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GUIDED BY

"Suyash Nikhare"

SUBMITTED BY

"Vijay Kumar Narware"

STUDENT REGISTRATION NO.: MIT2022C00063

MIT SCHOOL OF DISTANCE EDUCATION PUNE - 411 038

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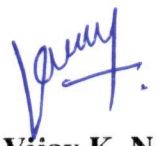
Student Sign: - 

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DECLARATION

I hereby declare that this project report entitled **"Supply Chain Analytics"** Bonafede record of the project work carried out by me during the academic year **2022-2023**, in fulfilment of the requirements for the award of **"Material Management"** of MIT School of Distance Education.

This work has not been undertaken or submitted elsewhere in connection with any other academic course.

Sign:-

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Sign:- 

Name:- Vijay K. Narware

Student ID: MIT2022C00063

Supply Chain Management

Project for the Supply Chain Management

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Vijay Kumar Narware

Abstract

The history of Supply Chain Management (SCM) has assumed a significant role in firm's performance and has attracted serious research attention.

Contents

Chapter 1

Historical Background of Supply Chain Management

In order to assess the shift from static to dynamic Supply Chain Management (SCM). it is customary to assess first the evolution of Supply Chain (SC) and SCM. The development of the idea of supply chain owes much to the emergence from the 1950's onwards of systems theory, and the associated notion of holism (that is the whole is greater than the sum of the parts) Interest in supply chain management has steadily increased since the 1980s when firms saw the benefits of collaborative relationships within and beyond their own organization (Rhonda and Robert, 1999).

The history of the supply chain initiative can also be traced to early beginnings (1984 or 1985)in the textile and apparel industries with the quick response program and later to efficient consumer response in the grocery industry in the US. The first initiatives were taken by apparel to study about Supply Chain. Besides the apparel and grocery industry initiatives, other early manufacturing efforts to improve supply chain performance have been documented. Some of these include: Hewlett-Packard, Whirlpool, Wal-Mart, West Co.. Becton Dickinson, Baxter, and Georgia-Pacific Corp considered SCM as a core competency (Rhonda and Robert, 1999).

Supply chain management (SCM) has been met with increased recognition during the last decade both by academicians as well as practitioners Patroklos et al. (2005). One way or another, the history of Supply Chain Management (SCM) has assumed a significant role in firm's performance and has attracted serious research attention over the last few years in the business strategy (Jain et al., 2010), whereby the trading partners within the supply chain commit to work in tandem to bring maximum value to the consumers and or their customers for the least possible chain cost and time (Benita, 1998).

More recently a variety of companies across many industries have begun looking at the entire supply chain process due to the high demand on the vertical integrations (Rhonda and Robert,

1999). In its inception, in the olden times, manufacturers were the drivers of the supply chain-managing.

Table 1.1: Era in the Evolution of SCM (Jain et al., 2010)

S/No	Era	Description
1	Creation Era	The term supply chain management was first coined by an American industry consultant in the early 1980s. However, the concept of supply chain in management, was of great importance long before in the early 20th century, especially by the creation of the assembly line.
2	Integration Era	This era of supply chain management studies was highlighted with the development of Electronic Data Interchange (EDI) systems in the 1960s and developed through the 1990s by the introduction of Enterprise Resource Planning (ERP) systems.
3	Globalization Era	This era is characterized by the globalization of supply chain management in organizations with the goal of increasing competitive advantage, creating more value-added, and reducing. costs through global sourcing
4	Specialization Era Phase - One Outsourced Manufacturing and Distribution	In the 1990s industries began to focus on core competencies and adopted a specialization model. Companies abandoned vertical integration, sold off non-core operations, and outsourced those. functions to other companies.
5	Specialization Era Phase Two - Supply Chain Management as a Service	Specialization within the supply chain began in the 1980s with the inception of transportation brokerages, warehouse management, and non asset based carriers and has matured beyond transportation and logistics into aspects of supply planning, collaboration, execution and performance management.

6	Supply Chain Management 2.0 (SCM 2.0)	Web 2.0 is defined as a trend in the use of the World Wide Web. that is meant.

the pace at which products were manufactured and distributed. But today, customers are calling the shots, and manufacturers are scrambling to meet customer demands for options/styles/ features, quick order fulfillment, and fast delivery (Jain et al., 2010). This demands an integrated flow of physical goods, information, funds and knowledge amongst suppliers, manufacturers, whole- sellers, logistics and financial providers, retailers and the end consumers (Benita, 1998).

Traditionally, (SCM) has been a melting pot of various aspects, with influences from logistics and transportation, operations management and materials and distribution management, marketing, as well as purchasing and information technology (IT) (Jain et al., 2010). There is no generally accepted definition of supply chain management or general understanding of how supply chain management impacts organizational characteristics and practices (Joel, 2000). There is a confusing profusion of overlapping terminology and meaning within supply chain management literature (Adr) . and however there many scholars and practitioners defining SC/SCM and its concept (Rhonda and Robert, 1999; Joel, 2000).

Study shows that there are many literatures which are still very fragmented and although several studies purport to discuss supply chain issues, according Jain et al. (2010) most of the existing re- search only examines one link of the chain, or most importantly only focuses on one ingredient in the supply chain performance mix. However, the overall evolutionary stages of SCM is summarized in six major stages using two phases; from number one to four included in phase one whereas five and six are in phase two the author as shown in Table 1.1.

1.1 Definition of Supply Chain Management

A preliminary definition of the term supply chain would encompass the linkage of stages in a process from the initial raw material or commodity sourcing through various stages of manufacture, processing, storage, transportation to the eventual delivery and consumption by the end consumer. This might suggest that supply chains are concerned primarily with logistics. However, the conceptualization of the term supply chain in the context of the Supply Chain Management (SCM) field is significantly more diverse (George and Bob).

The term "supply chain management" has been used to denote and defined as the integration of

logistics and physical distribution activities by wholesalers and retailers and manufacturers' efforts to effectively integrate purchasing and supply with other functions in the firm (Joel, 2000). The concept

is still evolving. In a bit broader sense, according to Gautam (2011) Supply chain Management encompass the planning and management of all activities involved in sourcing, procurement, conversion and logistic management. It is a system of organizations, people, technology, activities, information and resources involving in moving a product or a service from suppliers to customers. As of Beni Tait is an integrated process wherein raw materials are manufactured into final products, then delivered to customers (via distribution, retail, or both).

But As indicated above in the definitions, supply chain management is much more than just procurement. According to Rhonda and Robert (1999) among the misunderstanding evidenced, supply chain management is not: inventory management, logistics management, supplier partnerships, driven from the supply side, a shipping strategy, distribution management, the logistics pipeline, procurement management or a computer system. Supply chain is not logistic, rather, a logistic is an operational infrastructure of a supply chain. This is because that a supply chain refers to those activities to be performed in an integrated and coordinated way by the systemic entities managing flows (Carlo, 2011).

1.2 State-of-the-art of Supply Chain Management

Supply Chain Management is a set of synchronized decisions and activities utilized to efficiently integrate suppliers, manufacturers, warehouses, transporters, retailers, and customers so that the right product or service is distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying customer service level requirements. The objective of Supply Chain Management (SCM) is to achieve sustainable competitive advantage. The evolution of supply chain shows that there is steady increase in the complexity of supply chains and a corresponding rise in the visualization of the manufacturing process have spawned several noticeable trends in organizational dynamics. Over the decades, management of the supply chain has moved through three distinct phases, from decentralized (functional/departmental), to central- ized (corporate planning and purchasing), and finally to a combination of both. The pendulum is currently swinging toward centralized planning combined with decentralized execution. Tech- nology now allows for the rapid propagation of business information from all functional and geo- graphical areas of the extended enterprise, which enables decision makers to plan and execute with the intent of maximizing enterprise-wide profitability (Adr; Maha and Narayan, 2001).

The internal supply chain of the focal manufacturing company includes sourcing, production, and

distribution. Sourcing or purchasing of the company is responsible for selecting suppliers, negotiating contracts, formulating purchasing process, and processing order. Production is responsible for transforming raw materials, parts, or components to a product. Distribution is responsible for managing the flow of material and finished goods inventory from the manufacturer to customer. The internal supply chain is only involving functions, or departments, business units within the organization. But the concept and need of supply chain management is broaden and has evolved to include external suppliers too. The external supply chain is involving other companies which includes the relationships with the customer through marketing and sales; and with suppliers through the procurement function (Adr; Dobler and Burt, 1996; Hicks et al., 1999).

The olden times of SCM is characterized by:

- Adversarial arms-length trading.
- Buyers defined production and process specifications.
- Components were obtained from multiple sources.
- Little information was disclosed to suppliers on technologies, processes and production targets.
- Price competition was the primary criterion on which contracts were awarded.

However, the adversarial relationships proved counterproductive to both parties and by the year 1980s a partnership model was being adopted to reduce costs, resolve scheduling problems and other technical difficulties between suppliers and buyers which demands to include external sup- ply chain. Moreover, strategic change was required to implement the mover from internal SC to external SC that can involve other companies in the chain. The partnership, or obligational model developed at that time, is characterized by close operational and strategic links between buyer and supplier; the provision of technical and managed assistance to suppliers and the establishment of preferred supplier status such as single sourcing agreements (Dobler and Burt, 1996).

Moreover, the development of Enterprise Resource Planning Systems (ERP)is also one move that

integrates the internal supply chain management of the company tht contain most information and necessary data for a sufficiently early process evaluation (Sabrina and Carlo, 2007). ERP integrate the entire company's information system, process and store data, cut across functional areas, business units, and product lines to assist managers make business decisions. As an IT infrastructure,

ERP influences the way companies manage their daily operations and facilitates the flow of information among all supply chain processes of a firm (Adr). But this is still limited within the company and cann ot minimize the overall supply chain management problem.

Due this reason organizations are obliged to include the external supplier's relationship. some of the trends that are outsourcing of non-core activities to suppliers and focusing on their operations, a reduction in supply base as companies shift from multiple to single sourcing Long-term buyer supplier relationships, partnerships rather than adversarial trading. The outcome of these changes are that companies are establishing new relationships with their suppliers or buyers (Hicks et al., 1999; Dobler and Burt, 1996).

Within the supply chain, companies expect the supply chain management to focus on the following value adding outputs:

- **Quality**: Purchased materials and services should be virtually defect free. Many defects can be traced back to bought in items.
- **Cost**: Minimization of total cost of acquiring, transporting, holding, converting items as well as quality costs. "A 5% reduction in costs can have the same effect on the bottom line as a 25% increase in turnover" (Dobler and Burt, 1996)
- **Time**: Need to minimize time to market for new products as well as minimizing lead-times to increase flexibility.
- **Technology**: Ensuring that the firms supply base provides appropriate technology in a timely manner; ensuring that technology associated with core competence is carefully controlled.
- **Continuity of supply**: Need to reduce risk of supply disruptions. These may have impact on other functions (aluminum vs carbon fiber reinforced plastics in the aerospace industry). May involve the development of alliances.

1.3 The Shift of SCM from the Internal Functions to E-SC

Companies, it is not only obliged to include external suppliers or actors in the SC, but also increase the visibility of each actor in the SC. According to Maha and Narayan (2001), the

shift of supply chain is moved from department or function (from fifties to the late eighties)to integrated SCM (in the late eighties and early nineties, with the advent of Business Process Re-Engineering (BPR))and

then to value networked (current time due to the advent of Internet). E-commerce uses advanced technology to assist business transactions in a web-based environment and facilitates the transaction of information flow and fund flow.

E-distribution instructs where to locate the sources of supply and advises how to access them. as well as how to move the materials to the retailers via the Internet or a web-based environment. E-procurement is also part of the E-commerce, which completely revolutionizes a manufacturing or distribution firms supply chain, making a seamless flow of order fulfillment information from manufacturer to supplier (Com, 2009).

The e-business wave that started in the late 1990s saw the rapid growth of collaborative initiatives outside a company's four walls in areas such as customer self-service, e-procurement systems, advanced planning hubs and collaborative logistics (IBM, 2003). Moreover. the value of integrated network and E-commerce introduces the concept of information sharing and e-supply chain management. Information sharing through the Internet becomes so pervasive for companies to use in their supply chain. The Internet provides a tool that allows supply chain activities to be carried out in a synchronized, instantaneous manner, facilitating maximum supply chain performance. The positive benefits of integrating the Internet into management of the supply chain generally out- weigh the risks and associated costs, and firms who have completed such integration hold a current competitive advantage over those that have not (Frohlich, 2002; Sahin and Robinson, 2002).

The evolution of supply chains over the last two decades has showed the following major changes in supply chain management (IBM, 2003). These are:

1. Customers have become ever more demanding.
2. Product lifecycles have shrunk dramatically, and, as a result, speed-to-market and successful product innovation have become critical to corporate success.
3. Supply chains have become increasingly more global and complex, presenting greater challenges in managing supply and demand.
4. Companies have dramatically increased their use of global sourcing partners for cost and capability reasons, extending the number of players involved in delivering value to a customer.
5. Starting in the late 1990s, companies increased their use of e-business.

6. Cost reduction has been on the top of most managers minds.

Chapter 2

The move from Static SCM to Dynamic SCM

Supply chain is a complex network of business entities involved in the upstream and downstream flows of products and/or services, along with the related finance and information. The complexity is inherent in the Supply chain in forms of static complexity and dynamic complexity. In the case of static complexity, it is more related to the connectivity and structure of the subsystems involved in the SC such as companies, business functions and processes whereas, the dynamic complexity is the one that results from the operational behavior of the system and its environment (Com, 2009). Due to this reasons, effective SCM is concerned with the interchange of information, communications and relationship development, potentially throughout the entire supply chain, upstream to the raw material supply sources and downstream to the end consumer of the goods and services (George and Bob).

Supply chain management (SCM) has been met with increased recognition during the last decade both by academicians as well as practitioners. However, despite its significant advances and dramatic improvements in information technology (IT), the discipline of SCM remains incapable of addressing satisfactorily many practical real-world challenges. One key reason for this inadequacy is the interdependencies among various operations and the autonomous partners across the chain, which renders all traditional myopic models invalid (Patroklos et al., 2005) and made the supply chain inefficient.

Therefore, enterprises have become recently very interested in improving efficiency of supply chain management due to rising production and distribution costs, globalization of markets and demands of customers for diverse products with short life cycle. These all boost competition among companies. Uncertainty in all the supply chain stages has complicated supply chain management process. Uncertainty can cause halts in a supply chain as wrong predictions, late information, and trans- probation problems. Any halt in supply chain can lead to unsuitable

services to customers, i.e. in timely delivery of goods to customers. Companies overcome the uncertainty usually through holding

an emergency inventory. All the companies maintain the inventory to minimize the effect of uncertainty and to keep a streamlined, stable and profitable process form suppliers to customers. But due to high inventory costs, companies are inclined to minimize the inventory as well (Abbas and Maryam, 2011).

In order to achieve all these (at least to some extent) coordinating all different activities across the chain is an important responsibility of SCM, so that goods can be delivered timely to customers at a time when inventory and costs are low. An efficient SCM will reduce production costs, inventory and supply costs as well as service costs in each phase. To address these, different methods have been developed to model supply chains. The models can be divided into four categories (Go- sain et al., 2004):

- Deterministic models in which all parameters of the model are determined. Which is called static supply chain management.
- Stochastic models in which at least one parameter is not determined, but it follows a probability distribution function.
- Economic games theory models.
- Simulation based models. Most of the models are steady state models based on average performance or steady state conditions.

The above models have the tendency to move from static to dynamic supply chain management. The move from static to dynamic supply chain management is highly intensified and supported by the Information Technology (IT). However, the widespread use of information technology (IT) to create electronic linkages among supply chain partners with the objective of reducing transaction costs may have unintended adverse effects on supply chain flexibility. Increasing business dynamics, changing customer preferences, and disruptive technological shifts pose the need for two kinds of flexibility that interenterprise information systems must address the ability of interenterprise linkages to support changes in offering characteristics (offering flexibility) and the ability to alter linkages to partner with different supply chain players (partnering flexibility) (Gosain et al., 2004). In the next sections, the paper will discuss the static and dynamic SCM approaches in the SCM processes.

2.1 Static SCM

Static supply chain methods are easy to work and work very well when demand is uniform and are stable (Janat, 2009). Some of the static SCM models are integrated inventory management (Suresh and Yash, 1989). Economic Order Quantity (EOQ). EOQ with quantity discount, Safety stock levels, etc. But static models don't account the elements of time in the model.

Static models encountering dynamic specifications of SCM seem to be insufficient due to demand fluctuations, delivery time delays compared to order time (lead time) and sale prediction which will vary soon from time to time. The above issue indicates that studying dynamic specifications is a competitive advantage in modeling supply chain systems (Abbas and Maryam, 2011). Though the set-up in the supply chain often appears to be static, supply chains in reality are quite dynamic. Due to their dynamic nature, ideally supply chains react to change in their environment (Colin et al.). This leads to other models that can capture real dynamic nature of SC.

2.2 Dynamic Systems of SCM

by its nature, SC is dynamic. There are many models, that try to approximate the dynamic nature of SC into static. A dynamic model or mathematical model is a model, that describes how the system change in time and might have a variety of representations from the notation model of mathematics to diagrammatic (Crespo, 2010). Dynamic system is a method for understanding behaviors of complicated systems through simulation and is used to show behavior of a system against different strategies and policies in order to, be utilized in planning and decision-making processes.

This methodology was introduced 35 years ago by Forrester [1] in his first book titled Industrial Dynamic (1971), focusing on industrial applications as cited in (Abbas and Maryam, 2011). It is widely accepted that coordination of planning, production, and delivery processes is more effective and efficient when done at supply chain level than at individual firm level. To make supply chain level coordination possible, companies need to exchange information timely and seamlessly. This re- quire tight integration of systems among supply chain entities. In addition to the dynamic SCM models, collaborative Software Development (CSD) is also critical for successful system

development for supply chain coordination and management (Crespo, 2010). Challenges derive from the need to integrate various heterogeneous systems, facilitate proper information exchange and communication, and define organizational control and management.

According to Maha and Narayan (2001), the shift from static SCM to Dynamic SCM has increased **VISIBILITY** and access to real-time information will make a greater proportion of **SUPPLY** chain **EXECUTION** decisions pre-emptive rather than reactive. the rise of the Internet has enabled in- formation driven E-supply chain that possess unique properties, which are critical in the global
economy of tomorrow (Viswanathan and Roshan, 2011). Supply chain visibility allows end-to-end visibility of all supply chain transactional event and performance information (IBM, 2003).

2.3 Comparisons of Static and Dynamic SCM

Information visibility is generally useful for decision makers distributed across supply chains. Avail- ability of information on inventory levels, price, lead times, demand, etc. can help reduce uncertainties as well as alleviate problems associated with bullwhip effect. A majority of extant literature in this area assume a static supply chain network configuration. While this was sufficient a few decades ago, advances in e-commerce and the ease with which order processing can be performed over the Internet necessitates appropriate dynamic (re)configuration of supply chains over time. Each node in the supply chain is modeled as an actor who makes independent decisions based on information gathered from the next level upstream. A knowledge-based framework is used for dynamic supply chain configuration and to consider the effects of inventory constraints and 'good- will,' as well as their effects on the performance dynamics of supply chains. Preliminary results indicate that neither static nor dynamic configurations are consistently dominant. Scenarios where static configurations perform better than the modeled system are identified in some cases (ReP).

However, as of my opinion, though, the dynamic SC models are far better to capture the real essence of the Supply Chain complexity, but dynamic SC models are not fully addressed the complexity of the SCM. Rather they are and can be used as a complementary tool for other models. They have dramatically improved the SCM process as compared to the static SCM. Moreover, as I have gone through different dynamic SCM models, most of them require inputs or

start from the static assumption of SCM process. Therefore, as of my understanding, though the dynamic SC Models can capture the real complex nature of the SCM process, the importance of the static assumptions in the models cannot be ignored at all and the dynamic SCM is not fully replaced the static SCM as the moment.

Chapter 3

Contemporary Methods in Logistics and/or SCM

The concepts of Supply Chain Management (SCM) and its extension Demand Chain Management have been at the center of much recent research. The increasing interest in this area has led to the development of various models and tools aimed at supporting the design and analysis of complex logistics and supply chains (SCs)(Rik).

The logistics industry is an example of the erection and development of a vital new service-based and manufacturing industry. According to Johannessen (2003)(cited in Rafael lecture note: Supply Chain complexity; logistics is complex processes of relations between humans, nature, technology and resources that interact and unpredictably self-organize into emerging paradoxical patterns with value creating potential. According to Peter et al. (2010), the level of logistics complexity of companies is a driver of management choices in supply chain objectives and decision areas. They, Peter et al. (2010) found that there is a significant positive relationship between logistic complexity and supply chain management decision areas and objectives. Since logistics is part of the larger integrated process, supply Chain (Carlo, 2004), the complexity in logistics is also fully reflected on the Supply chain. Moreover, Nilsson and Waid range (2002), assess the logistics complexity based on significant properties (structure, dynamics and adaptation) on three levels of resolution (individual/parts, the firm and the network). .

In order to handle the complexity of logistics and supply chain, different tools and methodologies have been developed in firm and industry levels so as to represent and analyze the complex behavior of supply chains and logistics systems. Among the many, some of the models and methods to handle the complex behavior of logistics and supply chain are briefly discussed below.

In and itself SC is dynamic in nature. There are different SC models that try to address the

complex nature of SCM. Among the many, some of them will be addressed under this section. After evaluating some of the models, the paper try to address... draw backs if any and future improvement of

the model.

3.1 Artificial Neural Networks

Neural Networks which is commonly called Artificial Neural Networks (ANN) is a mathematical or computational model based on biological neural networks. According to MatAn ANN is a network of interconnected computing nodes, which interact with one another via connection weights. In a multi-tier ANN, the computing nodes are partitioned into one input, one output, and one or more hidden layers.

It consists of an interconnected groups of a neurons and processes information using a connectionist approach to computation. In most cases ANN is an adoptive system that change its structure based on external or internal information that flows through the network during the learning phase. It is used to model complex relationship between inputs and outputs or to turn pattern in data. Though ANN has emerged as one of sub-optimal or near-optimal solution, the capacity for adoption that allows ANNs to take account of new constraints as they arise has mad the concept very attractive for highly dynamic environment, especially in SCM. However, ANN can be used as a complementing tool for other techniques such as SD, Simulation (Soroush et al., 2009). Moreover, in order to use ANN in the SC, the supply chain has to be decomposed into components and the supply chain network has to be decomposed into multiple ANN (Mat).

3.2 Petri Nets

The other method that can help to handle logistics and supply chain complexity is Petri nets. Petri nets were originally developed in the 1960s to analyze problems in particle physics (Jensen, 1996)and consists of places, transitions, and arcs [1]. Petri nets are graphical and mathematical modeling tools applicable to many systems. They are promising tools for describing and studying information processing systems that are characterized as being concurrent, asynchronous, distributed, parallel, nondeterministic and/or stochastic (Tadao, 1989).

Petri nets have been considered for application in logistics and work-flow modeling since the 1990s. The existing Petri net techniques have primarily investigated the dynamic properties of single sup- ply chains subject to changes in key parameters such as order sizes and lead times (Tynjl, 2011).

Looking for an appropriate tool for the representation and analysis of the SC, Petri nets (PN) seem

to be very attractive because they provide a suitable framework for representing reasoning on concurrent active objects which share resources and their changing states. Due to their graphical nature and easy-to-validate specifications by analyzing the net structure. PN have proved helpful in rendering modelling simple and readable for complex problems Rik.

3.3 Discrete Event Simulation (DES)

Computer simulation is an application domain of programming languages that permits further division into three partitions: discrete event simulation. continuous simulation. and Monte Carlo simulation. The discrete event simulation utilizes a mathematical/logical model of a physical system that portrays state changes at precise points in simulated time. Both the nature of the state change and the time at which the change occurs mandate precise description. Customers waiting for ser- vice. the management of parts inventories, or military combat are typical application domains for discrete event simulation.

3.4 System Dynamics (SD)

System dynamics is an approach to understanding the behavior of complex systems over time. It deals with internal feedback loops and time delays that affect the behavior of the entire system. SD has three major elements feedback. accumulation of flows into stocks and time delays. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. These elements help describe how even seemingly sim- pile systems display baffling nonlinearity [2]. Forrester originally developed system dynamics solely for the purpose of improving policy making by managers of corporations (Michael and Linwood, 2007). According to Hayden (2006)and as partially agreed by Michael and Linwood (2007)because real-world systems are constantly open to their environments. equilibrium is not possible.

Though it is difficult to evaluate system dynamics, as there is no criteria set to perform such an evaluation, however; system dynamic has the following advantages and limitations (Patroklos et al., 2005; Bernard. 2006).

- Looks at the policies as well as the processes; System dynamics enables the policies to be included in the model as well as the process

- Provokes serious systems thinking; You have to look at the problem as a whole. Considering those influencing factors that affect the behavior of the system. Many problem-solving models only consider the problem itself, not considering the cause-and-effect interrelationships between system variables.

- Have both the conceptual and quantitative side; System dynamics has both a conceptual side (in problem definition and causal loop diagrams) as well the quantitative side, incorporating rates and levels, which are especially useful in simulations.

When Forrester has published his first model in SD related to SCM in 1958, it was considered as a breakthrough for decision makers. However, the model has received much critics over the year. Among others, some of the major drawbacks of SD, according to Hayden (2006); Patroklos et al. (2005); Bernard (2006)are:

- **May be difficult to apply at detailed levels;** Due to the amount of mathematical analysis re- quired it may be difficult to apply system dynamics at a very detailed level, especially without the use of a computer program.

- **Time factor- how long is the delay;** Especially at the conceptual level, there is no reference to the length of the delay between two elements of a cause-and-effect relationship; putting a delay into the diagram only makes you aware that there is a delay and that this will affect the outcome. At the quantitative level, it may be difficult to accurately predict the length of the delay, and this will effect the result of a computer simulation; a number of simulations would have to be run with varying lengths of delay in order to get a general idea of what the effect could be.

- **Setting the boundary;** It may be difficult to set the boundary of the system . You want to include all the factors that significantly affect the problem being represented, but you may end up with too few, too many, or the incorrect factors (Legasto and Maciariello,1980 [29]) how do you know which factors to include?

- **Temporal horizon what should it be set at?** There are two issues relating to this limitation; the length of time the model relates to (that is, 2 years or 50 years), and the inability to compare the effect of events that occur at

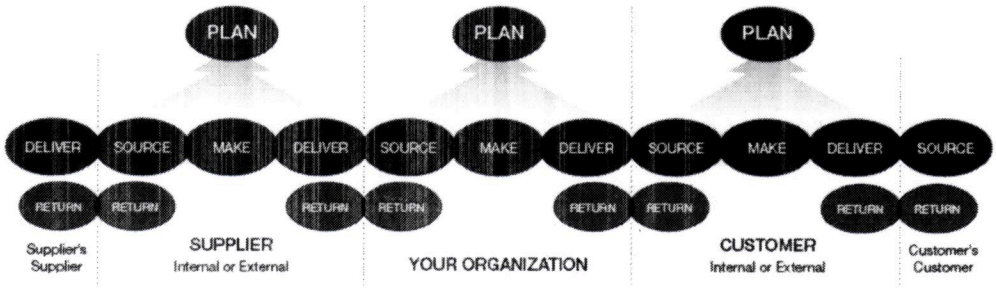
Irrespective of its critiques, SD has contributed in many areas of real world problem in the decision making areas especially in areas where dynamic behavior of complex systems such as in

supply chain management process.

3.5 Supply Chain Performance Improvement

Moreover, Over the past years, attention was mainly devoted to the performance of the single process inside the supply chain. Recently, however, there has been more concern over the performance of the global supply chain itself (Beamon, 1996, cited in Sabrina and Carlo (2007)).In order to evaluate this, recently the Supply Chain Counsel(SCC) has developed an evaluation matrix. As it is cited in Sabrina and Carlo (2007), the SCOR model is a framework linking business processes, evaluation metrics, the best practice and technological features of a, SC into an aggregate scheme, both from a logical and a terminological point of view.

SCOR model (SCC, 2010)



In order to understand better, it make sense to present the model developed by the Supply Chain Counsel (SCC). which is an industry body representing supply chain companies and industry players, has developed the Supply Chain Operations Reference (SCOR) that depicts the broad spectrum of generic functional process in the SC into Plan, Source, Make and Deliver as shown in figure **??**. Each of them are elaborated in the Table 3.1

3.6 Recommended Improvements on some of the Logistics and SCM Methods.

Though the above methods and models are capable of handling and modeling a complex and dynamic behavior of a system, it doesn't mean that, they are without limitation. As of my level of understanding, some of the gaps or limitations that I have point out are given below. Within its model, in addition to the limitation stated above, SD Doesn't include the cost of equipment. Much equipment are involved in the logistics and supply chain management, however, SD ignores the cost these equipment. Therefore, the inclusion of the cost of the

equipment as a variable to be modeled along with the original variables in the SD model. Though SD was developed to model policy sit-

Table 3.1: Emerging Best Practices in SCM Strategy (Carlo, 2011; SCC, 2010)

Functional Process	Emerging Practice
Plan	• Expanding planning to include customers and suppliers with joint objective of customer service, flexibility, cycle times and inventory. • Setting-up an end customer pulled-based planning approach (e.g. make-to-order)
Source	• Joint Development and sharing the risks/benefits. • Development of strategic supplier relationships • Automated vendor managed rapid replenishment of in- venture to point of use and time of use
Make	• Postponement manufacturing (pull vs push approach) • Design for supply chain/Manufacturing
Deliver	• Centralized safety stock with rapid response to make demand/inventory deployment. • ship direct to end-customer/single point of handling

auctions, it does not let the modeler to understand how these policies derive from actors' interactions.

Regarding ANN, it works correctly when it will be integrated in the RFID. this will help the ANN to capture information about the product, the producers. which are very important parameters in the SCM.

Supply chains are complicated dynamical systems triggered by customer demands. Proper selection of equipment, machinery, buildings and transportation fleets is a key component for the success of such systems. However, efficiency of supply chains mostly depends on management decisions, which are often based on intuition and experience. Due to the increasing complexity of supply chain systems (which is the result of changes in customer preferences, the globalization of the economy and the stringy competition among companies), these decisions are often far from optimum. An- other factor that causes difficulties in decision making is that different stages in supply chains are often supervised by different groups of people with different managing philosophies (Haralambos et al., 2008).

Therefore, if models that handle complex and dynamic behaviors include the joint co-operation between control experts and supply chain managers role in the models, the model will have the potential to introduce more realism to the dynamical models and develop improved supply chain management policies. Moreover, almost all the models don't consider the complexity of the supply chain networks among industries such as the effect of the supply chain network of electronic indus- try to the SC network of the car industry. however, one has to remind that as the complexity of the model increases in terms of extended properties (as stated above). the harder it is to use standard tools to evaluate certain properties of the outcomes of the model.

3.7 Conclusions

Based on the assessment made so far, the following conclusions and recommendations are summarized and presented below.

As it has been assessed, the history of SC and SCM are dated back in the 1980's. Since then, the concept is of SC and SCM is rapidly growing and has attracted many scholars. Its concept is also

moved from the internal supply chain (from functional department) to external suppliers and other.

SC networks. As its complex nature and dynamic behavior and due to the fact, that increasing the real-time visibility of all actors in the network is highly important, there are many models and tools developed and try to address these. The methods and models largely contributed to the Logistics and SCM processes but not completely addressed the situation. Some are limited on their scope, inclusion of the number of variables and parameters, actors in the supply chain etc. Moreover, nearly all the models are developed for a particular problem or scenario which may or May not directly related to logistics and SC/SCM. But their applications are extended to address the complex problem of SCM. In similar fashion there are no clear guidelines or steps how to use the different models in different scenario. All the models have gi-go scenario if they are wrongly modeled by the user. There are no means to protect making these errors in the use of the model in different scenario other than the situation they are developed. But as they are in their development stage, there would be more improvement in their application as well as usage in many scenarios. Some improvements and recommendations are proposed above in 3.7.

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