2	14	2
9	8	2	8	5	8	2
10	6	2	8	2	8	2
11	7	2	12	1	8	2
12	8	5	8	2	6	4
13	7	2	13	5	8	1
14	13	1	13	4	7	4
15	12	4	8	5	8	4
16	7	5	8	2	12	2
17	12	4	8	5	8	2
18	7	5	8	4	12	4
19	8	4	8	5	14	2

20	14	1	12	2	12	2
21	8	2	12	1	8	5
22	8	5	8	4	8	1
23	7	5	8	2	12	1
24	8	5	8	2	12	4
25	12	4	8	4	8	4
26	8	2	13	4	8	4
27	12	1	8	2	12	2
28	14	2	12	4	12	4
29	14	2	12	5	13	2
30	12	4	7	5	8	4
31	12	2	8	4	13	2
32	6	1	12	2	12	2
33	12	4	12	4	13	2
34	8	4	13	4	8	2
35	5	2	7	5	12	2
36	8	2	7	2	12	4
37	6	2	8	4	15	5
38	6	2	12	2	12	5
39	8	5	14	2	8	1
40	13	4	8	2	8	4

Continued Appendix A

41	8	2	14	2	8	2
42	14	5	12	2	4	2
43	8	4	12	2	7	2
44	13	4	12	5	12	2
45	12	4	8	4	7	5
46	12	2	12	4	6	5
47	8	1	12	4	8	5
48	12	4	12	4	12	5
49	12	2	8	1	8	2
50	12	2	7	5	12	2

Appendix B: Calculation of Total Inventory Available Per Period with and Without Transshipment

	Without Transshipment				With Transshipment			
Pr.No	T1	T2	T3	Total	T1	T2	T3	TOTAL
1	40	40	40	120	40	40	40	120
2	27	28	35	90	27	28	35	90
3	33	32	23	88	33	32	23	88
4	21	20	32	73	21	20	32	73
5	7	13	24	44	7	13	24	44
6	0	17	20	37	0	16	20	36
7	0	20	8	28	0	19	1	20
8	0	20	12	32	19	9	12	40
9	19	19	8	46	5	12	8	25
10	25	11	8	44	23	1	1	25
11	26	16	12	54	15	10	12	37
12	27	12	24	63	11	19	31	61
13	25	24	26	75	23	21	26	70
14	25	11	26	62	25	8	26	59

15	12	16	27	55	12	19	22	53
16	20	8	19	47	20	11	14	45
17	13	0	13	26	13	3	8	24
18	9	0	5	14	8	0	0	8
19	2	32	19	53	0	29	24	53
20	12	24	21	57	12	13	26	51
21	0	20	9	29	0	8	12	20
22	31	8	15	54	32	0	14	46
23	23	24	24	71	16	24	20	60
24	25	16	20	61	17	16	16	49
25	17	16	20	53	9	24	16	49
26	5	16	12	33	0	21	8	29
27	0	19	12	31	0	8	12	20
28	8	11	0	19	16	0	0	16
29	20	0	12	32	7	0	12	19
30	18	16	20	54	17	19	20	56
31	14	24	20	58	21	33	20	74
32	2	16	19	37	16	25	19	60
33	0	15	7	22	10	13	7	30
34	14	3	13	30	18	0	13	31
35	32	12	25	69	12	12	22	46
36	27	18	20	65	7	20	17	44
37	19	11	16	46	0	12	16	28
38	18	15	13	46	20	13	12	45
39	20	13	1	34	39	9	0	48
40	26	0	0	26	18	0	0	18
41	19	19	13	51	1	31	12	44
42	11	26	5	42	0	19	4	23
43	8	14	16	38	0	0	16	16
44	0	16	29	45	1	21	20	42
45	21	16	21	58	39	19	9	67
46	9	20	21	50	27	11	18	56
47	0	8	27	35	15	0	26	41
48	19	0	19	38	7	0	6	13
49	16	0	7	23	21	0	0	21
50	16	20	0	36	12	29	0	41

Appendix C: Calculation of Surplus Quantity per Period With and Without Transshipment

	Without Transshipment				With Transshipment			
Pr.No.	H1	H2	H3	Total	H1	H2	H3	Total
1	27	28	35	90	27	28	35	90
2	20	20	23	63	20	20	23	63
3	21	20	15	56	21	20	15	56
4	7	13	24	44	7	13	24	44
5	0	5	12	17	0	4	12	16
6	0	5	8	13	0	4	1	5
7	0	12	0	12	0	0	0	0
8	11	7	0	18	5	0	0	5
9	3	11	0	14	0	1	0	1
10	19	3	0	22	8	0	0	8
11	19	4	4	27	6	0	4	10
12	19	4	18	41	3	11	25	39
13	18	11	18	47	16	8	18	42
14	12	0	19	31	12	0	14	26
15	0	8	19	27	0	11	14	25
16	13	0	7	20	13	3	2	18
17	1	0	5	6	0	0	0	0
18	2	0	0	2	0	0	0	0

19	0	24	5	29	0	13	10	23
20	0	12	9	21	0	1	12	13
21	0	8	1	9	0	0	0	0
22	23	0	7	30	16	0	6	22
23	16	16	12	44	9	16	8	33
24	17	8	8	33	9	8	4	21
25	5	8	12	25	0	13	8	21
26	0	3	4	7	0	0	0	0
27	0	11	0	11	0	0	0	0
28	0	0	0	0	0	0	0	0
29	6	0	0	6	0	0	0	0
30	6	11	12	29	5	12	12	29
31	2	16	7	25	9	25	7	41
32	0	4	7	11	10	13	7	30
33	0	3	0	3	0	0	0	0
34	6	0	5	11	0	0	2	2
35	27	5	13	45	7	5	10	22
36	19	11	8	38	0	12	5	17
37	13	3	1	17	0	0	0	0
38	12	3	1	16	14	1	0	15
39	12	0	0	12	18	0	0	18
40	13	0	0	13	0	0	0	0

Continued Appendix C

41	11	5	5	21	0	10	4	14
42	0	14	1	15	0	0	0	0
43	0	2	9	11	0	0	0	0
44	0	4	17	21	0	0	5	5
45	9	8	14	31	27	11	2	40
46	0	8	15	23	15	0	11	26
47	0	0	19	19	7	0	6	13
48	7	0	7	14	0	0	0	0
49	4	0	0	4	0	0	0	0
50	4	13	0	17	0	10	0	10
Total	404	351	406	1161	284	273	306	863
Cost	1212	1053	1218	3483	852	819	918	2589

Appendix D: Calculation of Stock out Quantity per Period with and without Transshipment

Without Transshipment					With Transshipment			
Pr.No	O1	O2	O3	Total	O1	O2	O3	Total
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	1	0	0	1	0	0	0	0
6	7	0	0	7	0	0	0	0
7	8	0	0	8	0	0	3	3
8	0	0	2	2	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	2	0	2	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	8	0	8	0	4	0	4

18	0	8	7	15	0	7	12	19
19	6	0	0	6	0	0	0	0
20	2	0	0	2	0	0	0	0
21	8	0	0	8	8	0	0	8
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	3	0	0	3	0	0	0	0
27	12	0	0	12	12	0	0	12
28	6	1	12	19	0	10	12	22
29	0	12	1	13	7	12	1	20
30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	4	0	0	4	0	0	0	0
33	12	0	6	18	2	0	5	7
34	0	10	0	10	0	0	0	0
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	1	0	0	1
38	0	0	0	0	0	0	0	0
39	0	1	7	8	0	0	0	0
40	0	8	8	16	0	3	8	11

Continued Appendix D

41	0	0	0	0	0	0	0	0
42	3	0	0	3	7	0	0	7
43	0	0	0	0	0	11	0	11
44	13	0	0	13	0	0	0	0
45	0	0	0	0	0	0	0	0
46	3	0	0	3	0	0	0	0
47	8	4	0	12	0	0	0	0
48	0	12	0	12	5	12	6	23
49	0	8	1	9	0	0	7	7
50	0	0	12	12	0	0	0	0
Total	96	74	56	226	42	59	54	155
Cost	192	148	112	452	84	118	108	310

Appendix E: Calculation of Order Quantity per period without and With Transshipment

	Without Transshipment				With Transshipment			
Pr.No.	Q1	Q2	Q3	Total	Q1	Q2	Q3	Total
1	13	12	0	25	13	12	0	25
2	7	8	17	32	7	8	17	32
3	12	12	8	32	12	12	8	32
4	13	7	8	28	14	7	8	29
5	7	8	12	27	7	9	12	28
6	0	12	12	24	0	12	19	31
7	0	8	8	16	0	19	1	20
8	8	13	12	33	14	9	12	35
9	8	8	8	24	5	11	8	24
10	6	8	8	22	20	1	1	22
11	7	12	8	27	9	9	8	26
12	8	8	6	22	8	8	6	22
13	7	13	8	28	7	13	8	28
14	13	11	7	31	13	8	12	33
15	12	8	8	28	12	8	8	28
16	7	8	12	27	7	8	12	27
17	12	0	8	20	13	3	8	24
18	7	0	5	12	8	0	0	8

19	2	8	14	24	0	16	14	30
20	12	12	12	36	12	13	14	39
21	0	12	8	20	0	8	12	20
22	8	8	8	24	16	0	8	24
23	5	8	12	25	7	8	12	27
24	0	8	12	20	8	8	12	28
25	12	8	8	28	9	11	8	28
26	5	13	8	26	0	21	8	29
27	0	8	12	20	0	8	12	20
28	8	11	0	19	16	0	0	16
29	0	0	12	12	7	0	12	19
30	26	5	8	39	12	7	8	27
31	12	8	13	33	12	8	13	33
32	2	12	12	26	6	12	12	30
33	0	12	7	19	10	13	7	30
34	8	3	8	19	18	0	11	29
35	5	7	12	24	5	7	12	24
36	0	7	12	19	7	8	12	27
37	14	8	15	37	1	12	16	29
38	6	12	12	30	21	24	12	57
39	8	13	1	22	18	9	0	27
40	13	0	0	13	1	0	0	1

Continued Appendix E

41	8	14	8	30	0	21	8	29
42	11	12	4	27	0	19	4	23
43	8	12	7	27	1	0	16	17
44	0	12	12	24	0	21	15	36
45	12	8	7	27	12	8	7	27
46	9	12	6	27	12	11	7	30
47	0	8	8	16	8	0	20	28
48	12	0	12	24	7	0	6	13
49	12	0	7	19	21	0	0	21
50	12	7	0	19	12	19	0	31

F

Appendix G: % Reduction of Total Expected Cost with Transshipment for Different Transshipment Costs

Without Transshipment		With Transshipment					
Pr. No	Ec	Ec1	Ec2	Ec3	%R Ct1	%R Ct2	%R Ct3
1	270	270	270	270	0	0	0
2	189	189	189	189	0	0	0
3	168	168	168	168	0	0	0
4	132	132	132	132	0	0	0
5	53	49	50	51	7.54717	5.660377	3.773585
6	53	22	29	36	58.49057	45.28302	32.07547
7	52	19	30	41	63.46154	42.30769	21.15385
8	58	21	27	33	63.7931	53.44828	43.10345
9	42	6	9	12	85.71429	78.57143	71.42857
10	66	38	52	66	42.42424	21.21212	0
11	81	32	34	36	60.49383	58.02469	55.55556
12	123	117	117	117	4.878049	4.878049	4.878049
13	141	126	126	126	10.6383	10.6383	10.6383
14	97	83	88	93	14.43299	9.278351	4.123711
15	81	75	75	75	7.407407	7.407407	7.407407

16	60	54	54	54	10	10	10
17	34	9	10	11	73.52941	70.58824	67.64706
18	36	39	40	41	-8.33333	-11.1111	-13.8889
19	99	77	85	93	22.22222	14.14141	6.060606
20	67	41	43	45	38.80597	35.8209	32.83582
21	43	20	24	28	53.48837	44.18605	34.88372
22	90	74	82	90	17.77778	8.888889	0
23	132	99	99	99	25	25	25
24	99	63	63	63	36.36364	36.36364	36.36364
25	75	66	69	72	12	8	4
26	27	8	16	24	70.37037	40.74074	11.11111
27	57	24	24	24	57.89474	57.89474	57.89474
28	38	46	48	50	-21.0526	-26.3158	-31.5789
29	44	40	40	40	9.090909	9.090909	9.090909
30	87	87	87	87	0	0	0
31	75	123	123	123	-64	-64	-64
32	41	90	90	90	-119.512	-119.512	-119.512
33	45	15	16	17	66.66667	64.44444	62.22222
34	53	19	32	45	64.15094	39.62264	15.09434
35	135	66	66	66	51.11111	51.11111	51.11111
36	114	52	53	54	54.38596	53.50877	52.63158

Continued Appendix G

37	51	7	12	17	86.27451	76.47059	66.66667
38	48	45	45	45	6.25	6.25	6.25
39	52	67	80	93	-28.8462	-53.8462	-78.8462
40	71	27	32	37	61.97183	54.92958	47.88732
41	63	49	56	63	22.22222	11.11111	0
42	51	21	28	35	58.82353	45.09804	31.37255
43	33	31	40	49	6.060606	-21.2121	-48.4848
44	89	27	39	51	69.66292	56.17978	42.69663
45	93	117	117	117	-25.8065	-25.8065	-25.8065
46	75	79	80	81	-5.33333	-6.66667	-8
47	81	51	63	75	37.03704	22.22222	7.407407
48	66	46	46	46	30.30303	30.30303	30.30303
49	30	23	32	41	23.33333	-6.66667	-36.6667
50	75	42	54	66	44	28	12
Total	3935	3091	3284	3477	21.44854	16.54384	11.63914

```
//Appendix H
/** Without Risk Pooling */

#include<iostream.h>
#include<stdlib.h>
#include<conio.h>
#define SIZE 100


typedef struct {
int sno;
int demand;
int inhaninventory_start ;
int inventoryreached_day;
int totalinventory_start;
```

```
int surplusquantity;
int stockoutquantity;
int orderedquantity;
int leadtime;
int recievingday_inventory;
int intransitinventory;
}inventory;

inventory inventory_arr[SIZE];

void main(){
     int nodays;
     int maxinventory;
     int i;
     clrscr();
     cout<<"-------------INVENTORY SIMULATION MODEL--------
-------"<<endl;
     cout<<"How many days you want to keep the record:
"<<endl;
     cin>>nodays;

     cout<<"What is the maximum inventory;"<<endl;
     cin>>maxinventory;



for(i=0;i<nodays;i++)
{
  inventory_arr[i].sno=0;
//inventory_arr[i].demand=0;
  inventory_arr[i].inhaninventory_start =0;
  inventory_arr[i].inventoryreached_day=0;
  inventory_arr[i].totalinventory_start=0;
```

```
  inventory_arr[i].surplusquantity=0;
  inventory_arr[i].stockoutquantity=0;
  inventory_arr[i].orderedquantity=0;
  inventory_arr[i].leadtime=0;
  inventory_arr[i].recievingday_inventory=0;
  inventory_arr[i].intransitinventory=0;
}


for ( i=0; i<nodays;i++)
{
cout<<"Please Enter the values for "<< i+1 <<" day"<<endl;
cout<<"Enter the Demand: ";
cin>>inventory_arr[i].demand;

cout<<"Enter the Lead Time: ";
cin>>inventory_arr[i].leadtime ;

//inventory_arr[i].intransitinventory=0;

if(i==0){
inventory_arr[i].inhaninventory_start=maxinventory;
}

//cout<<"Enter the Reached Inventory for"<<i+1<<" day";
//cin>>inventory_arr[i].inventoryreached_day ;
//}

inventory_arr[i].totalinventory_start=inventory_arr[i].inha
ninventory_start+
inventory_arr[i].inventoryreached_day;
```

```
inventory_arr[i].surplusquantity=inventory_arr[i].totalinve
ntory_start-inventory_arr[i].demand;

if(inventory_arr[i].surplusquantity >= 0)
inventory_arr[i].stockoutquantity=0;
else{
inventory_arr[i].stockoutquantity= -
(inventory_arr[i].surplusquantity);
inventory_arr[i].surplusquantity=0;
}

inventory_arr[i].orderedquantity=maxinventory-
(inventory_arr[i].surplusquantity+inventory_arr[i].intransi
tinventory) ;

int lead=  inventory_arr[i].leadtime;

for(int j=1;j<=lead;j++)
{

inventory_arr[i+j].intransitinventory+=inventory_arr[i].ord
eredquantity;
}




inventory_arr[i].sno=i+1;

inventory_arr[i].recievingday_inventory=inventory_arr[i].sn
o + 1+inventory_arr[i].leadtime ;
```

```
inventory_arr[i+1].inhaninventory_start=inventory_arr[i].su
rplusquantity;

int x=inventory_arr[i].sno+1+inventory_arr[i].leadtime;

if(inventory_arr[x-1].inventoryreached_day==0){

inventory_arr[x-1].inventoryreached_day
=inventory_arr[i].orderedquantity;
}
else{

inventory_arr[x-
1].inventoryreached_day+=inventory_arr[i].orderedquantity;
}


if(inventory_arr[i].surplusquantity<0)
inventory_arr[i].surplusquantity=0;


if(inventory_arr[i].orderedquantity <0)
inventory_arr[i].orderedquantity=0;

if(inventory_arr[i].surplusquantity >=30)
```

```
inventory_arr[i].orderedquantity=0;


//inventory_arr[i+1].totalinventory_start=inventory_arr[i+1
].inhaninventory_start+inventory_arr[i+1].inventoryreached_
day;


//inventory_arr[i+1].


/*

cout<<"---------------------------"<<i+1<<"----------------
-";
cout<<"no."<<inventory_arr[i].sno<<endl;
cout<<"demand:"<<inventory_arr[i].demand<<endl;
cout<<"inhand inventory at
start"<<inventory_arr[i].inhaninventory_start<<endl;
cout<<"inventory reached at the
day"<<inventory_arr[i].inventoryreached_day<<endl;
cout<<"total inventory at
start"<<inventory_arr[i].totalinventory_start<<endl;
cout<<"surplus"<<inventory_arr[i].surplusquantity<<endl;
cout<<"stockout"<<inventory_arr[i].stockoutquantity<<endl;
cout<<"ordered
quantity"<<inventory_arr[i].orderedquantity<<endl;
cout<<"lead time:"<<inventory_arr[i].leadtime<<endl;
cout<<"receiving day
inventory"<<inventory_arr[i].recievingday_inventory<<endl;
cout<<"intransit
inventory"<<inventory_arr[i].intransitinventory<<endl;
```

```
getch();
*/



}

int r,x;

cout<< "which day u want to see the result: ";
cin>>x;

r=x-1;



//cout<<"---------------------------"<<i+1<<"--------------
---";
cout<<"no."<<inventory_arr[r].sno<<endl;
cout<<"demand:"<<inventory_arr[r].demand<<endl;
cout<<"inhand inventory at
start"<<inventory_arr[r].inhaninventory_start<<endl;
cout<<"inventory reached at the
day"<<inventory_arr[r].inventoryreached_day<<endl;
cout<<"total inventory at
start"<<inventory_arr[r].totalinventory_start<<endl;
cout<<"surplus"<<inventory_arr[r].surplusquantity<<endl;
cout<<"stockout"<<inventory_arr[r].stockoutquantity<<endl;
cout<<"ordered
quantity"<<inventory_arr[r].orderedquantity<<endl;
cout<<"lead time:"<<inventory_arr[r].leadtime<<endl;
cout<<"receiving day
inventory"<<inventory_arr[r].recievingday_inventory<<endl;
```

```
cout<<"intransit
inventory"<<inventory_arr[r].intransitinventory<<endl;
getch();


}
```

```
//APPENDIX I
/** With Risk Pooling */

#include<iostream.h>
#include<stdlib.h>
#include<conio.h>
#define SIZE 50

typedef struct {

int sno;
int demand;
int inhaninventory_start ;
```

```
int inventoryreached_day;
int totalinventory_start;
int surplusquantity;
int stockoutquantity;
int orderedquantity;
int leadtime;
int recievingday_inventory;
int intransitinventory;
}inventory;

inventory inventory_arr[SIZE][SIZE];


void sort(int x[],int n){
int i,j, temp;
for(i=0;i<n-1;i++)
for(j=i+1;j<n;j++)
{
if(x[i]> x[j])
           {
          temp=x[i];
          x[i]=x[j];
          x[j]=temp;
          }
 return;
}
}


void main(){
     int nodays;
     int maxinventory;
```

```
      int i;
      clrscr();
      cout<<"-------------INVENTORY SIMULATION MODEL--------
-------"<<endl;
      cout<<"How many days you want to keep the record:
"<<endl;
      cin>>nodays;

      cout<<"What is the maximum inventory: "<<endl;
      cin>>maxinventory;

      int k, noper=3;
      for(k=0;k<noper;k++) {
      //cout<<"Please enter the value for retailer" << k+1
<<endl;

for(i=0;i<nodays;i++ {
inventory_arr[k][i].sno=0;
//inventory_arr[k][i].demand=0;
inventory_arr[k][i].inhaninventory_start =0;
inventory_arr[k][i].inventoryreached_day=0;
inventory_arr[k][i].totalinventory_start=0;
inventory_arr[k][i].surplusquantity=0;
inventory_arr[k][i].stockoutquantity=0;
inventory_arr[k][i].orderedquantity=0;
inventory_arr[k][i].leadtime=0;
inventory_arr[k][i].recievingday_inventory=0;
inventory_arr[k][i].intransitinventory=0;
}

}
```

```
/*for(k=0;k<noper;k++){
cout<<"Please enter the values for retailer"<< k+1<<endl;
cout<<endl;
*/

for ( i=0; i<nodays;i++){
for(k=0;k<noper;k++){
cout<<"Please enter the values for retailer"<< k+1<<endl;
cout<<endl;
cout<<"Please Enter the values for "<< i+1 <<" day"<<endl;
cout<<"Enter the Demand: ";
cin>>inventory_arr[k][i].demand;

cout<<"Enter the Lead Time: ";
cin>>inventory_arr[k][i].leadtime ;

//inventory_arr[k][i].intransitinventory=0;

if(i==0){
inventory_arr[k][i].inhaninventory_start=maxinventory;
}

//cout<<"Enter the Reached Inventory for"<<i+1<<" day";
//cin>>inventory_arr[k][i].inventoryreached_day ;
//}

inventory_arr[k][i].totalinventory_start=inventory_arr[k][i
].inhaninventory_start+inventory_arr[k][i].inventoryreached
_day;

inventory_arr[k][i].surplusquantity=inventory_arr[k][i].tot
alinventory_start-inventory_arr[k][i].demand;
```

```
if(inventory_arr[k][i].surplusquantity >= 0)
inventory_arr[k][i].stockoutquantity=0;
else{
inventory_arr[k][i].stockoutquantity= -
(inventory_arr[k][i].surplusquantity);
inventory_arr[k][i].surplusquantity=0;
}



for(int y=0;y<3;y++)
for(int z=0;z<nodays;z++){
int s1=inventory_arr[0][z].surplusquantity;
int s2=inventory_arr[1][z].surplusquantity;
int s3=inventory_arr[2][z].surplusquantity;

int arr[]={s1,s2,s3};

sort(arr,3);

cout<<"1:="<<arr[0];
cout<<"2:="<<arr[1];
cout<<"3:="<<arr[2];

if(arr[0]<0 || arr[1]<0 || arr[2]<0)
{
 if(arr[0]<0){
            int temp=-arr[0];
            if(arr[2]>temp){
               arr[2]-=temp;
               arr[0]=0;
              }
```

```
            else{
            int temp2=temp-arr[2];
            arr[2]=0;
            arr[1]-=temp2;
            arr[0]=0;
            }
 }


if (arr[0] <0)
arr[0]=0;




if (arr[1] <0)
arr[1]=0;

if (arr[2] <0)
arr[0]=0;

inventory_arr[0][z].surplusquantity=arr[0];
inventory_arr[1][z].surplusquantity=arr[1];
inventory_arr[2][z].surplusquantity=arr[2];

}
}
inventory_arr[k][i].orderedquantity=maxinventory-
(inventory_arr[k][i].surplusquantity+inventory_arr[k][i].in
transitinventory) ;

int lead=  inventory_arr[k][i].leadtime;
```

```
for(int j=1;j<=lead;j++)
{

inventory_arr[k][i+j].intransitinventory+=inventory_arr[k][
i].orderedquantity;
}

inventory_arr[k][i].sno=i+1;

inventory_arr[k][i].recievingday_inventory=inventory_arr[k]
[i].sno + 1+inventory_arr[k][i].leadtime ;

inventory_arr[k][i+1].inhaninventory_start=inventory_arr[k]
[i].surplusquantity;

int
x=inventory_arr[k][i].sno+1+inventory_arr[k][i].leadtime;


if(inventory_arr[k][x-1].inventoryreached_day==0){

inventory_arr[k][x-1].inventoryreached_day
=inventory_arr[k][i].orderedquantity;
}
else{

inventory_arr[k][x-
1].inventoryreached_day+=inventory_arr[k][i].orderedquantit
y;
}

if(inventory_arr[k][i].surplusquantity<0)
```

```
inventory_arr[k][i].surplusquantity=0;

if(inventory_arr[k][i].orderedquantity <0)
inventory_arr[k][i].orderedquantity=0;

if(inventory_arr[k][i].surplusquantity >=30)
inventory_arr[k][i].orderedquantity=0;


//inventory_arr[i+1].totalinventory_start=inventory_arr[i+1
].inhaninventory_start+inventory_arr[i+1].inventoryreached_
day;

/*
cout<<"---------------------------"<<i+1<<"----------------
-";
cout<<"no."<<inventory_arr[k][i].sno<<endl;
cout<<"demand:"<<inventory_arr[k][i].demand<<endl;

cout<<"inhand inventory at
start"<<inventory_arr[k][i].inhaninventory_start<<endl;
cout<<"inventory reached at the
day"<<inventory_arr[k][i].inventoryreached_day<<endl;
cout<<"total inventory at
start"<<inventory_arr[k][i].totalinventory_start<<endl;
cout<<"surplus"<<inventory_arr[k][i].surplusquantity<<endl;
cout<<"stockout"<<inventory_arr[k][i].stockoutquantity<<end
l;
cout<<"ordered
quantity"<<inventory_arr[k][i].orderedquantity<<endl;

cout<<"lead time:"<<inventory_arr[k][i].leadtime<<endl;
```

```
cout<<"receiving day
inventory"<<inventory_arr[k][i].recievingday_inventory<<end
l;
cout<<"intransit
inventory"<<inventory_arr[k][i].intransitinventory<<endl;
getch();
*/

}
cout<<endl;
}

/*
for(int y=0;y<3;y++)
for(int z=0;z<nodays;z++){
int s1=inventory_arr[0][z].surplusquantity;
int s2=inventory_arr[1][z].surplusquantity;
int s3=inventory_arr[2][z].surplusquantity;
int arr[]={s1,s2,s3};
sort(arr,3);

cout<<"1:="<<arr[0];
cout<<"2:="<<arr[1];
cout<<"3:="<<arr[2];
if(arr[0]<0 || arr[1]<0 || arr[2]<0)
{
 if(arr[0]<0){
            int temp=-arr[0];
            if(arr[2]>temp){
           arr[2]-=temp;
           arr[0]=0;}
            else{
```

```
            int temp2=temp-arr[2];
            arr[2]=0;
            arr[1]-=temp2;
            arr[0]=0;
            }
         }


if (arr[0] <0)
arr[0]=0;

if (arr[1] <0)
arr[1]=0;

if (arr[2] <0)
arr[0]=0;

inventory_arr[0][z].surplusquantity=arr[0];
inventory_arr[1][z].surplusquantity=arr[1];
inventory_arr[2][z].surplusquantity=arr[2];

}
}
*/
/*if (arr[0] <0)
arr[0]=0;

if (arr[1] <0)
arr[1]=0;

if (arr[2] <0)
arr[0]=0;
```

```
*/

int r,x;
cout<< "which day u want to see the result: ";
cin>>x;
r=x-1;


//cout<<"---------------------------"<<i+1<<"--------------
---";

for(k=0;k<noper;k++){
cout<<"values for retailer "<<k+1<<endl;

cout<<endl;
cout<<"Day no: "<<inventory_arr[k][r].sno<<endl;
cout<<"demand:"<<inventory_arr[k][r].demand<<endl;


cout<<"inhand inventory at
start"<<inventory_arr[k][r].inhaninventory_start<<endl;
cout<<"inventory reached at the
day"<<inventory_arr[k][r].inventoryreached_day<<endl;
cout<<"total inventory at
start"<<inventory_arr[k][r].totalinventory_start<<endl;
cout<<"surplus"<<inventory_arr[k][r].surplusquantity<<endl;
cout<<"stockout"<<inventory_arr[k][r].stockoutquantity<<end
l;
cout<<"ordered
quantity"<<inventory_arr[k][r].orderedquantity<<endl;
cout<<"lead time:"<<inventory_arr[k][r].leadtime<<endl;
```

```
cout<<"receiving day
inventory"<<inventory_arr[k][r].recievingday_inventory<<end
l;
cout<<"intransit
inventory"<<inventory_arr[k][r].intransitinventory<<endl;
getch();
}
}
```