Chapter 2

LITERATURE REVIEW AND OBJECTIVES
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Due to rapid advancement/development in the field of Information technology both in hardware and software, companies are forced to implement these technologies in their Supply Chain to survive in this competitive world of global market. Many researchers/academicians and practitioners are constantly working in this area to develop new optimization methods to control Supply Chain drivers effectively to improve the performance of Supply Chain.

In the present research study, about 150 research/technical papers are reviewed, contributed by several researchers and practitioners. It is revealed from the review that there is a need for IT based effective inventory management to improve the performance of complex Supply Chains.

Inventory and information being major drivers in a Supply Chain Management, and lot of work/research has been carried out and going on, still there is an opportunity to work in the area. Thus present research work is carried out on optimal inventory management in a supply chain using Data Mining, Genetic Algorithm and RFID techniques.

In the present study/chapter, extensive state-of-art literature review in the areas/fields of Supply Chain Management, Inventory Management in a Supply Chain, Data Mining implementation in SC, Application of Genetic Algorithm in SC, and Impact of RFID on Supply Chain giving more emphasis on inventory management related topics has been carried out from published papers, white papers and as well as renowned text books and the overview of the same is presented.

2.1 SUPPLY CHAIN MANAGEMENT

2.1.1 Reasons for Forming Supply Chain Management

Davis (1993) [34] listed reasons why SCM needs renewed attention: reduced profit margins due to pressure from increasing competition, needs for administrating multisite manufacturing, cut-throat marketing channels, maturation of the world economy, customer service demands for quick and more reliable delivery, and pressure to reduce inventories.
According to Cooper and Ellram (1993) SCM is designed to solve these problems and is important to reduce inventory investment in the chain, to increase customer service, and to build a competitive advantage for the channel. With a changing management focus, companies also began to realize that maximization of efficiency in one department or one functional unit is less desirable than optimal performance for the whole company. Needs for effective vertical integration and consumers' desire for a wider variety and complexity of products have led to demand for SCM (Lummus, Vokurka, & Alber, 1998) [76].

2.1.2 Classical Definition of SCM

The concept of SCM is relatively new to academics and practitioners, appearing first in 1982 (Cooper, Lamber, & Pagh, 1997) [25].

Although the term, supply chain management, has been used since the 1980s and the academic and trade presses have given extensive attention to the concept, confusion still persists in defining what is SCM (Bechtel & Jayaram, 1997) [12]. Many researchers have tried to define the meaning of SCM.

The summary of each author's definitions of SCM are given below:

Summary of Definitions on SCM

Alber & Walker (1997) "The global network used to deliver products and services from raw materials to end customers through an engineered flow of information and physical distribution."

Cooper & Ellram (1993) "An integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user ... greater coordination of business processes and activities ... across the entire channel and not just between a few channel pairs." [63].

Giunipero & Brand (1996) "Definitions can be grouped into three major categories: 1) The management of the flow of goods from supplier to final user; 2) The system-wide coordination of product and information flows; and 3) The development of relationships and the integration of all activities that provide customer value throughout the distribution channel."
Jones (as cited in Goffin, Szwejczewski, & New, 1997) "Managing the entire chain of raw material supply, manufacture, assembly, and distribution to the end customer."

Lee & Ng (1997) "A network of entities that starts with the suppliers' suppliers and ends with the customers' customers for the production and delivery of goods and services."

Lummus, Vokurka, & Alber (1998) "A network of entities through which material and information flow. Those entities include suppliers, carriers, manufacturing sites, distribution centers, retailers and customers."

Palcivich (1997) "All of those activities associated with moving goods from raw materials through the end user: sourcing and procurement, production scheduling, order processing, inventory management, transportation, warehousing, and customer service. Importantly, it also embodies the information systems to monitor these activities."

Spekman, Kamauff, & Myhr (1998) "A process for designing, developing, optimizing, and managing the internal and external components of the supply system, including material supply transforming, materials and distributing finished products or services to customers, that is consistent with overall objectives and strategies."

Although subtle differences are found in the word choice and expression, commonalities contribute to an understanding of core concepts in the definition of SCM.

Although practitioners have a narrow definition of the SCM, examples of significant evidence in some industries can be found, that reflect the broad concepts of SCM. Those examples are Quick Response (QR) in apparel industry, Efficient Consumer Response (EQR) in grocery industry and health care products industry, and Efficient Food service Response (EFR) in food services industry (Bechtel & Jayaram, 1997 [12]; Lee & Ng, 1997 [74]). All these efforts are for better flow of material and information in the supply chain through coordination between companies and across functional boundaries.
2.1.3 Key Management Processes in the Supply Chain

According to Davis (1993) [34], key business processes of SCM can be grouped into three activities: supply, transformation, and demand. *Transformation* refers to a broader meaning than *manufacturing* in that the term encompasses material handling and distribution functions. Harrington (1999) [5] also identified four distinct management processes in the supply chain as plan, source, make, and deliver. In Harrington's discussion, *source*, *make*, and *deliver* are execution processes that form a link in the supply chain, and *plan* is a process of managing the customer-supplier links.

2.1.4 Supply Chain Management Activities

Cooper and Ellram (1993), reported eleven points of the characteristics of SCM in their conceptual study on SCM. Main focuses refer to efforts for reduction of redundant inventories and cost in the supply chain, amount of information sharing and monitoring, amount of coordination and time horizon to endure relationships between multiple levels of the channel, channel leadership, compatibility of corporate philosophies, breadth of supplier base, and speed of operations.

Alber and Walker (1997) [5] introduced methods to synchronize supply and demand for better balanced SCM. These methods include processes to align run cycles with customer demand cycles, have batch sizes equal the batch size necessary to meet customer demand, identify demand characterization, be able to manage demand, compare the actual throughput and the capacity utilization against the customer demand profile, communicate point-of-sales (POS) information, eliminate the traditional manufacturing strategy, disseminate information rapidly, and have better planning and control.

In a trade article, Copacino (1998) [26] analyzed the data from eight-industry segments which consists of several rounds of group discussions with experts in the industries. The author identified characteristics and capabilities of leaders who have shown successful performances in SCM. Those characteristics are deep functional excellence in key functional areas such as procurement, manufacturing,
transportation and distribution, and customer care; management of unexpected surge and uncertainty caused by poorly planned promotions, product proliferation, product-line complexity, and poorly coordinated new product introductions; world-class information technology; virtual logistics; and ability to integrate channel partners with collaboration across the channel.

The utilization of information technology are computer-to-computer communication, electronic data interchange (EDI), POS data communication, and barcoding. Electronic links between suppliers and carriers or customers are critical for information sharing. Technologies at each stage of the supply chain should be compatible with their partners' to better streamline the information. Types of information fed into this electronic links are data on sales, usage, product changes, promotions, discontinuations, and product and process (Sabath, 1995).

Higginson & Alam, 1997 [57]; Vass & Kincade, 1999 [139] suggest that the success of any new management initiative, top management's awareness of benefits, willingness to implement; and desire to continue change are required to be a better participant in SCM. Top management is responsible for creating the culture of the company. When the outcome of a chain is uncertain to a company, strong leadership relieves employees from insecurity and motivates them to act toward the new direction. Bechtel and Jayaram (1997) [12] noted that the most important barrier to reengineering is people, not systems or technology.

2.2 INVENTORY MANAGEMENT

Tersin, (1988) [130] suggests that Inventory management includes a company's activities to acquire, dispose, and control of inventories that are necessary for the attainment of a company's objectives.

The management of inventories concerns the flow to, within, and from the company and the balance between shortages and excesses in an uncertain environment.

According to McPharson (1987, p360) [79], in apparel manufacturing, "inventory management systems are designed to obtain concise and accurate information for control and planning of planned goods, issues, cuts, projections, WIP and finished goods." Inventory management has been a concern for academics
as well as practitioners, in that overall investment in inventory accounts for relatively large part of a company's assets. Inventory may account for 20 to 40% of total assets (Tersin, 1988 [130], Verwijmeren, Vlist, & Donselaar, 1996) [141].

Inventories tie up money, and success or failure in inventory management impacts a company's financial status. Having too much inventory can be as problematic as having too little inventory. Too much inventory requires unnecessary costs related to issues of storage, markdowns and obsolescence, while too little results in stockouts or disrupted production. Besides, long-run production associated with a high level of inventory conceals production problems (e.g., quality), which can damage a company's long term performance (Vergin, 1998) [140].

Therefore, the primary goal of inventory management has been to maximize a company's profitability by minimizing the cost tied up with inventory and at the same time meeting the customer service requirements (Lambert, Stock, & Ellram, 1998) [70].

Traditionally, inventories caused conflicts between functional units within a company or between companies. For example, within a company, purchasing, production, and marketing people want to build a high level of inventory for raw material cost reduction, efficient production run, and customer service level, while warehousing and finance people want to reduce the inventory level for storage space and economic reasons (Tersine, 1988) [130]. As global competition between suppliers in the open markets has increased, power has been shifted from suppliers to customers (Verwijmere, Vlist, Donselarr, 1996) [141].

Therefore, the customers' need to reduce the inventory based on frequent small lot orders has resulted in their partners holding the inventory (Thomas, 1998) [133].

2.2.1 Inventory management indicators

Inventory turnover and fill rate are examples of popular indicators for measuring an organization's performance in inventory management (Vergin, 1998 [140]; Branam, 1984 [16]; Lambert, Stock, & Ellram, 1998 [70]). Inventory turnover
is the velocity of inventory passing through an organization calculated by dividing the annual sales by the average on-hand inventory. Fill rate is the percentage of units available when requested by the customer.

2.2.2 Role of Inventory

Traditionally, a relatively high level of inventory has been kept in a company. The reasons for building inventory can be found in inventory's five functional roles: economies of scale, balance of supply and demand, specialization in manufacturing, protection from uncertainties, and inventory as buffer (Lambert, Stöck, & Ellram, 1998 [70]; Schroeder, 1993 [111]; Tersine, 1988 [130]; Vergin, 1998 [140]). First, purchasing or producing a bulk of items (i.e., economies of scale) enables a company to cut costs by allowing setup cost reduction, price discounts, and spreading the factory overhead expenses. Second, inventory provides balance between supply and demand. Supply and demand do not always match at any given time for reasons such as seasonal demand pattern or seasonal supply pattern. Third, inventory enables a manufacturer to specialize in the item by obtaining focused factory and learning-curve effects. Focused factory is a small factory dedicated to a specific product with a single product line to maximize productivity and quality. Fourth, inventory serves to protect uncertainties in demand and supply. Inventory is necessary in case demand for finished goods fluctuates or if the suppliers' ability to meet the buyers' demand is not reliable.. Lastly, inventory is used as buffer in the supply chain.

It takes time to transit inventory from one operation to another within a company or one node to another in the supply chain (i.e., supplier to manufacturer, manufacturer to distributor, and distributor to customer).

2.2.3 Overview of Inventory Control

To help and solve the problems of inventory, mathematical models which describe the inventory situation have been developed and applied in many industries. Inventory control models can be used to describe either replenishment from an outside vendor or internal production. Therefore, inventory control and production
planning are often synonymous. Examples of these models are Simple Economic Order Quantity (EOQ) model, EOQ with quantity discounts, Material Requirements Planning (MRP), Newsboy model, Lot size - Reorder point (Q, R) model, and Periodic-Review system (Nahmias, 1997) [90]. Which model to apply is determined by several factors: order repetitiveness (i.e., single order vs. repeat order), order quantity (i.e., fixed quantity vs. variable quantity), knowledge of demand (i.e., constant demand vs. variable demand, independent demand vs. dependent demand), inventory review frequency (i.e., periodic vs. continuous review), and knowledge of lead time (i.e., constant lead time vs. variable lead time) (Verwijmeren, Vlist, & Donselaar, 1996 [141]; Tersine, 1988 [130]).

The models are built to answer the basic questions: when to place a reorder and how large an amount to order. An order can be placed only once if the item is a high fashion item with a very short life cycle. For many products, most items are basic goods and are restocked through repeat orders. When repeating orders, a fixed quantity can be ordered whenever the inventory level drops below a certain point (simple EOQ model). Different quantities can be ordered to raise the inventory to a certain level every constant unit of time ((S, T) models). If an item is a raw material or a component of which demand is dependent upon finished goods, the order quantity and order timing is determined by the production schedule of the finished goods (MRP). The production schedule is based on a company's own demand forecasting method or demand from customers' orders. Newsboy model and (Q, R) model take uncertainties in demand and lead-time into consideration.

The inventory control models mentioned above assume that the inventory levels are reviewed continuously. Periodic-Review system is used when the inventory levels are known only at discrete points in time.

In the late 1970s and early 1980s, just-in-time (JIT) manufacturing practice was introduced, which also revolutionized inventory management. Many large manufacturers operate on JIT delivery of piece goods in order to reduce inventory carrying costs. A core concept of JIT pursues waste elimination and zero-inventory by practicing small lot orders on a daily basis and increasing communication between suppliers and customers (Fischer, 1995; Germain & Droge, 1998; Kim,
Studies of JIT impact on inventory performance (Droge & Germain, 1998 [39]) revealed that a significant relationship exists between JIT implementation and reduction in inventory level.

JIT and other inventory control models provide direction for inventory management, however, not all U.S. companies have found the answer for the inventory problems. A study with the annual logistics survey conducted by the University of Tennessee reported that 43% of U.S. companies carry as much or more inventory than they did five years ago (Inventories point, Dec. 1996). Despite the optimistic interpretation that the remaining 57% of companies have achieved remarkable progress in inventory management, differences among industries was not reported in detail.

Vergin's study (1998) [140] on inventory turnover in the Fortune 500 industrial companies for the years of 1986 through 1995 revealed that although inventory turnover ratios have increased by an average of 14.7%, the extent of changes in inventory turnover ratios were significantly different among industries. The oil and gas extraction industry performed best with a 44% increase in the ratio, while the textile mill products industry had a 12% decrease.

Vergin (1998) [140] also suggested that the dramatic improvements reported in previous studies through a case study method in a certain company or industry may not be true to another company or industry.

These results from a few studies on one inventory metric indicate that more empirical studies with companies or industries, of various characteristics, are needed to generalize the findings.

2.2.4 Decisions on Production and Inventory Management

Many authors have proposed factors, which management should be consider for better inventory management. Branam (1984) [16] specifically emphasized the importance of in-plant throughput time reduction because throughput time is the ultimate constraint on inventory turnover ratio (inventory turnover ratio = annual cost of goods sold/average on hand inventory), which is one of the major performance indicators in inventory management. The author's interpretation of the
in-plant throughput time is the time span from the point of raw material receipt to final assembly.

Tersine (1988) [130] pointed out the factors for better inventory management as better forecasting, improved transportation, improved communication, improved technology, better scheduling, and standardization.

Pachura (1998) [92] suggested that management should start the process of improving inventory management by determining the manufacturing type, benchmarking the inventory control performance, validating strategy (i.e., make-to-order, make-to-stock, build-to-forecast), determining underlying causes through the use of an operational review, and implementing corrective action. Higginson and Alam (1997) [57] suggested specific techniques for inventory management by focusing on cycle time.

Improved communication, suppliers' involvement in forecasting and inventory management, supplier relationships, production scheduling, and cross-functional approach within a company are the factors noted by Lambert, Stock, and Ellram (1998) [70] for improving inventory management. For better performance in inventory management most of the authors pay attention to production activities and time-based strategies, which are the main interests of this study. Production activities are closely related to production volume and timing and consequently raw material purchasing.

2.3 INVENTORY MANAGEMENT IN SUPPLY CHAIN

Inventory management is one main aspect of SCM. The main goal of SCM is to better manage inventory throughout the chain via. Improved information flow aimed at improved customer service, higher product variety, and lower costs (Lawrence & Varma, 1999 [71]; Vergin, 1998 [140]).

Verwijmeren, Vlist, and Donselaar (1996) [141], used the term "Networked Inventory Management" for the inventory aspect of SCM. The efficiency of SCM can be measured by inventory performance such as the speed of inventory passing through the chain and the load of inventory throughout the chain (Jones & Riley, 1985) [63]. Inventory of various forms from raw materials through WIP to finished goods is fed into the chain from suppliers, production, and subsequently distribution centres to customers. This flow of inventory requires responsibilities of channel
members for the planning, acquisition, storage, movement, and control of materials and final products (Tersine, 1988) [130]. High levels of inventory are found when the supply chain members less communicate due to lack of information sharing between chain members and inefficiency of SCM.

Whether a supply chain is efficiently managed or not well managed can be determined by looking at the indicators of inventory management such as inventory turnover ratio. Inventory turnover ratio has been a useful indicator to measure the efficiency of inventory management of an industry.

If other information such as absolute value of total sales volume and on hand inventory is given together, inventory turnover ratio can tell more about the efficiency of a company's performance (Pearson, 1994) [98].

Nahrniias, (1997) [90], says that Manufacturers could not reduce their buffer stocks without trusting in their partnerships and sharing forecasting information on actual demand at retail level because of the "bullwhip effect" which means the effect of retail sales fluctuation grows larger as it traverses to upstream chain members. More customer requirements for broader product coverage and greater delivery capabilities escalate manufacturer's problem in production process complexity and forecasting of future demand.

When customers are trying to operate on fewer inventories, manufacturers can respond in two ways: (a) carrying more inventories to compensate for the shorter lead times or (b) improving the management of the supply chain (Mirsky, 1997) [84].

Tersine (1988) [79] and Pachura (1998) [92] noted that manufacturers tend to respond to their customers requirement by building more finished goods inventory instead of working to improve their manufacturing capabilities. Increased attention to managing inventory has led to larger manufacturer inventories for some companies because the retailers' demands for manufacturers' self-monitoring and replenishing of the retailer inventory are obtained at the expense of manufacturers' storage burden (Vergin, 1998) [140].
A trade article reported that a supplier’s decision to cut inventory quantities of raw materials also results in high inventories in manufacturing sites (Good Business, Apr.3, 1997) [51]. In case raw materials are available only in a certain period, manufacturers need to order enough to meet the anticipated peak demand of finished goods, which causes the excessive inventory level of raw materials. For these reasons, manufacturers have not only internal problems with inventory, but also problems caused by trading partners on both ends of the supply chain.

According to Frazelle (2002) [46], inventory management is one of the logistics activities that is targeted by SCM optimization efforts. He describes the objective of inventory management as the optimization of inventory levels, achieved by maintaining the least amount of inventory necessary to meet service level requirements.

Frazelle (2002) [46], emphasizes the importance of inventory management in SCM. He points out that inventory availability is the most important factor driving customer service levels, while at the same time representing the riskiest and most expensive component of supply chain logistics. He notes that the challenge “is to increase the financial return on inventory while simultaneously increasing customer service levels”.

Dimitris Folinos et al [35], revealed that the goal of SCM is to meet the needs of the final customer by supplying the right product at the right place, time and price. Companies use SCM as a way to meet the competitive challenges of today’s business environment. The focus of SCM has shifted from engineering efficient functional process to the coordination of activities in a supply chain network.

Werner Jammernegg et al [143], studied the opportunities and challenges for improving the performance of supply chain processes by coordinated application of inventory management and capacity management. They also illustrated the approach by a supplier company in the telecommunication and automotive industry (tier 2), where a manufacturer (production facility) is located in a country with low labour costs and high worker deployment flexibility. Using process simulation, they demonstrated how the coordinated application of methods from inventory...
management and capacity management resulted in improved performance measures of both intra-organizational (costs) and inter-organizational (service level) objectives.

2.3.1 Vendor Managed Inventory in a supply chain

Daniel et al [29], state that Marie automotive manufactures, has acknowledged the need to enhance their competitiveness and to collaborate within the supply chain. They supplement their study with a real life case study. They improved current business by establishing vendor managed inventory partnerships with their suppliers and by providing access to suppliers regarding sensitive information of customer’s inventory level and demand so as to replenish the customers stock when needed.

Andrew Blatherwick [6], focuses on the concept of vendor-managed inventory. He reviews its success since it was first implemented by Wal-Mart and K-Mart. The VMI strategy is effective when the relationship between major retailers and major suppliers is constructive and open and the party who is most able and in the best position to manage the supply relationship is in control of the supply chain.

Disney, S.M et al [36], compare the bullwhip properties of a vendor managed inventory (VMI) supply chain with those of a traditional “serially-linked” supply chain. The emphasis of this investigation is the comparative impact the two structures have on the “bullwhip effect” generated. The analysis show that with VMI implementation two sources of the bullwhip effect may be completely eliminated, i.e. rationing and gaming and the order batching effect or the Burbidge effect. Finally that VMI offers a significant opportunity to reduce the bullwhip effect in real-world supply chains.

Pamela Danese [94], highlights how vendor managed inventory can be extended both upstream and downstream in the supply network to co-ordinate the material and information flows among a number of different suppliers, manufacturing and distribution plants. The research is based on data and information gathered during an in-depth case study within the supply network. The findings offer guidance for managers facing the decision-making process concerning the implementation of the VMI both upstream and downstream in the supply network.
Tinglon Zhang et al [135], focused on simultaneously reducing inventory levels of raw materials, work-in-process, and finished items as it is a major focus for supply chain management. In order to achieve a higher degree of coordination and automation among the supply chain parties, the supply chain sometimes invests in reducing the ordering cost to streamline and speed up transactions via the application of information technology.

Disney, S.M et al [37], investigate the impact of a vendor managed inventory strategy upon transportation operations in a supply chain. Specifically, the issue of batching to enable better use of transport vehicles is studied. A system dynamics methodology is used to develop difference equation models of three scenarios traditional, internal consolidation and VMI. The holistic nature of inventory management within VMI enables batching to minimize transport demand without negatively impacting the overall dynamic performance of the supply chain.

2.4 DATA MINING IMPLEMENTATION IN A SUPPLY CHAIN

Some of the recent research works on data mining implementation in a SC available in the literature are described in this section.

A. L. Symeonidis et al., [128] have introduced a successful paradigm for coupling Intelligent Agent technology with Data Mining. Considering the state-of-the-art Multi-Agent Systems (MAS) development and SCM evaluation practices, they have proposed a methodology to identify the appropriate metrics for DM-enhanced MAS for SCM and used those metrics to evaluate its performance. They have also provided an extensive analysis of the methods in which DM could be employed to improve the intelligence of an agent, age. A number of metrics were applied to evaluate their results before incorporating the selected model with their agent. Their mechanism proved that their agent was capable of increasing its revenue by adjusting its bidding strategy.

Mouhib Al-Noukari et al., [87] have explained a data mining application in car manufacturing domain and experimented it. Their application results demonstrated the capability of data mining techniques in providing important analysis such as launch analysis and slow turning analysis. Such analysis helped in providing car market with base for more accurate prediction of future market demand.
Tao Ku et al. [129] have presented a complex event mining network (CEMN) and defined the fundamentals of radio-frequency identification (RFID)-enabled SC event management. Also, they have discussed how a complex event processing (CEP) could be used to resolve the underlying architecture challenges and complexities of integrating real-time decision support into the supply chain.

Finally, a distributed complex event detection algorithm based on master-workers pattern was proposed to detect complex events and trigger correlation actions. Their results showed that their approach was more robust and scalable in large-scale RFID application.

Se Hun Lim [112] has developed a control model of SCM sustainable collaboration using Decision Tree Algorithms (DTA). He has used logistic regression analysis (LRA) and multivariate determinate analysis (MDA) as a benchmark and compared the performance of forecasting SCM sustainable collaboration through three types of models LRA, MDA, DTA. Forecasting SCM sustainable collaboration using DTA was considered as the most outstanding feature. The obtained result has provided useful information of SCM sustainable collaboration determining factors in the manufacturing and distributing companies.

Shu-Hsien Liao et al., [117] have investigated functionalities that best fit the consumer's needs and wants for life insurance products by extracting specific knowledge patterns and rules from consumers and their demand chain. They have used the Apriori algorithm and clustering analysis as methodologies for data mining. Knowledge extraction from data mining results was illustrated as market segments and demand chain analysis on life insurance market in Taiwan in order to propose suggestions and solutions to the insurance firms for new product development and marketing.

Xu Xu et al. [145] have proposed an approach that combines expert domain knowledge with Apriori algorithm to discover the pattern of supplier under the methodology of Domain-Driven Data Mining (D3M). Apriori algorithm of data mining with the help of Fuzzy Set Theory (FST) was employed during the process of mining.
The obtained overall patterns help in deciding the final selection of suppliers. Finally, AHP was used to efficiently tackle both quantitative and qualitative decision factors involved in ranking of suppliers with the help of achieved pattern. An example searching for pattern of supplier was used to demonstrate the effective implementation procedure of their method. Their method could provide the guidelines for the decision makers to effectively select their suppliers in the current competitive business scenario.

2.5 APPLICATION OF GENETIC ALGORITHM IN A SUPPLY CHAIN

A fresh genetic algorithm (GA) approach for the integrated inventory distribution problem (IIDP) has been projected by Abdel et al. [1].

They have developed a genetic representation and have utilized a randomized version of a formerly developed construction heuristic in order to produce the initial random population.

In Pupong et al. [101] have put forth an optimization tool that works on basis of a multi-matrix real-coded Generic Algorithm (MRGA) and aids in reduction of total costs associated within supply chain logistics. They have incorporated procedures that ensure feasible solutions such as the chromosome initialization procedure, crossover and mutation operations. They have evaluated the algorithm with the aid of three sizes of benchmarking dataset of logistic chain network that are conventionally faced by most global manufacturing companies.

A beneficial industry case applying genetic algorithms (GA) has been proposed by Kesheng Wang et al. [68]. The case has made use of GAs for the optimization of the total cost of a multiple sourcing supply chain system. The system has been exemplified by a multiple sourcing model with stochastic demand. A mathematical model has been implemented to portray the stochastic inventory with the many to many demand and transportation parameters as well as price uncertainty factors.
A genetic algorithm which has been applied by Chih- Yao Lo [20] to deal with the production-inventory problem with backlog in the real situations, with time varied demand and imperfect production due to the defects in production disruption with exponential distribution. Besides optimizing the number of production cycles to generate a \((R,Q)\) inventory policy, an aggregative production plan can also be produced to minimize the total inventory cost on basis of the reproduction interval searching in a given time horizon.

In Barlas et al. [146], have developed a System Dynamics simulation model of a typical retail supply chain. The intent of their simulation exercise was to build up inventory policies that enhance the retailer's revenue and reduce costs at the same instant. Besides, the research was also intended towards studying the implications of different diversification strategies.

A supply chain model functioning under periodic review base-stock inventory system to assist the manufacturing managers at HP to administer material in their supply chains has been introduced by Lee et al. [73]. The inventory levels across supply chain members were obtained with the aid of a search routine.

Steven Prestwich et al. [122] have described a simple re-sampling technique called Greedy Average Sampling for steady-state GAs such as GENITOR. It requires an extra runtime parameter to be tuned, but does not need a large population or assumptions on noise distributions. While experimented on a well-known Inventory Control problem, it performed a large number of samples on the best chromosomes yet only a small number on average, and was more effective than the other four tested techniques.

2.6 IMPACT OF RFID ON A SUPPLY CHAIN

RFID technologies may improve the potential benefits of supply chain management through reduction of inventory losses, increase of the efficiency and speed of processes and improvement of information accuracy. Various RFID systems can be obtained by combining different tags, readers, frequencies and levels of tagging, etc. The cost and potential profit of each system change in a wide range.
In this paper, a state-of-the-art on RFID technology deployments in supply chains is given in order to analyze the impact on the supply chain performance. Potential benefits, particularly against inventory inaccuracy problems, the bullwhip effect and replenishment policies, are briefly surveyed. Various works addressing analytic modelling, simulations, case studies and experiments as well as ROI analyses are reviewed. Finally, conclusions and future research perspectives are presented.

RFID is an example of an Automatic Identification and Data Collection (AIDC) technology (Frazelle, 2002) [46]. AIDC systems share common elements: (1) an object to be identified, such as a pallet or carton, (2) an identifier (ID), such as a label or tag, that is affixed to the aforementioned object, and (3) a device to read the ID and transmit information about it to some other system (Hill & Cameron, 2003) [58]. Bar code and magnetic stripe systems are common types of AIDC technologies used to track inventory (Frazelle, 2002) [46].

Brynes (2004) [17] suggests that the key to successful RFID implementations is to focus first on analytical applications. These applications would selectively target specific areas to improve supply chain coordination, visibility, and responsiveness. Unlike a production-oriented approach that tries to make existing supply chain processes more efficient, Brynes (2004) says that the goal of the analytical approach is to uncover ways to use RFID technology to create new and more effective supply chain processes. He suggests, for example, that RFID might be used to better align inventory levels with demand for short-lifecycle products, thereby minimizing markdowns and out-of-stock conditions.

Zhou [150] analyzes the benefit of RFID item-level information visibility using a manufacturing example in multiple periods. He considers the reduced uncertainty as a key factor to increase the benefit in both static and dynamic scenarios. The analysis shows that the benefit due to item-level visibility increases through the improvement of the information system. The results also show that the information visibility in multiple periods can provide improved decision making.

The benefits of information sharing have been proposed to depend on the predictability of demand. For example, Cachon and Fisher (2000) [18] anticipate that information sharing can have a significantly greater value in situations with unknown demand, for example, early sales of new products or promotion situations.
Also Raghunathan (2001) has proposed information sharing to be less beneficial in situations where demand is predictable, and where past demand can be used to form a reasonably accurate demand forecasts.

Evans, G.N. et al [42] outlined cost benefits for information system implementation using electronic data interchange as the enabling tool. Highlights rarely cited on-cost benefits through the examination of supply chain dynamics, and their relative reductions created through increased stability. They also examine two business re-design strategies, namely lead time reduction via information systems implementation and information integration in the form of actual customer demand fed forward to all supply chain members and highlights global integrated logistics information systems and describes their role in overall supply chain system optimization.

Patrick Walsh et al [96] addressed the need of industrial organizations to reduce information processing time, improve added and residual value of information, and reduce processing and distribution costs and "lead-times". They observed that the information supply-chain as an important entity, whose performance and optimization very significantly affect the efficiency and performance of industrial enterprises. A conceptual modeling and simulation environment was proposed for analyzing information on supply chain management strategies.

Mohsen attaran [85] discusses the evolution of RFID, its capabilities and its application in various industries, implementation challenges, identifies adoption phases, and reviews RFID's success factors. RFID is the most recent prolific technology that provides supply chain collaboration and visibility.

Handled properly, RFID technology can result in an evolutionary change incorporating legacy systems with the real-time supply chain management of tomorrow. Its stumbling point seems only to be a variety of issues outside the technology itself: marketing problems, false promises, security and privacy considerations, and a lack of standards. They integrate RFID with existing supply chain management, customer relationship management (CRM), and enterprise resource planning (ERP) applications.
Joseph G. Szmerkovsky et al. [64] studied the effect on manufacturers and retailers of attaching radio frequency identification (RFID) tags at the item level in a vendor managed inventory system. The model considered has one manufacturer and one retailer. They study the demand processes between an RFID system which uses continuous review and a non-RFID system which uses periodic review when shelf-space is limited. The processes determine the optimal inventory policies in a centralized system and establish conditions under which the RFID system is preferable to the system without RFID. Finally, it studies the decentralized system and show how the sharing of the tag price can be used to coordinate the supply chain and how it can be exploited in manufacturer and retailer dominated systems.

Suhong Li et al. [125] discuss the technology behind RFID systems, identify the applications of RFID in various industries, and discuss the technical challenges of RFID implementation and the corresponding strategies to overcome those challenges. The technical challenges of RFID implementation include tag cost, standards, tag and reader selection, data management, systems integration and security. The corresponding solution is suggested for each challenge.

Shoiu-Fen Tzeng et al. [116] had presented an in-depth analysis toward understanding the business value components an organization can derive from adopting radio frequency identification. Although this subject is currently a hot topic, many organizations are slow in warming up to the idea of using RFID to conduct more effective and efficient business processes.

Ajith Kumar Parlikad et al. [4] discussed that with the increasing pressure on manufacturing companies to manage their end-of-life products, the availability of information to improve product recovery decisions is becoming critical. In fact, a fundamental obstacle in making efficient product recovery decisions is the loss of information associated with the product after the point-of-sale. They showed qualitatively that the availability of product information has a positive impact on product recovery decisions, and discuss how radio-frequency identification based product identification technologies can be employed to provide the necessary information. The paper also investigates how recovery decisions can be modelled to represent the impact of product information on those decisions.
Mikko karkainen [82] reveals that short shelf-life grocery goods present some of the biggest challenges for supply chain management due to a high number of product variants, strict traceability requirements, short shelf-life of the products, the need for temperature control in the supply chain, and the large volume of goods handled. A Radio Frequency Identification (RFID) based data capture system can help solve the problems associated with the logistics of short shelf life products. They discuss the potential of utilizing RFID technology for increasing efficiency in the supply chain of short shelf life products. Further they also analyze the potential impact of RFID for other supply chain participants.

2.7 BULLWHIP EFFECT

The bullwhip effect is an important phenomenon of supply chain management that has been studied for about fifty years. It was explained by Stevenson [123] that the demand variations of the customer become increasingly large when they diffuse back-wards through the chain. The bullwhip effect was first introduced by Forrester [44]. He observed a fluctuation and amplification of demand from the downstream to the upstream of the supply chain. He stated that the variance of the customer demand increases at each step of the supply chain (customer, retailer, distributor, producer, and supplier). Furthermore, he concluded that the main cause of this amplification is the difficulties in the information sharing between each actor of the supply chain.

Sterman [121] describe an effective method to understand the bullwhip effect named as "beer game". It is a useful teaching tool where each participant represents an actor of a beer supply chain such as retailer, wholesaler, distributor and manufacturer. This game has been played many times by numerous students, professionals and managers.

Every time, the same results are obtained; a small change in a consumer demand is translated into considerable fluctuation in both orders and inventory upstream. This fluctuation is caused by the lack of information sharing among the entire chain.

Agrawal et al. [3] analyze the impact of information sharing and lead time on the bullwhip effect and inventory levels in a two-level supply chain.
They showed that, even if the information is shared inter and intra echelon, it cannot completely eliminate the bullwhip effect. Their results show that lead time reduction is more interesting to reduce the bullwhip effect than information sharing.

To conclude based on literature review, there is a lack of research on how companies actually utilize IT in the management of their supply chains. Furthermore, only very few works are available in the literature for optimal inventory control with the aid of data mining, Genetic Algorithm and RFID concepts to improve the performance of the Supply Chain. These identified shortcomings of prior research create a need for research that this study aims to address.

2.8 RESEARCH OBJECTIVE

Hence, the main objective of the research is to optimize the inventory in a supply chain by determining the optimal inventory levels at each stage of the supply chain to minimise the supply chain cost as well as to study the impact of RFID on inventory management in a supply chain by demonstrating a few case studies.