Study of Select Issues in the Supply Chain Management of Advanced Manufacturing Systems

VIVEK CHANDRA PANDEY

DEPARTMENT OF PRODUCTION ENGINEERING
DELHI UNIVERSITY
NEW DELHI – 110007, INDIA

FEBRUARY 2010

Study of Select Issues in the Supply Chain Management of Advanced Manufacturing Systems

by

VIVEK CHANDRA PANDEY

Department of Production Engineering

Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

DELHI UNIVERSITY

NEW DELHI – 110007, INDIA

FEBRUARY 2010

CERTIFICATE

This is to certify that the thesis entitled **"Study of Select Issues in the Supply Chain Management of Advanced Manufacturing Systems"** being submitted by Vivek Chandra Pandey to the Delhi University Delhi for the award of the degree of Doctor of Philosophy is a bonafide record of original research work carried out by him . He has worked under our guidance and supervision and has fulfilled the requirement for the submission of the thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

(Dr. S.K. GARG)
Professor and Head
Department of Production Engineering
Delhi College of Engineering, Bawana Road
New Delhi – 110042 (INDIA)

(Dr. RAVI SHANKAR)
Professor, Department of Management studies, Vishwakarma Building
Indian Institute of Technology Delhi
New Delhi – 110016 (INDIA)

ACKNOWLEDGEMENT

I am immensely grateful to my supervisors Dr S.K. Garg and Dr. Ravi Shankar for their stimulated guidance, unwavering support and encouragement. This thesis could not have attained its present form, both in content and presentation, without their active interest, direction and guidance. Their unmatched excellence in the subject, bountiful energy, and personal care has been the source of great inspiration. They have devoted their invaluable time and took personal care in motivating me whenever I was disheartened due to tough times in the research. I also sincerely thank Mrs Garg and Mrs Shankar for their kind concern and affectionate encouragement during my research work.

I express my gratitude to Prof. P.B. Sharma, Vice-Chancellor, Delhi Technological University for inspiring me with valuable suggestions and words of encouragement.

I am thankful to Prof. S. Majhi, Head Department of Mechanical Engineering, Delhi Technological University, for his help and support through out my research work.

I am thankful to Prof. C.K. Datta, Ex Prof. and Head Department of Production Engineering, erstwhile Delhi College of Engineering for his help and support in initial stage of my Ph.D. I am also thankful to Prof. C.K. Khandooja, Ex-Professor, Department of Mechanical Engineering for his encouragement throughout my research work.

I am thankful to Dr. R.K. Singh, Department of Production Engineering Delhi Technological University, for his valuable support and guidance throughout my research work. I express my gratitude to all the distinguished faculty members of Department of Production Engineering, Delhi Technological University and erstwhile Delhi College of Engineering for their moral support and encouragement throughout my Ph.D. In particular, I wish to thank, Dr. R.S. Mishra, Dr. B.D. Pathak, Dr. S.S. Kachchawah, Dr. Nagesh, Mr. M.S. Ranganathan, Mr, A.K.Madan, Mr. Praveen Kumar and Mr. M.S. Niranjan.

I am thankful to fellow research scholars, Dr. Pramod, Dr. Aman Agrawal, Mr. Nitin Upadhe, Mr. Ravinder Kumar and Ms. Reshu for their consistent support and cooperation in terms of knowledge sharing and encouragement.

I am thankful to Dr. Ashish Agrawal, Reader, School of Engineering and Technology Indira Gandhi National Open University (IGNOU) for his valuable support and encouragement throughout my research work.

I am thankful to Mrs.Poonam Nain, Netaji Subhash Institute of Technology, Delhi and Mr. Vijay Pal Nain, President Puran Murti Educational Society for giving me all kind of support and encouragement to complete the thesis work.

I am grateful to Prof. Majed Al-Mashari, King Saud University, Riyadh, Prof. S.S. Yadav, Department of Management Studies, IIT Delhi and Prof. M.K. Tewari, IIT Khadagpur, for their support and encouragement in my research work.

I am thankful to all the respondents who responded to my questionnaire and participated in brainstorming sessions as a part of my research work. In this context I pay special thanks to Mr. Tapan Sahu, Maruti Udyog Limited, Gurgaon, Mr. Dheeraj Mohan, Jay Bharat Maruti Limited, Gurgaon, Mr.Manoj Manga, EMCO, Pressmaster Pvt. Limited, Faridabad, Mr. Ashwin Dhingra, Macht Technologies Pvt. Limited Gaziabad and Mr. Ravi Rana, Micromatic Machine tools Pvt. Limited, Delhi for their active support during course of my research.

No amount of formal acknowledgement can ever be sufficient for my wife Rashmi and kids Ira and Ish, who tolerated my busy schedule and provided continuous emotional support at home. I thank them for their hearty support, patience, sacrifice and participation to accomplish this task

I am also thankful to my in-laws, my brothers and all the well-wishers for their direct and indirect support during the course of this research work.

At last, I am grateful to my parents for their support, blessings and sacrifice during the course of this research.

(Vivek Chandra Pandey)

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADC	Automatic Data Capture
AGV	Automatic Guided Vehicle
AMS	Advanced Manufacturing Systems
AMT	Advanced Manufacturing Technologies
ANOVA	Analysis of Variance
ASRS	Automatic Storage and Retrieval System
B2B	Business to Business
B2C	Business to Customer
BSC	Balanced Score Card
BTO	Built to Order
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Design
CMS	Cellular Manufacturing System
CNC	Computer Aided Manufacturing
CPFR	Collaborative Planning Forecasting & Replenishment
CRM	Customer Relationship Management
EDI	Electronic Data Interchanger
EIP	Enterprise Information Portal
EoM	Ease of Measurement
EPOS	Electronic Point of Sales

ERP	Enterprise Resource Planning
ERP II	Enterprise Resource Planning (Web enabled)
EVA	Economic Value Aided
FMCG	Fast Moving Consumer Goods
FMS	Flexible Manufacturing System
FoU,	Frequency of Use
FT	Future Technologies
GDP	Gross Domestic Product
GT	Group Technology
ICT	Information and Communication Technologies
IMD	International Institute of Management Development
IRR	Internal Rate of Return
ISM	Interpretive Structural Modeling
IT	Information Technology
JIT	Just in Time
KPMG	Klynveld Peat, Marwick Goerdeler
LASER	Light Amplification and Stimulated Emission of Radiations
MRP II	Manufacturing Resource Planning
NPV	Net Present Value
OEM	Original Equipment Manufacturer
PLC	Programmable Logic Controllers
3’PL	Third Party Logistics
4’PL	Fourth Party Logistics

PUV	Perceived Usage Value
RFID	Radio Frequency Identification
ROA	Return on Asset
ROI	Return of Investment
SCM	Supply Chain Management
SOE	State Owned Enterprises
SPSS	Statistical Package for the Social Sciences
SSIM	Structural Self-Interaction Matrix
ToP	Trend of Profit
TQM	Total Quality Management
VMI	Vendor Management inventory
WEF	World Economic Forum

TABLE OF CONTENTS

CHAPTER 8: MODELING INTEGRATION AND AGILITY OF SUPPLY CHAIN USING INTERPRETIVE STRUCTURAL MODELLING 220-275

ABSTRACT

This research is aimed to examine the issues related to technology enablement, information sharing, performance measurement system, integration and agility of the supply chain management. A questionnaire based survey has been conducted to gain insights of various issues related to AMT- enablement of supply chain in select sectors of Indian manufacturing Industries. Four sectors of the Indian manufacturing industry namely auto, machinery, machine tools and electrical / electronics have been covered. A literature review has been conducted to identify the gaps in SCM research especially in Indian context. This research has attempted to fill some of the gaps in the contemporary research. Therefore, some hypotheses are framed and a questionnaire instrument is developed. The Descriptive statistics and hypothesis testing provide us insights about SCM and AMT practices in the Indian industries. To identify the need and analyze the benefit of AMT to Indian Industries factor analysis and discriminate analysis has been done using the data obtained through the questionnaire. Due to need of integration and agility in Indian Industries an ISM- based framework has been developed for acquiring integration and agility.

The major contribution of the research is as follows:

- A literature review has been conducted to identify various issues, related to SCM in general, and use of AMT in supply chains in particular. Therefore, a questionnaire has been developed to identify the issues related to AMT- enablement of supply chains in Indian manufacturing Industry.
- Various issues related to the AMT-enablement of supply chains in Indian manufacturing companies have been identified and discussed on the basis of the empirical study.

- Two sets of hypotheses concerning common supply chain issues and sector-specific practices have been formulated and tested.
- Different AMT has been categorized, their adoption level, reasons of adoption and benefits perceived has been analyzed statistically using data obtained from survey. Interesting observations has been reported about AMT adoption in the way to consolidate supply chain management.
- The impact of variety of information sharing on the competitive strengths of Indian Manufacturing Enterprises has been identified using correlation analysis on data received in the survey.
- The Performance measurement system of Indian manufacturing enterprises has studies for different performance metrics, identified with balanced score card approach. Each performance indicator has been surveyed for three perspective namely Frequency of use, Perceived usage value and Ease of Measurement. Important observations have been reported for different performance Indicators.
- In order to synthesize the work, an Interpretive Structural Modeling based framework has been developed for integration and agility of Supply Chain Management. This develop the relationships among important enablers for integration and agility of supply chain management.

These relationships are useful to make supply chain integrated and agile.

The present research focuses on various issues related to AMT- enablement of supply chains. It provides a better understanding of the status and readiness of AMT-enablement of supply chains in select sectors of Indian Manufacturing Enterprises.

Key Words: Advanced manufacturing technologies, Supply chain management, Information sharing, Performance measurement system, Integration, Agility, Empirical Study, Interpretive structural modeling.

CHAPTER 1
INTRODUCTION

1.1 SUPPLY CHAIN MANAGEMENT

Since the globalization and economical reforms in India that started in early nineties, cost quality and responsiveness have assumed an important role in the survival of an organization. Further short product life cycle is a common phenomenon now, which has resulted into creating uncertainty in the business environment. Many companies have identified supply chain management as a way to effectively tackle these situations.

Supply chain management is the integration of the key business processes from end user through original supplier that provides product, service and information that add value for customer and other stake holder (Lambert et al. 1998). The Supply chain of a typical manufacturing system is illustrated in Figure 1.1.

SCM is a set of approaches utilized to efficiently integrate suppliers, manufacturer, ware houses and stores so that merchandise is produced and distributed at the right quantities to the right locations, and at the right time in order to minimize system wide costs while satisfying service level requirements (Agrawal and Shankar, 2003). So a typical supply chain consists of suppliers and manufacturers, who convert raw materials into finished products and distribution centers and warehouses, from where finished products are distributed to customers

SCM focuses on information sharing and better collaboration among the supply chain partners. Some of the benefits of SCM, include, lower inventory levels, better responsiveness, and lower throughput time. Firms may also achieve volume, design, and technology flexibilities through SCM (Pagel, 1999). These benefits are the source of motivation for the companies in embracing the concept of SCM.

The objective of every supply chain is to maximize the overall value generated in the delivery of products or services. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request. For most commercial supply chain, value will be strongly correlated with supply chain profitability, the difference between the revenue generated from the customer and overall cost across the supply chain. The higher the supply chain profitability, the more successful the supply chain. The cash transfer adds to the supply chain's costs. All flows of information, product, generate costs within the supply chain. Therefore, the appropriate management of these flows is a key to supply chain success.

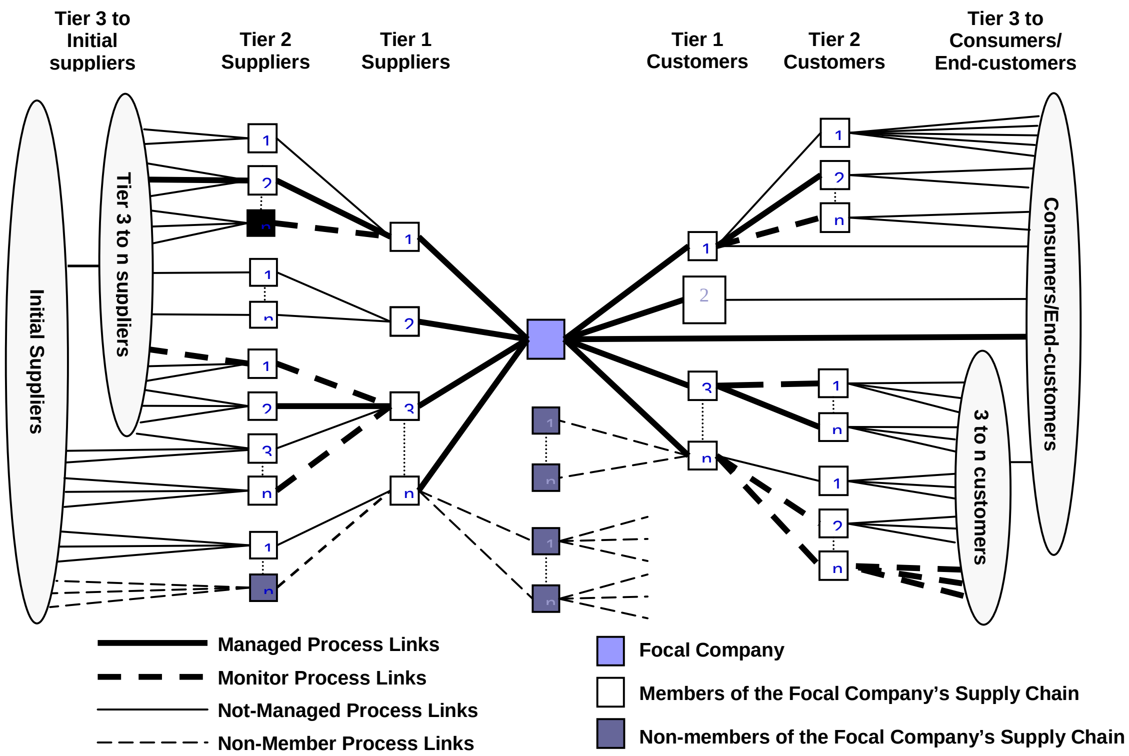


Figure 1.1: Supply Chain of a Manufacturing System (Adapted from Lambert et al. 1998)

In a SCM environment, AMT's support enablers such as flexibility, data sharing, data processing, training and education, communication, empowerment and job satisfaction. Technological support can impact on Partnership, information sharing, operational flexibility, performance measurement; management commitment; and demand characterization, the major dimensions of SCM. Considering the need for integrated business processes in SCM, AMT could play a major role in promoting effective integration of suppliers and customers along the value chain. Few studies can be found on AMT in SCM. Little has been done to explore what is needed in the way of successful implementation of AMT in the context of SCM.

1.2 ADVANCED MANUFACTURING SYSTEMS AND SUPPLY CHAIN

Manufacturing industry has been undergoing through a substantial technological growth since the introduction of numerical control machines about 55 years ago (Mukundan, 2003). Changes due to this growth are primarily because of the use of computers and automation. Computers have assisted in the development of numerous innovations in manufacturing including miniaturization and automation. In large manufacturing industries like the automotive industry, heavy machines industry, computer hardware industry etc product design and development are now done completely by the computers. Computer Aided Design workstations have replaced drafting tables. Product designers and engineers use CAD and Computer aided Engineering (CAE) systems to create three-dimensional geometrical objects that can be shaded, analyzed, and optimized to refine the product design. Manufacturing engineers use Computer-Aided Manufacturing (CAM) systems for process planning, tool design, and machine programming. Robots are used to weld structural frames, and computerized numerical processors are guiding manufacturing tools. Information technology is used in production planning, production and inventory control, sales, market research and forecasting, and after sales service The sweeping changes in the computer-related technologies in the late 1990s have brought paradigm shift in the business environment and strategic thinking of the organizations. To remain competitive in this ever-changing business scenario, the organizations are focusing more and more on the globalization of businesses and collaboration in the product development across the value chain i.e. supply chain. Manufacturing is the central activity that encompasses product, process, resources and plant. Manufacturing activities across the enterprises with real time exchange of information result in the optimization of design, resources and processes, which is in the true spirit of collaborative product commerce globally for maximum profitability. Redesigned best practices are requisite for the continued health and growth of the industry. Key factors contributing to this need include:

- Customers demand greater product variety, as well as shorter delivery times.
- Outsourcing and supplier relationships are becoming increasingly strategic to overall business plans.
- Fast time-to-market with new products is a requirement.
- Manufacturing and aftermarket support must be considered not at only at local level but, globally for maximum profitability.

1.3 SOME RELATED ISSUES OF SCM OF THE AMS

The literature related to different aspects of SCM is quite extensive. The same is true for AMS. This section gives a brief overview of literature in the area of SCM and AMS. SCM literature can be classified into three broad categories based on methodology:

- Conceptual and non-quantitative models including framework, taxonomies and literature reviews
- Case and empirical studies, and
- Quantitative models.

However, content wise there are some issues (such as information sharing, use of IT in supply chain, logistics related issues, performance measurement of a supply chain etc., which are widely discussed in the literature and have figured in each of the above three categories. These issues are presented under the following subsections.

1.3.1 Information Sharing related Issues

The integration and optimization of information flow is one of the core concerns of SCM (Lee and Whang, 2000). IT has a substantial impact on information sharing. The findings of KPMG 1997 global supply chain survey put IT as a major enabler of SCM (Freeman, 1998). In describing the role of IT in SCM, Chopra and Meindl (2001) state: "IT enables the gathering and analysis of information, which can be used to make a good decision. IT systems can be used to make the strategic, planning or operational decisions in a supply chain". IT systems enable companies to make decisions, which are based on real-time information sharing (Kwan, 1999). Regarding the use of IT in supply chains, Scala and McGrawth (1993) have observed that the way IT could be deployed in a supply chain is a crucial issues and depend on many factors such as maturity and compatibility of IT tools that supply chain partners use, level of costs involved, strategic alliances among supply chain partners, level of integration etc. The use of IT in a supply chain is not free from obstacles. Many authors (Kwan, 1999; Kadambi, 2000; Jharkharia and Shankar, 2000; Li, 2002) have identified the issues, which influence the IT-enablement of a supply chain. Some of these issues are: top management commitment, resistance to change and innovations, disparity in trading partners' capabilities etc. There are some technical, human and managerial issues, which need to be addressed during the formulation of a strategy for the IT-enablement of a supply chain (Williams *et al.*, 2002).

1.3.2 Logistics related Issues

Logistics, which is often considered a subset of SCM has a key role in supply chain management. Realizing its importance, Heskett (1977) had predicted that globalization would have huge impact on the importance of good logistics design and developments within the corporate strategy. The outsourcing of logistics activities to a third party logistics service provider (3PL) is a common phenomenon these days. As IT has the capability to automate many routine logistics activities, Razzaque and Sheng (1998) argue that one of the most important reason for employing 3PL is their ability to support clients with expertise and experience that otherwise would be difficult to acquire or costly to have in house. In logistics outsourcing mutual trust and information sharing motivate the partner companies to collaborate further for mutual benefits (Bagchi and Virum, 1998). Virum (1993) analyzed the primary drivers for an organization to rely on logistics outsourcing and came up with some points in favor of logistics outsourcing. These are: better transportation solutions, cost savings and improved services, need for more professional and better equipped logistics services, development of necessary technological expertise and computerized systems which is beyond the scope of many companies, more flexible processes, simplification of administrative processes, and access to ready made logistics services when entering new markets. However, despite all these advantages of outsourcing two-thirds of the user companies (shipper) experience significant hurdles in logistics alliances (Lieb and Randall, 1996). According to Greco's (1997) survey one of the main reasons for problems in logistics outsourcing is that these decisions are not given the strategic attention that they deserve.

1.3.3 Performance Measurement related Issues

Performance measurement of a supply chain is often not given due consideration in the design and analysis of the supply chains. The impact of good or bad performance of any link of the supply chain is observed on the performance of the entire supply chain (Keebler, 2001). Beamon (1999) has provided a framework for supply chain performance measurement. In a survey by McMullan (1996) the most commonly used performance measures for a supply chain are identified as on-time delivery, customer complaints, back orders, stock outs etc. However, in India there seems to be no serious attempt towards the performance measurement of an integrated supply chain. The case studies and interaction with the managers also suggest that that supply chain performance measurement effort in India is at present targeted only at a small segment of the supply chain.

1.3.4 Miscellaneous Issues

There are various other issues involved for the effective management of a supply chain such as supply chain strategy, organizational changes required, top management commitment etc. McMullan (1996) has on the basis of a survey suggested that many firms will have to change their organizational structure to successfully implement SCM. The amplification of demand variability in the upstream of a supply chain is a common phenomenon, which is more visible in the consumer goods sector. This is known as bullwhip effect. Lee *et al.* (1997) have identified four major causes of bullwhip effect, which are (i) demand forecast updating, (ii) order batching, (iii) price fluctuation, and (iv) rationing and shortage gaming. It is observed and suggested by authors that real time information sharing in the supply chain and improved collaboration among the supply chain partners can effectively control the bullwhip effect (Lee *et al.*, 1997; Lee and Whang, 2000).

1.4 CHARACTERISTICS OF EFFECTIVE SUPPLY CHAIN

Supply chain management concerns diverse areas such as demand forecasting, procurement, manufacturing, distribution, inventory, transportation, and customer services. All these areas may be dealt under strategic, tactical, or operational perspective. Issues like strategic partnership, flexibilities, responsiveness, and supply chain performance are contemporary research issues in the domain of effectiveness of supply chain. In coming paragraph we discuss few characteristics of competitive supply chain.

1.4.1 Supply Chain Agility

Agility is the business-wide capability that embraces organizational structures, information systems, logistics processes, mindsets etc. (Power et al., 2001). Agility is defined as the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety (Figure 1.2).

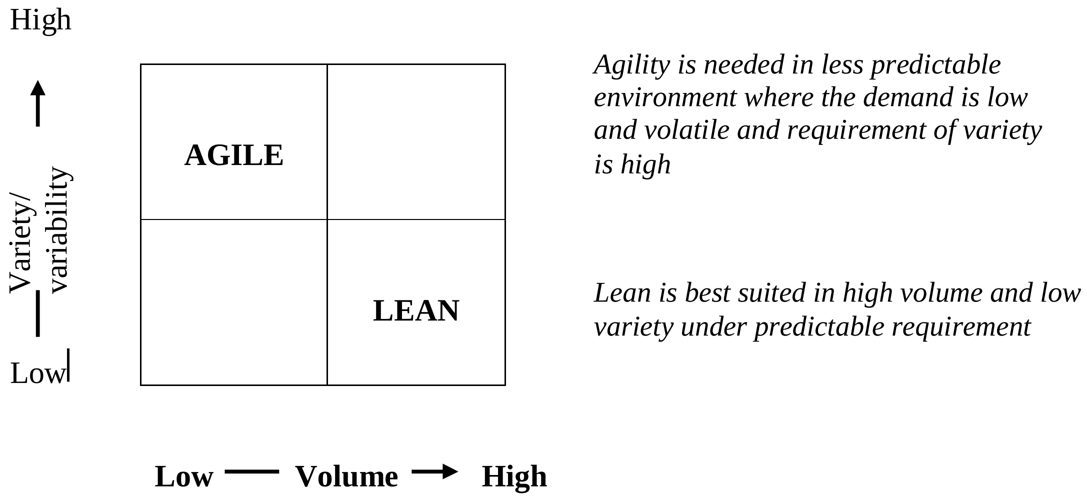


Figure 1.2: Agile or Lean (Adapted from Mason-Jones et al., 2000a)

Thus agility maximize profit through providing exactly what the customer requires and reducing costs while not impeding the ability to meet customer service requirements. On the other hand, leanness will maximize profit through cost reduction and providing service suitable for a level schedule (Christopher, 2000)

The lean and agile paradigms, though distinctly different, can be and have been combined within successfully designed and operated total supply chains (Mason- Jones and Towill, 1999). The Decoupling point represented by ▼ in Figure 1.3 is the position in the material flow streams at which the customer order penetrates.

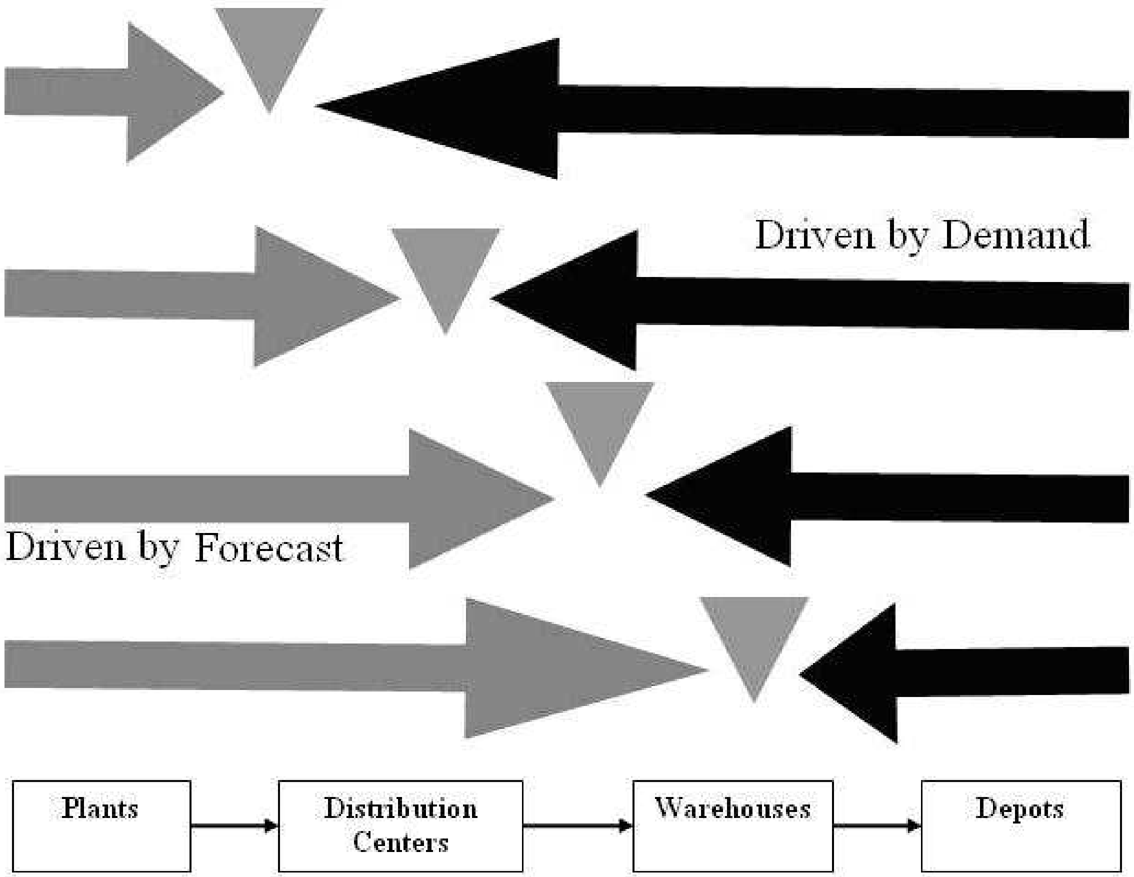


Figure 1.3: Material flow decoupling points (Adapted from Mason-Jones et al., 2000b)

The leagile is a combination of the lean and agile paradigms within a total supply chain strategy by strategically positioning the decoupling point so as to best suit to the need of responding to a volatile demand downstream yet providing level scheduling upstream from the market place (Mason-Jones et al. 2000b; van Hoek et al., 2001).

1.4.2 Supply Chain Integration

In order to achieve lean or agile supply chain, all the entities of the supply chain need to be integrated. The difficulty in achieving a total integration is due to dynamic and conflicting objectives employed by different supply chain partners. However in today's competitive market most companies have no choice; they are forced to integrate their supply chain and engage in strategic partnering (Simchi-Levi et al., 2008). Strategic partnership is one of the important ingredients to facilitate the integration and performance of a supply chain. A general trend characterizing buyer-supplier relationships is a shift from an arm's length relationship to a partnership approach (Lamming, 1986; Ellram, 1990). Literature on buyer-supplier relation describes the advantages of a close collaboration between buyer and supplier along the entire supply chain. Strategic partners share risks and benefits, exchange operational and financial information, and make joint investments in facilities and systems. In that sense, trust becomes a significant factor in the supply chain integration.

1.4.3 Supply Chain Flexibility

A key characteristic of an agile supply chain is its ability to remain flexible to cope-up with the changes in its environment and also within (Vickery et al., 2003; Prater et al., 2001; Olhager, 2003). The performance dimensions of flexibility for a supply chain partner may be broken down into two capabilities: the promptness with and degree to which a partner can adjust to its supply chain speed, destination and volumes (Prater et al., 2001). A supply chain partner's agility is determined by how its physical components (i.e. sourcing, manufacturing and delivery) are configured to incorporate speed and flexibility. As the levels of speed and, more importantly, flexibility increase, the stage of supply chain agility improves. The firm can, to some degree, make up deficiencies in the speed or flexibility of one of the supply chain parts by excelling in the other parts (Garg et al., 2001). For example, the delivery part of supply chain may be inherently inflexible, such as the one found in sea transportation. Supply chain agility may be increase if the firm is able to compensate for these shortcomings by setting up its inbound logistics (i.e. sourcing) or manufacturing operations to be faster or more flexible. Similarly, if the speed in outbound logistics is inflexible, higher speed and flexibility in manufacturing and sourcing could help in compensating for the slow outbound operations (Simchi-Levi et al., 2008).

1.4.4 Responsiveness in Supply Chain

Responsiveness of a supply chain is its ability to cope up with the changes in customer demand and yet remain efficient in its operations. Responsiveness, competency, quickness and flexibility help in improving agility of a supply chain (Christopher 2000; Goh and Ling, 2003). The development of strategies for competing on the basis of agility is crucial for the management of a total supply chain (Power et al., 2001). Towill (1996) expresses this in terms of creating architecture for "seamless supply chain" where territorial boundaries between trading partners are eliminated and they effectively operate as if they are part of the same organization.

1.4.5 Trust in Supply Chain

Trust is perceived as a state of readiness for unguarded interaction with someone or something (Ba, 2001). Trust is frequently defined as a willingness to take risk (Agrawal and

Shankar, 2003) and a willingness to rely on an exchange partner in whom one has confidence. However, in many research works, trust has been more commonly stated as "perceived trustworthiness" or confidence (Agrawal and Shankar, 2003; Handfield and Bechtel 2002) have stated that the primary relational requirement for improved responsiveness is the development of greater levels of trust between purchasing organizations and their suppliers. The nature of trust and the nature of the business transaction often temper the relationships. Trust among the trading partners in inter-organizational relationships improves communication and dialogue and creates common strategic visions (Sahay, 2003).

Now a days supply chain, enabled with latest ICT tools, primarily the internet, provide opportunity for cost reduction while improving the agility and integration of supply chain. But using the internet as a platform for managing the supply chain trading partner inherits a risk of insecure transaction as websites can be counterfeited, identities can be forged and nature of the transaction can be altered. Geographic dispersion of trading partners creates new and unprecedented opportunities for consumer abuse through fraud and deception. The use of digital signature has yet not fully guaranteed that the message has come from the person signing it. This can be due to fact that the institution issuing the signature has inadequate administrative routine (Ba, 2001). Therefore, one of the most prevalent issues in the introduction of e-commerce system along the supply chain is its ability to establish dynamic and flexible structures for buyer-supplier relationships and on-line trust that deterministically drive both parties towards strategic partnerships sand cooperation (Agrawal and Shankar, 2003).

1.5 SUPPLY CHAIN MANAGEMENT IN INDIA

Worldwide interest in supply chain management has increased steadily since the 1980s when organizations began to see the benefits of collaborative relationships. This management concept is however, relatively new in India (Vrat, 1998). Prior to 'liberalization', India has a policy of national sufficiency and non-reliance on imports or foreign economic investments that has designed to protect domestic markets from competitions. Protected tariffs, import quotas, exchange rate controls and regulated licensing for capital goals discouraged innovation, cost reduction and acquisition of technological capabilities, causing inefficiencies, sluggish export performance, and slow economic growth. By the mid 1990s the Indian government had liberalized foreign exchange and equity regulations to encourage foreign direct investment. As the country settled down to the realities of liberalization, there was a quantum leap in economic growth, which was reflected in Indian industries (Sahay et al. 2003). Liberalization efforts also increased disposal income of middle class families by stimulating credit purchases. Indian consumers became more demanding for quality products and services forcing enterprises to enhance product quality, increase variety, shorten product development process and improve services. To remain competitive, Indian industries found that existing supply chain systems were not configured to meet the increasing requirements of consumers in a newly liberalized economy (Kapoor and Ellinger, 2004). Increasing uncertainty of supply networks, globalization of business, proliferation of product variety and shortening of product life cycles have forced Indian industries to look beyond their four walls for collaboration with supply chain partners (Sahay, 2003). With a gross domestic product (GDP) of over US $ 474.3 billions, the Indian Industries spends 14% of GDP on logistics (Sahay and Mohan, 2003). Considering this scenario, it is necessary to study supply chain practices being followed by Indian industries and to suggest areas for improvement.

1.6 MOTIVATION FOR THIS RESEARCH

Enterprises have now realized that management of supply chain is essential for the survival in the global market and so they focused on improving the customer service level, reducing operating expenses and increasing revenue growth by effectively managing their supply chains. Studies have revealed that companies that have completed supply chain project related to performance improvement typically enjoy improvements in individual supply chain functions (Cross, 2000).

Following are some of the ground realities that point out the significance of SCM in current market scenario and motivated to pursue research in this area:

- Leading international journals like *Academy of Management Journal, Assembly Automation, Business process management Journal, California Management Review, European Journal of operation Research, European Journal of purchasing and supply Management, Harvard Business Review, Human Systems Management, IBM Systems Journal, IIE Solutions, Industrial and commercial Training, Industrial management & data systems, Industrial marketing research, Information & management, Information & software Technology, Information management & computer security, Integrated Manufacturing systems, International Journal of Agile Management Systems, International Journal of Information Management, International Journal of logistics management, International Journal of production and operational management, International Journal of physical distribution and logistics management, International Journal* *of production Economics, International Journal of Quality and reliability management,* etc. are exclusively covering various issues related to supply chain.

- Special issues have been published on SCM by reputed journals such as Production Planning and Control, International Journal of Operations and Production Management, IEEE Transactions on Engineering Management, International Journal of Technology Management, etc.
- Seminars and workshops are being organized globally to address the issues related to SCM. A number of international conferences addressing various issues , related to SCM have been held during past few years.
- All over the world companies are streamlining their supply chains and improving their relationship with supplier and customers.
- Companies are focusing on integration of their supply chain activities in order to become more agile.
- Companies are attempting to minimize bullwhip effect by using advanced IT tools

1.7 RESEARCH OBJECTIVES

The main objectives of this research are:

- identification of issues governing enablers and inhibitors for the effectiveness of advanced manufacturing system's supply chain,
- study of supply chain issues in advanced manufacturing systems through a questionnaire based survey,
- development of a framework for the AMT-enablement of supply chain for AMS.
- Categorization of various AMT's according to their uses in Indian enterprises

- to model supply chain performance variables related to integration and agility to capture the effect of integration and responsiveness variables under different market scenario.

1.8 RESEARCH METHODOLOGY

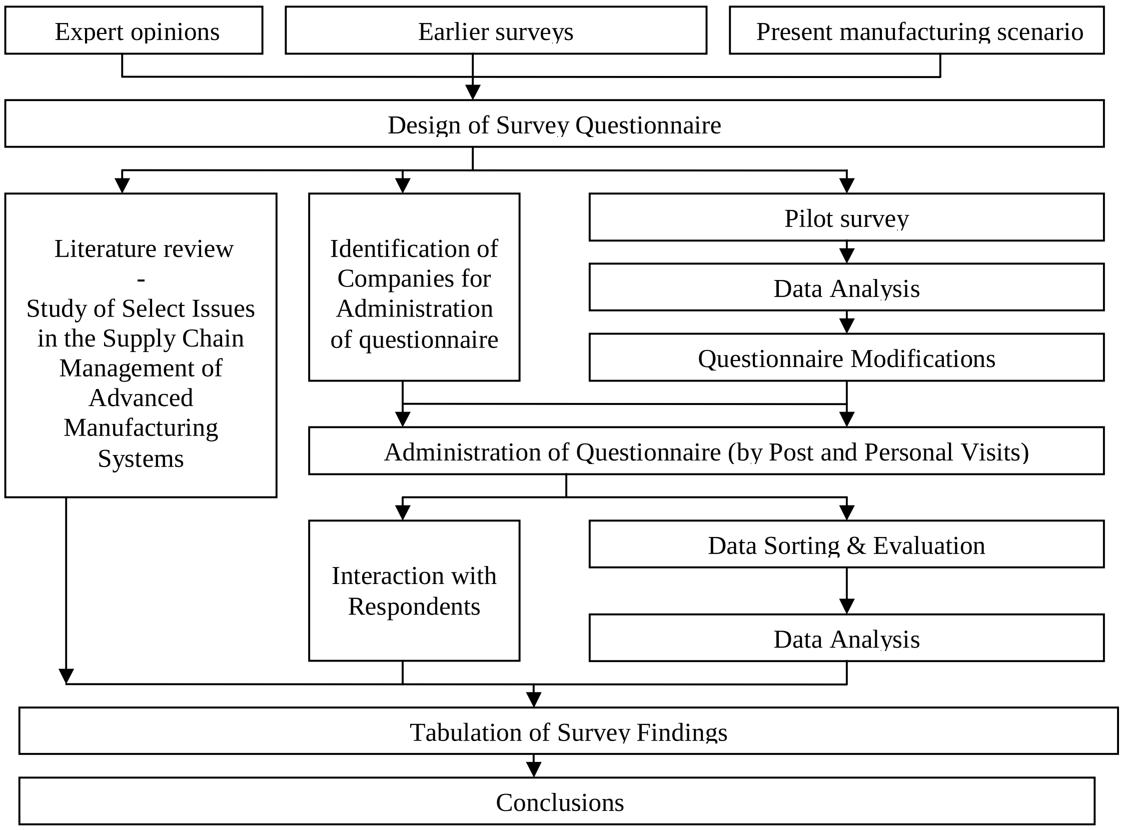


Figure 1.4: Schematic diagram of research methodology

- *Questionnaire-based survey approach:* This is used to gain a broad insight of SCM practices in India (Figure 1.4).
- Various statistical tools have been used to analyze the data obtained from the questionnaire survey. Descriptive Statistics, inferential statistics.

- Regression analysis, gap analysis and cluster analysis has been done on the data related to information sharing and performance measures.
- Interpretive Structural Modeling (ISM) has been developed for Integration and Agility of the Supply Chain Management.

1.9 RESEARCH OVERVIEW

A structured questionnaire was developed for conducting a national-wide survey on select issues of supply chain management of AMS in Indian context. It was developed on a five-point Likert scale. The questionnaire was validated through a pilot survey and necessary modifications have been made to get the required information from manufacturing industries within the purview of this survey.

Results from descriptive analysis of the questionnaire survey have been used to focus on three important issues of supply chain management. These are technology enablement of SCM, Information sharing in SCM and Performance Measurement system in SCM. In Advanced manufacturing systems, aforesaid issues have significant role similar to logistics related issues in FMCG sector.

Synthesis of the research finding helps to develop Interpretive Structural Model for Integration and agility of the Supply Chain in Indian perspective

1.10 ORGANIZATION OF THESIS

The Organization of the research scheme is depicted in Figure 1.5. This is followed by brief description of different chapter, which embody this research.

Chapter 1

It contains an introduction to supply chain management. The growing importance and relevance of supply chain management in today's context have been discussed in this chapter. The issues related to supply chain of the advanced manufacturing system has been discussed. Some of the important characteristics of the supply chain of the advanced manufacturing systems that make it more competitive in the market discussed briefly. The issues related to agility, integration, supply chain performance measure, information sharing have also been discussed. The status of supply chain management being used in manufacturing systems in India has been presented. Motivation of research and objectives of this research have been presented. Finally overviews of the conducted research and the methodologies used for this research have been reported in this chapter.

Chapter 2

It provides the literature review on different aspects of the supply chain such as integration, agility, responsiveness, flexibility, trust, information sharing, and performance measurement system. The literature review on the features and technological requirements of advanced manufacturing system have been also included in the chapter. Though the literature review the limitation and gaps in the contemporary research will also be identified which provide the motivation for the current research work. The chapter presents literature on methodologies used in this research such as Questionnaire survey and Interpretive Structural Modeling (ISM).

Chapter 3

This chapter covers the development of the questionnaire, its structure, source and content validation. The questionnaire was administered in four sectors, namely automobile, machineries, machine tools, and electrical and electronics. A sample size of 1176 was selected for administering the questionnaire. In all 206 valid responses were received resulting in a response rate of 17.51 %. The respondent profile is also analyzed in this chapter. The respondents are categorized as original equipment manufacturers (OEM's) and suppliers, and the observations and results of the survey are reported in this chapter. Results of non-response bias test, factor loading, reliability analysis and descriptive statistics are reported.

Chapter 4

The objective of this chapter is to understand the similarity/ dissimilarity with respect to the issues related to adoption of AMT-enablement between original equipment manufacturer (OEMs) and suppliers, and among different sectors within the Indian. To assess the sectoral nature different hypothesis has been formulated. These hypotheses have been tested using t- test and ANOVA. Based on the results of hypothesis testing, various aspects of sectoral differences have been discussed and inferred.

Chapter 5

This Chapter focused on adoption of Advanced Manufacturing Technologies (AMT) and its effect on supply chain management in India. AMT have been classified into three categories (simple, complex and integrated) for the present analysis. A general conclusion can be reached that Indian firms surveyed have high adoption of simple technologies, are going to adopt complex technologies, and are not yet ready to invest much in integrated technologies. Factor Analysis is used to identify common components among 17 selected AMT that were surveyed. These technologies can be nicely interpreted by four common factors: "Expensive", "production", "Integration" and "quality". Discriminant analysis is used to identify critical benefits of the AMT that contribute significantly to the success of supply chain.

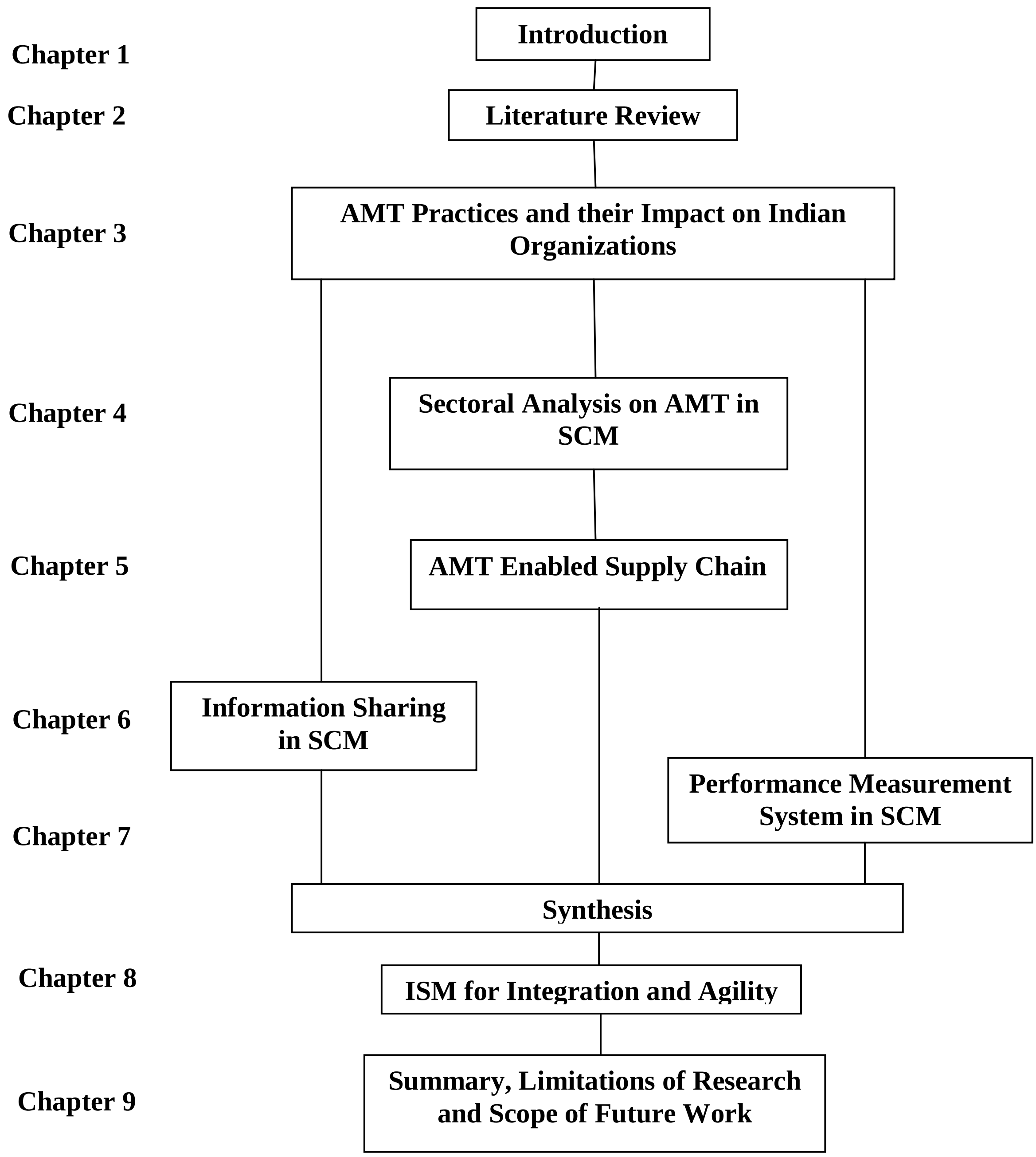


Figure 1.5: Chapter Plan of the thesis

Chapter 6

It presents the issue related to information sharing. This issue has been widely discussed, information sharing with customer and information sharing with supplier both presented with its impact on performance and competitive strength of the enterprises. Inferential statistics like t-test and Pearson correlation coefficient has been used to discuss the results of information sharing in supply chain. The data from the responses has been thoroughly used in this chapter. Different types of information sharing with its relative importance if share with customer and supplier has been presented in this chapter.

Chapter 7

This chapter presents the status of Supply Chain Management performance measures used by respondents in the questionnaire based survey. Different performance measures variables in four major categories have been included in the questionnaire. The respondents have been asked to rate different measures in the Likert scale on the basis of their frequency of use, perceived use value and ease of measurement. Linear regression model has been developed to establish the relationships among the three values of the each variable namely FoU, PUV and EoM. Gap analysis and Cluster analysis has been done to find the relative usefulness of the different performance measure in the sample of Indian manufacturing enterprises.

Chapter 8

Based on the literature review and survey results, different variables of supply chain integration and agility are identified. These variables have been modeled using Interpretive Structural Modeling to provide a framework for the effective deployment of management strategies towards and integrated and agile supply chain. On the basis of driving and dependence power these variable are further categorized as independent, dependent, linkage and autonomous variable. Managerial implications of the results are also discussed in this chapter.

Chapter 9

It contains the summary of the conducted research in this thesis, research findings, key insights from the survey and major implications of this research have also been presented in this chapter. This chapter concludes with the limitations of this research work and directions and scope for further research.

1.11 CONCLUSION

In this chapter, an overview of context related to the research has been presented. The motivation and objectives of the research have also been presented in this chapter. A brief description of research methodology to be used in this research has also been presented. In the research overview, a summary of the entire research reported in this thesis has been presented.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

SCM has become a subject of interest in academicians, consultants and business managers in recent years. The origin of SCM can be traced in the work of Forrester (1965), who, in his industrial dynamics model (widely known as Forrester effect), suggested that five flows of any economic activity namely money, orders, materials, personnel and equipment are interrelated by an information network, which is now called a supply chain. The Forrester has provided a basis for further understanding of dynamics of a supply chain.

SCM has gained attention of academicians, consultants and business managers as it focuses on material, information and cash flow from vendors to customers or vice versa. A key feature of present day business is the idea that it is the supply chain that competes, not companies (Christopher and Towill, 2001), and the success or failure of a supply chain is ultimately determined in the marketplace by the end consumer.

Houlihan (1985) was probably the first researcher who introduced the term SCM (Ganeshan et al., 1999). He stated that SCM goes beyond the boundaries of an organization and links operating decisions in strategic considerations. After Houlihan (1985), numerous other researchers have added to the body of literature by providing concepts, frameworks and empirical studies to help design and manage supply chains.

Prida and Gutierrez (1996) and Tan (2001) have explored the evolution of SCM grew as the manufacturer began to realize the potential of strategic partnerships with their immediate value chain members. Instead of duplicating non-value added activities such as receiving inspection, manufacturers trusted suppliers' quality control by purchasing only from a handful of qualified or certified suppliers (Tan, 2001). Simchi-Levi et al. (2000) has observed that the rapid development in the IT tools for sharing of information have also contributed to the evolution of SCM. The growth of SCM has been noted to take place in three stages.

(i) traditional purchasing role,

(ii) SCM through subcontracting and

(iii) SCM through innovation (Prida and Gutierrez, 1996).

Stevens (1989) was among the first few researchers who developed the strategy for an integrated supply chain. According to him, the companies that consider supply chain during strategic debate would be more successful in terms of the increased market share and lower asset-base.

The modern supply chains are not confined to a particular country or a geographic location; rather these supply chains have now become global. Dornier et al. (1998) have summarized the characteristic of the global supply chain. These are:

(i) substantial geographical distances,

(ii) forecasting difficulties and inaccuracies,

(iii) exchange rates and macroeconomic uncertainties, and

(iv) infrastructure inadequacies

2.1.1 Technology Enablement in SCM

To facilitate the development of supply chain strategies and new sources of competitive advantage, an important input factor for supply chain firms today is their technology strategies and infrastructure. The focus of enterprise systems is shifting from an internal to an external orientation. Liu et al. (2005) claimed that collaborative SCM systems can be supported by enhanced information sharing and collaborative planning among partners, and are supported primarily through mechanisms such as information integration and process coordination. In the digital era, an integrated system of information such as enterprise resource planning (ERP) that treats the functional and different business units of a firm as a cohesive whole would definitely help businesses to excel in achieving the competitive priorities set by supply chain firms. Madu and Kuei (2004) also noted the development of ERP II – a web-enabled application of ERP. ERP II enables supply chain enterprises to operate with cleaned-up data rather than a haphazard collection of data, thereby improving their business processes. In addition, Rosenbaum (2001) also noted that information communication technology (ICT) such as the internet, which connects different actors along the supply chain, and three-dimensional computer-aided design (3D CAD) for interacting with customers and suppliers, have an enormous impact on how companies manage their supply chains. Meanwhile, an enterprise information portal (EIP) is viewed as a knowledge community Kakumanu and Mezzacca (2005) stressed that EIP provide delivery mechanisms that overcome information barriers between technical, functional, and cultural silos that limit the internal creation and development of competitive advantages within organizations.

Technology adoption and organizational conditions are critical factors that affect knowledge creation in a supply chain. Cassivi (2006) analyzed how e-collaboration tools affect different partners along the supply chain, and suggested that they play an important role in facilitating access to information, which affects knowledge creation capabilities, and assisting in the design of flexible supply chains. Kodama (2005) examined the dynamism of the knowledge creation process at Fujitsu Ltd. The results show that new product development in a high-tech field requires the merging and integration of different technologies to network strategic communities inside and outside the company in order to share and transfer and thus create knowledge. Based on a survey of 105 R&D partnerships in the global telecommunications industry, Feller et al. (2006) suggest that a higher overall use of knowledge transfer mechanisms among supply chain partners leads to better learning results, and in turn, knowledge creation.

2.1.2 Divided Functional Approaches in SCM Conceptualization

While the meaning of SCM is still under debate, SCM in its broadest sense, is increasingly seen as a management philosophy (Rose, 1998; Chandra and Kumar, 2000) that embodies a set of distinctive management principles, assumptions and practices (Dean and Bowen, 1994). In the both the theoretical and empirical literature, diverse views on exact elements of this management approach exist. Tan (2001) noticed that some researchers have conceptualized SCM from the perspective of purchasing and supply functions and defined SCM as a set of decision or activities of purchasing and supplier management. Others have considered it from the perspective of logistics and transportation functions and defined it as the transportation functions and defined it as the management of materials, products and information flows from source to user (Thomas and Griffin, 1996; Copanico, 1997). The global supply chain forum has defined SCM as the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and stakeholders (Lambert et al., 1998a).

2.2 AN OVERVIEW OF DEFINITIONS OF SUPPLY CHAIN AND SCM

Besides the definitions given in the earlier section, a number of other definitions, presented by various authors, are available in the literature on supply chain management. However, unanimity on these definitions among authors hardly exists. Giunipero and Brand (1996) have noted the development of few typologies of SCM. Thereafter, most definitions have moved beyond the simple flow of goods perspective and now consider the integrative nature of supply chains. For example, Mabert and Venkataraman (1998) incorporate the product design and process in their definitions of supply chain. Alber and Walker (1998) have added the critical element of financial flows through the supply chain. Tyndall et al. (1998) have given a more comprehensive definition of SCM and incorporated the flows of materials, cash, and information in their definition. Ballou et al. (2000) have addressed integration at three levels within a function, across functions, and across organizations. Ayer (2001) has focused on the flows and has added a knowledge dimension in his definition by stating that it is also the deployment of the intellectual capital.

A classification of various definitions of SCM, on the basis of their focus area, has been shown in Table 2.1.

Table 2.1: Focus Areas of SCM Concepts

S.N.	SCM Focus Area	Remarks
1	Flow of material and logistics	Focus is on flow of goods and logistics
2	Flow of information	Information sharing among trading partners is a part of all definitions
3	Integration	This includes trust, strategic partnership and customer relationship
4	Agility	This covers agility, flexibility, and responsiveness in a supply chain
5	Comprehensive	Comprehensive definition covers miscellaneous aspects with all four areas mentioned above

On the basis of the focus area as discussed in the Table 2.1, various definitions of SCM have been classified in Table 2.2.

Table 2.2: Definitions of SCM

S.N.	References	Definitions
Focus: Logistics and Flow of Material		
1	Alber and walker(1998)	Supply chain management (SCM) manages the global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash.
2	Behnzhad (2000)	SCM refers to the management of activities that procure raw and final products, and deliver the products through a distribution system to the end-user.
3	Lambert et al. (1998b)	A supply chain is the alignment of firms that bring products or services to market.
4	Shankar and Jaiswal (1999)	Supply chain is the network of autonomous and semi-autonomous business entities, which are involved through upstream and downstream linkages in the different processes and activities that produce value in the form of physical products and services in the hands of the ultimate customers
5	Simchi-Levi et al.(2000)	SCM is a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide cost while satisfying service level requirements.
6	Turner (1993)	SCM is a technique that looks at all the links in the chain from raw material supplies through various levels of manufacturing to warehousing and distribution to the final customer.
Focus: Flow of Information		
7	Aitken (1999)	A network of connected and interdependent organizations mutually and co- operatively working together to control, manage and improve the flow of information and materials
8	Berry et al.(1995)	Supply chain is a system whose constituent parts include material supplies, production facilities, distribution services and customer lined together by feed forwards flow of information.

S.N.	Reference	Definitions
9	Christopher (1998)	A supply chain is a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users.
10	Evans et al. (1995)	SCM is used to describe the management of materials, suppliers, production facilitates, distribution services and customers linked together via the feed forward flow of information and feedback flow of information.
11	Thomas and Graffin(1996)	SCM is the management of material and information flows both in and around facilities, distribution services and customers, which are linked together by the flow of goods and information.
12	Towill et al (1992)	The supply chain is commonly regarded as a sequence of material suppliers, production facilities, distribution services and customers, which are linked together by the flow of goods information.
Focus: Functional and Process integration		
13	Ballou et al.(2000)	A supply chain may be defined as all those activities associated with the transformation and flow for goods and service, including their attendant information flows, from sources of raw material to end users. Management refers to the integration of all these activities, both internal and external to the Firm. They address integration at three levels: within a function, across functions, and across organizations
14	Beamon (1998)	A supply chain may be defined as an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in order to (1) acquire raw materials, (2) Convert these raw materials into specified final products and (3) deliver these final products to retailers. This chain traditionally characterized by a forward flow of materials and a backward flow of information.
15	Ellram and cooper 1993)	SCM is an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer.
16	Houlihan (1988)	SCM covers the flow of goods from supplier through manufacturer and distributor to the end user
17	Lambert cooper (2000)	SCM is an integration of key business process from end user through original suppliers that provides products, services, and information that add value for customers, and other stakeholders.

S.N.	Reference	Definitions
18	Lummus and Alber (1997)	A supply chain is the network of activities through which material flows. These entities may include suppliers, carriers, manufacturing sites, distribution centers, and customers.
19	Norina and Bailey (2001)	SCM can be defined as an integration of each chain member's organizational activities in order to achieving system- wide objective
20	Stevens (1989)	A supply chain is a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via a feed forward flow of materials, a feedback flow of information and flows of cash and resources
Focus: Supply Chain agility		
21	Mason-jones et al.(2000a)	The businesses in the agile supply chain must be able to cope with market demand and they should also be able to exploit its volatility for their strategic advantage.
22	Christopher and Towill (2000)	Agile supply chain requires minimum total lead- times defined as the time taken from a customer raising a request for a product or service until it is delivered.
23	Towill(1997)	A seamless supply chain is lean enterprise, which operates with minimum entropy. All the players think, communicate, and act as one so that the total chain benefits through achieving a high customer service level.
24	Christopher, 2000; Goldman et al., 1995; van Hoek al., 2001	To be truly agile, a supply chain must possess a number of distinguishing enable attributes such as marketing/customer sensitivity, cooperative relationship, process integration, and information integration.
25	Yusuf et al.(2003)	The agile chain has a stronger impact on competitiveness' because it enables mobilization of global resources to track evolving changes in technology and material development. as well as market and customer expectations
26	Narasimhan and Das(1999)	A key determinant of the ability of supply chain to make rapid changes is the selection, development and integration of suppliers with appropriate capabilities
27	Power et al.(2001)	The management of agile supply chain uses technology to promote productivity, new product development and customer satisfaction.
28	Christopher et al.(2004)	The idea of agility in the context of supply chain management focuses around "responsiveness."

S.N.	Reference	Definitions
Miscellaneous		
29	Ayers (2001)	SCM is more than the physical movement of goods from 'earth to earth' and is also the information, money movement, and the creation and deployment of intellectual capital.
30	Beamon (1999)	A supply chain is ant integrated process where raw materials are transformed into final products and delivered to customers.
31	Chopra and Meindl (2001)	A supply chain consists of all stages involved, directly or indirectly in fulfilling a customer request. The supply chain not only includes the manufacturers and suppliers, but also transporters, warehouses, retailer, and customers.
32	Cooper et al.(1997)	The integration of business processes across a supply chain is what we are calling SCM
33	Fawcett and Magnan (2001)	SCM is the collaborative effort of multiple channel members to design, implement, and mange seamless value added processes to meet the real needs of the end customer. The deployment and integration of people and technological resources as well as the coordinated management.
34	Ganeshan et al.(1999)	A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products to customers.
35	Harland (1996)	SCM may be defined as managing business activities and relationship (1) internally within an organization, (2) with immediate suppliers, (3) with first and second tiers suppliers and customers along the supply chain, and (4) with the entire supply chain.
36	Kalakota and Whinston (1997)	A supply chain is a collection of interdependent steps that, when followed, accomplish a certain objective such as meeting customer requirements.
37	Lee and Billington (1992)	A supply chain is a network of facilities that performs the functions of procurement of material, its transformation to intermediate and finished product, and its distribution to end customers.
38	Lummus and Bokurka (1999)	A supply chain links all the activities involving raw material sourcing, parts manufacturing, assembly, warehousing, inventory tracking, and delivery to customer.
39	Mabert and Venkatraman (2000)	Supply chain is the network of facilities and activities that performs the functions of product development, procurement of materials, from vendors, the movement of materials between facilities, the manufacturing of products, the distribution of finished goods to customers, and after market service for sustainment.

S.N.	Reference	Definitions
40	Mentzer et al. (2000)	SCM refers to the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across business within supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole.
41	Metz (1998)	SCM is a process-oriented, integrated approach for procuring, producing, and delivering products and services to customers.
42	Monczka and Morgan (1997)	Integrating supply chain is about going from the external customer and then managing all processes that are needed to provide the customer with value in a horizontal way.
43	Monczka et al.(1994) and Monczka et al.(1998)	SCM is a concept whose primary objective is to integrate and manage the sourcing, flow and control of materials using a total systems perspective across multiple functions
44	Poirier (1999); Poirier and Bauer (2001)	SCM refers to the methods, systems, and ownership that continuously improve an organization's integrated processes for product and service design, sales forecasting, purchasing, inventory management, manufacturing or production, order Management, logistics, distribution, and customer satisfaction.
45	Quinn(1997)	A supply chain is all activities associated with moving goods from the raw material stage through to the end user. This includes sourcing and procurement, production scheduling, order processing, inventory management, transportation, warehousing, and customer service.
46	Swaminathan and Tayur (2003)	SCM is the efficient management of the end-to-end process, which starts with time when it has been sold, consumed, and finally, discarded by the consumer. This complete process includes design, procurement, planning and forecasting, production, distribution, fulfillment, after-sales support, and waste disposal.
47	Tyndall et al.(1998)	SCM is the coordinated flow of materials and products across the enterprise and with the trading partners. It also includes the management of information flow, cash flow, and process/work flows.

After analyzing the above definitions, following issues has been observed and considered important in the definition of supply chain management:

(i) Supply chain integration

(ii) Information sharing

(iii) Lead time reduction

(iv) Service level improvement

(v) Trust development among trading partners

(vi) Delivery speed

(vii) Data accuracy and

(viii) Supply chain performance measures

2.3 INTEGRATION RELATED ISSUES IN SUPPLY CHAIN

It is quite common today for descriptions of supply chain management to include the term 'integrated' or 'integration' in discussing how relationships should be built across companies. While there is no precise definition of supply chain integration, both practitioner and academic literature make common use of the term. As defined by Ellram and Cooper (1993), supply chain management is "an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer." Monzcka and Morgan (1997) stated that "integrated supply chain management is about going from the external customer and then managing all the processes that are needed to provide the customer with value in a horizontal way." Lummus and Vokurka (1999) in a summary definition of supply chain management offered that "... supply chain management coordinates and integrates all of these activities into a seamless process." They also discussed the total integration required for managing the supply chain.

Several authors within the field of supply chain management have proposed definitions for integration (Pagell, M. 2004; Vickery, et al., 2003). In his 2004 study of factors that enable and inhibit integration, Pagell (2004) proposes the following definition:

Integration is a process of interaction and collaboration in which manufacturing, purchasing, and logistics work together in a cooperative manner to arrive at mutually acceptable outcomes for their organizations.

Naylor et al., (1999) stated that the goal of an integrated supply chain is to remove all boundaries to ease the flow of material, cash, resources, and information. Van Donk and van der Vaart (2005) suggested that removing barriers (or boundaries) can be achieved by developing integrated activities in a number of areas (scope) and with a certain intensity (level) in each area. They looked at four logistical areas as dimensions of scope including flow of goods, planning and control, organization, and flow of information. The level of integration was measured by the extent of integrative activity developed.

Integration appears to be viewed from many perspectives. There is widespread support for the concept of integration backwards from customers to suppliers (Trent and Monczka, 1998; Frohlich and Westbrook, 2001; Ragatz, et al., 2001; Narasimhan and Das, 2001; Morgan and Monczka, 1996). Purchasing serves as an integrating mechanism and plays a key role in aligning supplier performance with the firm's competitive priorities.

Integration has also been viewed from the downstream side of the supply chain (forward integration), including the flow of material from manufacturers and logistics providers to end customers. This concept has been studied from both the logistics and customer perspectives by several authors. Romano (2003) proposed that logistics processes are a key area for integration between firms. Christopher and Towill (2002), Childerhouse and Towill (2002) and Lee (2002) all focused on customer integration through reductions in demand uncertainty and development of market-specific strategies.

Integration is not only important between firms, but also within companies. Research along two dimensions indicates its importance. The first is the integration of processes within and across firms through the use of information flows. Vickery et al. (2003) suggest that integrated information technologies are key to supply chain integration. They included both inter-firm electronic data exchange, but also intra-firm through Material Requirements Planning (MRP) systems. Other research on supply chain integration involves social interaction within and between firms. Cousins and Menguc (2005) found that increased levels of interaction, through communication, regular meetings, and other team activity improved supply chain integration.

Because of the importance of external supply chain integration (Hendricks et al., 2007), the researchers analyze its relationship to other strategies. Many studies have taken the first steps in exploring linkages between supply chain integration and other strategies such as diversification (Narasimhan and Kim, 2002), materials flow (Childerhouse and Towill, 2003), information systems (Kim and Narasimhan, 2002; Hendricks et al., 2007), socialization (Cousins and Menguc, 2006). However, there is a missing link between external supply chain integration strategies and order winning strategies. It is the interest of this paper to fill that existing gap.

First, high integration among partners in supply chains can turn into more responsive firms to face volatile demand due to increased information visibility and operational knowledge (Kim, 2006). Secondly, highly integrated supply chain partners have the potential to decrease net costs of doing business and total delivered costs to customers (Swink et al., 2007).

Information sharing enables the chain members to capture, store, and provide information required for ensuring effective decision making (Simatupang and Sridharan, 2002). The chain members become able to gain adequate visibility to monitor and control the progress of products as they pass through each process in the supply chain. This activity covers data acquisition, processing, representation, storage, and dissemination of demand conditions, end-to-end inventory status and locations, order status, cost-related data, and performance status. Visibility of key performance metrics and process data enables the participating members to elicit the bigger picture of the situation that takes into account important factors in making effective decisions. Several criteria, such as relevancy, accuracy, timeliness, and reliability, can be used to judge the quality of information sharing. Advanced information technology such as decision support systems, enterprise resource planning, the internet can be used to convey up-to-date data about demand planning, product movements, workflow, costs, and performance status.

Information sharing serves as a glue that integrates all the elements of collaboration. What makes information sharing valuable to the chain members is ultimately the ability to make better decisions and take actions on the basis of greater visibility. Visibility should inform action and that action becomes visible if the chain members understand better the underlying principles that link integrated information and performance drivers. Information sharing thus generally facilitates decision synchronization through providing relevant, timely, and accurate information required to take effective decisions about supply chain planning and execution. It enables participating members to make use of integrated information to help fulfill demand more quickly with shorter order cycle times (Fisher, 1997).

The current global business arena has become highly competitive and competitiveness has become a major focus area of firms and companies across the globe (Porter, 1990; IMD, 2006; WEF, 2007; Pillania, 2007; Pillania, 2008). Business organizations across the world are under increasing pressure than ever to stay dynamic and responsive in all their competitive frontiers. Indian manufacturing companies have realized the need for elevating traditional procurement function to modern strategic sourcing for value addition across the supply chain. Sourcing costs represent 40 to 80 percent of the cost of goods sold, and 30 to 50 percent of revenues – a ratio that has remained constant in most industries for many years. Companies excelling in strategic sourcing save almost 10 to 20 times as much as it costs to operate their sourcing operations. The effort required to reduce 10 percent of the sourcing cost is much less than gaining similar amount of revenue (Chopra and Meindl, 2003). Strategic sourcing includes a wide range of activities namely creating an overall strategy for sourcing, evaluating and selecting suppliers, procuring materials/services and managing supplier relationships (Anderson and Katz, 1998). Strategic sourcing is increasingly seen to be a business capability of firms. Sourcing if properly structured can effectively combine the core competencies of a given firm with the skills and capabilities of its suppliers. Sourcing decisions are vital for any organizations that want to leverage on its core competencies and outsource other activities in order to gain and retain competitiveness.

The following sections outline the literature support for the importance of supply integration and the performance measures that might indicate the benefits of integration. The work of Frohlich and Westbrook (2001) is the most comprehensive evidence of supply chain integration as a specific strategy followed by manufacturers. They show evidence of the level of integration and the direction of that integration (toward suppliers or toward customers). They also demonstrate that those firms that are outward-facing, choosing to act on supply chain integration, had the highest level of performance improvements. The outward-facing group grasped the importance of supply chain integration and also incorporated it into their operation.

Table 2.3: Issues in Integration of Supply Chain

S.N.	Authors	Issues
1	Dore (1983)	Stresses the role of culture in subcontracting relationships.
2	Lamming (1986)	States four stages of buyer-supplier relationship; Traditional model, stress model, resolved model, and Japanese model, and classifies supplies into three classes, & discusses the influence of new technologies and operational practices on buyer- supplier relationship.
3	Sako (1992)	Highlights the role of goodwill and trust in Japanese subcontracting
4	De Toni, et al. (1994)	Analyze the critical aspects of service in modern supply transaction and show by means of case study, some important organizational effects of buyer-supplier interactions in the area of service provisions.
5	Helper and Sako (1995)	Discuss how long term closely linked relationship have performed, advantages for automakers and their suppliers in both USA and Japan.
6	Harland (1996)	Comprehensively discusses supply network strategies through a case of health suppliers & providers an extension of operation strategy elements to supply network strategies such as price, delivery speed, flexibility, product quality etc.
7	Stuart (1997)	States that most of the evolved relationships cover buyer's perspective and reason for failure of relation is not focusing on supplier' perspective.
8	Nielson (1998)	Describes the concept of closeness and identifies role closeness plays in successful partnering.
9	Carter et.al (1998)	Shows through his empirical study findings that which actions of buyer are unethical.
10	Roberts and Mackay (1998)	Discuss the role of e-commerce to support buyer-supplier relationship in supply chain.
11	Bensaou, (1999)	Describes how USA and Japanese firms balance their portfolios of relationships and states how differently a firm should manage one type of relationship from another type of relationship.
12	Carr and Pearson (1999)	Conclude through their empirical study finding that which actions of buyer are unethical.

13	Nellore and Taylor (2000)	Discuss the method of selecting suppliers & states how to work with suppliers.
14	Cox (2001a) and (2001b)	Describes how to achieve a better deal & how to find ways to transform the current power relationship between buyers and suppliers such that buyers can achieve more effective value and achieve leverage in the value chain.
15	Williams et al. (2002)	Consider e- supply chain as adaptable to change with contractual and partnership relationship.
16	Croom and Johnston (2003)	Conclude through empirical study internal customer service improvement as an important issue for the success of e-procurement deployment in e-supply chain.
17	Pagell, M. (2004),	Describes eight alignments reflecting positive interrelationships between manufacturing and supplier-selection strategies. Each alignment indicates performance information needed. For examples, top executives express the need to have information on profitability, customer relation, and quality of work life under the following circumstance – management representing a strategic criterion for supplier selection and quality reflecting a manufacturing strategy
18	Sachan and Datta (2005)	They support an increased use of participant observation in qualitative logistics research, particularly when investigating interorganizational aspects. The analysis highlights values, general limitations and challenges of using participant observation in logistics.
19	Bagchi et al.(2005)	Describe the relationship of collaboration and integration, as the terms are in some cases used interchangeably and truly, much of the supply chain collaboration is aimed towards integrating operations across firms
20	Mollenkopf and Dapiran, (2005a)	Some do not consider SCI as part of their job, others balance between being pure “resource providers” and taking the riskier role of “supply chain designers”. The analysis of the roles LSPs can play in supply chains enriches the understanding of the SCI phenomenon.
21	Mollenkopf and Dapiran, (2005b)	Describes that some Australian and New Zealand firms who are operating at world-class levels with respect to logistics/supply chain capabilities. The majority of firms, however, still focus their efforts on internal logistics integration issues, compared with external integration issues. A comparison of industry groups shows that the motor/transport and the chemicals/petroleum sectors perform the best, while there is much room for improvement in the food, clothing/textile and primary industry sectors.

22	Sahin and Robinson, (2005)	They focused on traditional communication methods, information sharing within a firm, and information sharing between firms, and supplier development.
23	Zailani and Rajgopal (2005)	They point out the difficulties of drawing general conclusions on integration because of dissimilarities in different sectors.
24	Cagliano et al. (2006)	Highlight the adoption of e-commerce in supply chains that simultaneously affected by two contextual meta-variables: external pressure, which is influenced by supply chain structure, demand and industry characteristics; and internal readiness, which is influenced by IT, organizational and buying need characteristics..
25	Cousins and Menguc (2006)	Their results weakly support the hypothesized positive relationships of collaboration and performance in the chosen cross-border context. They conclude that experience in cross-border supply chain operations does not guarantee success in supply chain management. However, those companies with large export volumes, implying frequency and leveraged resources in operations, seemed to be better able to collaborate for successful outcomes.
26	Germain and Iyer, (2006)	Downstream integration predicts logistical performance only when internal integration is high" also offer evidence that SCI impacts first on chain performance which, in turn, impacts on overall performance: "The effect of integration on financial performance appears to be transmitted through logistical performance"
27	Kim, (2006a)	Advocate that companies applying this strategy will notice significant operational improvement
28	Kim, (2006b)	Advocate that an integrated supply chain management system has significant impact on the organizational performance. Thirteen research questions were formed and used to guide this investigation of such impact.
29	Gripsrud et al. (2006)	Supply Chain Integration impacts first on chain performance which, in turn, impacts on overall performance: "The effect of integration on financial performance appears to be transmitted through logistical performance"
30	Kannabiran and Bhaumik (2007)	They explore the critical distribution practices of supply chains that make supply chains agile. Collaborative distribution, order commitment, distribution flexibility and inventory management are the key SCM distribution practices associated with agile supply chains, and have significant impact on organizational performance.

31	Power and singh (2007)	They explore potential benefits from improved coordination constrained by the perceived costs, and risks, of transition to new structural forms. The reported the implication for practice that increases use of Internet technologies creates substantial pressure to invest in organizational change. The attractiveness of investing in technologies that place managers in a position where they need to promote organizational change in order to extract adequate returns creates a significant dilemma. On the one hand Internet technologies enable extensive sharing and integration of data among trading partners, but at the same time they create conditions requiring managers to embrace fundamental organizational change in order to leverage the potential of such integration.
32	Swink and Robinson, (2007)	They suggest that specific supply chain characteristics need to be balanced by selecting a coordination mechanism that uses information optimally to support the material flow.

Pagel (2004) goes one step beyond the Frohlich and Westbrook model of arcs of supply chain integration to prescribe actions that facilitate or hinder integration. He found that organizational structure that encourages the flow of goods and services, cultures that encourage openness and teamwork, mechanisms that improve open communication (specifically through cross-functional teams and job rotation based on proximity), well-designed measures and reward systems, and consensus between functional and strategic goals are all important to the integration of operations, purchasing, and logistics.

2.4 AGILITY RELATED ISSUES IN SUPPLY CHAIN

Agility means being able to reconfigure operations, processes and business relationships efficiently, while at the same time flourishing in an environment of continuous change. Companies, and this includes automotive suppliers, need to open their collective minds to a paradigm shift in how they design, manufacture and market their products. Cooperation amongst suppliers must improve to support the need for quick decision making and these suppliers must work together to achieve the overall goal of improving manufacturing. There have been three major phases or paradigm shifts of industrial production in the modern world (Womack and Jones, 1990) and each phase was brought in by an area of the world, which mastered its implementation. Craft production was mastered and dominated by Europe. Mass production was mastered and dominated by the USA and lean / JIT production has been mastered and dominated by the Japanese. Agile production, the next phase in manufacturing, would appear to be the next requirement for world-class manufacturing performance and a necessary requirement for synchronous supply.

However, a large number of Indian manufacturing Enterprises operate with poor forecasting and planning systems and operate with long cycle times. They also can have problems with unreliable inventory control systems, with no stock tracing and poor cost control. This can lead to excess obsolete stock and eroding customer service levels (Sahay et al., 2003).

In recent years, there has been an increase in the development of new theories in this area; many empirical studies have been conducted. Researchers and practitioners have struggled in the last two decades with the question of what is the best strategy concerning suppliers (Talluri et al., 2006) and customers (Gassmann et al., 2006). Empirical evidence suggests that most successful manufacturers seem to be those that have carefully linked their internal processes to external suppliers and customers in unique supply chains (Frohlich and Westbrook, 2001; Mollenkopf and Dapiran, 2005a).

2.5 INFORMATION SHARING AND TECHNOLOGY- RELATED ISSUES

The integration and optimization of information flow is one of the core concerns of SCM (Copper et al., 1997; Evans and Worsted, 1997; Durocher and Kilpatrick, 2000; Lee and Whang, 2000; Moberg et al., 2002). Regarding effects of information sharing on supply chain performance, Lin et al (2002) have observed that greater the information sharing among the firms, the lower the total cost, the higher the order fulfillment rate, and shorter the order cycle time. Lau et al. (2002) have proposed a framework for investigating that the levels of benefits by sharing information vary with for different players involved in the supply chain.

2.5.1 Types and Levels of Shared Information

The shared information normally relates to: inventory level, sales order status, sales forecast, production/delivery schedule etc. Lummus and Vokurka (1999a), and Lee and Whang (2000) have identified the types of information being shared among the supply chain partners.

On the other hand, Seidmann and Sunderrajan (1998) have identified four levels of information sharing among the organization namely order information exchange, operational information exchange, strategic information sharing, and strategic and competitive information sharing.

How to sharing these information in a supply chain is another issue, which needs coordination among the supply chain partners. Shaw (2000) has suggested three types of coordination (listed in order of increasing need for partnerships and commitments for supply chain information sharing. These are:

2.5.1.1 Simple Information Exchanges

It is the most common type of coordination between channel partners. It is typified by the vendors and their customers passing each other's data unique to their business.

2.5.1.2 Formulated Information Sharing

It is a type of coordination, in which an organization provides its supplies with demand parameters and priorities, or a formula, to guide restocking. For example, Wal-Mart provides its major suppliers with its sales data and re-stocking algorithms. Then its suppliers decide the schedules based on the shared information.

2.5.1.3 Modeled Collaboration

It involves sharing operational models between two supply-chain partners so that each has a real-time view of the other's capability, factory load, on-hand inventory, and committed orders. As an example, a component manufacturer shares its production plans and a simulation model of its production lines with its customers. The customer then can use the model and decide its orders and their timing, information that can be added to the production plan by the customers.

Lau et al. (2002) have proposed a systematic framework for investigating the impacts of sharing production information on the supply chain performance. It is observed from this framework that the levels of benefits by sharing information vary with different players involved in the supply chain.

2.5.2 Incentives of Information Sharing

Many authors (e.g. Munson et al., 2000; Ballou et al., 2000; Feldman and Muller, 2003) have suggested that incentives should be provided to the supply chain partners for long-term collaboration and information sharing. Ballou et al. (2000) have discussed these incentives and noted that a bigger partner can support the smaller partners in the following ways: (i) by providing status of the preferred partner in the supply chain, (ii) by providing training, information or problem solving assistance to the suppliers, and (iii) through another form of incentive as the use of referent power. Here the bigger partners may allow the small partners to use their brand image (e.g."Intel Inside") for their benefits. In terms of financial incentives, some large companies have set example by subsidizing the EDI start-up costs of their small trading partners(Munson et al., 2000). However, supply chain partners often behave opportunistically and provide incomplete and false information to other partners in the real life situations (Feldman and Muller, 2003).

2.5.3 Bullwhip Effect in Supply Chains

In the process of information flow in a supply chain, information distortion in the form of upward demand amplification is a common phenomenon in a supply chain. Fluctuations in demand are magnified as the orders propagate upstream through the supply chain. This process is commonly known as bullwhip effect (Lee et al., 1997a and 1997b). This effect increases variability which leads to excessive inventory, poor customer service, lost revenues, misguided capacity plans, and missed production schedules in the chain (Lee et al., 1997a). Many authors (e.g. Le et al., 1997a and 1997b; Chen et al., 2000; Franso and Wouters, 2000) have done considerable research in the area of Bullwhip effect. Lee et al. (1997a, 1997b) have explored the causes of bullwhip effect.

2.5.4 Role of IT in Supply Chain Information Sharing

Powell and Dent-Micaleff (1997) define IT as any form of computer-based information systems, including mainframe as well as microcomputer applications. The computer-based information system does not exclude users of such a system or the methods of developing information systems. With these broad understanding of IT, not only hard-and software system's influence on supply chains can be analyzed, but the methods of their use as well. Porter and Miller (1985) have noted that with the use of IT, organizations can provide a much higher value to the customers. An integrated set of IT not only eliminates many redundant processes but also provides opportunities for coordinating and integrating many disparate processes.

Table 2.4: Benefits of IT in SCM

S N	Remarks	Reference
1	IT plays the role of a facilitator in SCM	Lee and Whang (2000)
2	IT assists in the integration and coordination among the supply chain members	Metz (1998), Spokman et al.(1998), Lancioni et al (2000), Garcia-Dastugue and Lambert (2003)
3	Assists in making good operational planning and strategic decisions.	Chopra and Meindle (2001), Gunasekaran and Ngai (2003)
4	Allows information to share on a real time basis which leads to increased efficiency and customer service.	Kumar (1996), Kwan (1999), Lee and Whang (2000), Zhao and Xie (2002)
5	Effective coordination of logistics activities	Bowersox et al. (1989), Lewis and Talalayevsky (1997), Tan (2001), McLaughlin et al (2003),
6	Competitive advantage to user firms	Sanders and Premus (2002)
7	Improved cost, lead times, quality and product development	Sanders and Premus (2002)
8	Helps in e-Business	Swaminathan and Tayur (2003), Gunasekaran and Ngai, (2004)
9	Allows to share information on a real time basis which leads to the reduction of bullwhip effect	Lee et al. (1997a and 1997b) Simchi-Levi et al. (2008)
10	Through internet, IT creates new avenues in traditional supply chain	Swaminathan and Tayur (2003)
11	IT is useful in purchasing and inventory management	Presutti (2003), Lancioni et al. (2003)
12	Useful in customer service across the supply chain	Lancioni et al. (2003)
13	Knowledge management in SCM	Spekman et.al (2002), Gunasekaran and Ngai (2003)

Simchi-Levi et al. (2008) have outlined the main roles of IT in SCM. These are:

- Collect information on each product from production to delivery or purchase point, and provide complete visibility for all parties.

- Access any data in the system from a single-point-of-contact.
- Analyze, plan activities, and make trade-offs based on information from the entire supply chain.

Various researchers have made some remarks about the use of IT in SCM. These observations have been summarized in Table 2.4

2.5.5 IT Tools in Managing Supply Chains

The common IT tools, which are being used in a managing, a supply chain, are: Intranet, Extranet, Internet, Electronic Data Interchange (EDI), Bar Coding, Enterprise Resource Planning (ERP), and SCM Software. Besides these commonly used tools, other miscellaneous tools such as smart card, global positioning system (GPS) etc have also been used in the management of supply chains. Through any one of these or a combination of these advanced IT tools can be used for the IT-enablement of a supply chain, the Internet based technologies such as intranet, extranet and Internet are acknowledged as the latest and most powerful tools to support SCM initiatives (Henriott, 1999).

Internet is relatively fast and cheaper with no incremental fee associated with the frequency and length of information transfers. Internet-based electronic ordering requires less clerical to cost clerical labor. The transmission of electronic orders using Internet is estimated to cost only 10 to 20 percent of the cost of traditional orders (Foster, 1999). The internet and its forms such as intranet and extranet have the potential to accomplish many key goals of SCM (While, 1996). These have the potential to accurately transfer complex information (such as product design) and to reduce the delays as information passes up and down the supply chain (Elliman and Orange, 2000). Internet has also proved to be an enabler of electronic commerce (E-Com) and virtual market place such as free market etc. The underlying objective of these Internet-markets is to reduce the costs through greater process efficiency (Berryman et al., 1998). The traditional use of EDI using the value added networks (VANs) had set up enormous barrier to its usage and acceptance. It was not only costly but also technically prohibitive. The current use of the Internet as a medium of EDI has provided new opportunities in e-commerce especially among the mid-sized and small firms (Angeles, 2000). Extranet implementations provide the opportunity for demand data and supply capacity data to be visible to all companies within a manufacturing supply chain and, as such, companies are in a position to anticipate demand fluctuations and respond accordingly (Kehoe and Boughton, 2001).

EDI is a critical IT component for information sharing in SCM. Besides its ability to increase accuracy and timeliness of information transferred, it may also improve the cycle reliability and help to decrease the cycle time. Bar coding is gaining popularity in inventory management. It allows fast and accurate entry of data, which makes the inventory management more accurate and reliable (Lancioni et. al., 2000).

To improve the SCM activities, ERP and SCM software are also being widely used among various industries. Besides the commonly used IT tools, many advanced IT tools such as smart card, global positioning system (GPS) etc. are also being used in SCM (Lau and Lee, 2000: Mittal and Shankar, 2002).

2.6 LOGISTICS RELATED ISSUES

Logistics, which is often considered as a subset of SCM, has a key role in SCM (Chopra and Meindl, 2001). Many authors (Bowersox and closs, 1996; Lamming 1996; Cooper et al., 1997; Lambert et al., 1998a; Turner, 1993; Fisher, 1997) have observed that the SCM is a theory grounded in the field of logistics. Heskett (1997) had predicted that the globalization would have a huge impact on the importance of good logistics design and development within the corporate strategy. He therefore, suggested that logistics management must participate in the strategic decisions making. Highlighting the importance of logistics in SCM, Houlihan (1985) comments that a holistic approach to international SCM requires the incorporation of a logistics focus into the strategic decisions of the firm. Fuller et al (1993) have termed logistic as an inventive way of creating value for customers, an immediate source of saving, a discipline on marketing, and a critical extension of production flexibility. LaLonde and Masters (1994) advise to coordinates the logistics operations of supply chain members in order to get the benefits of forward and backward integration. Goh and Ang (2000) observed that efficient and developed logistics is a key factor in trade. Efficient logistics operations can also help the companies to reduce export prices making them competitive globally.

2.7 PERFORMANCE MEASUREMENT RELATED ISSUES

Supply chain performance measurement is an often-neglected area because of the complexities involved in the measurement (Beamon, 1999; Keebler, 2001).Therefore traditionally; the performance evaluation is limited to the performance of a single company in a supply chain. But, the impact of good or bad performance of any link in the supply chain is reflected on the performance of the entire supply chain (Keebler, 2001). Therefore, for effective SCM, it is necessary to expand the performance measurement beyond the boundaries of a company and involve all the supply chain players in it. Jharkharia and Shankar (2001) have investigated into the needs of measuring supply chain performance and observed that a performance measurement system allows the supply chain to identify its strengths and weaknesses.

Many authors (Beamon 1999; Tarr, 2001; Keebler 2001; Pires and Aravechia, 2001; Lapide, 2001) have identified the drawbacks of existing supply chain performance measurement systems. These authors have observed that the focus of most firms in a supply chain is on the performance of a single firm. The integration aspect of the supply chain has not been discussed in depth.

2.7.1 Supply Chain Performance Measures

The selection of appropriate performance measures in a supply chain is a crucial issue. Many authors have expressed their opinion about the design and the measures to be used in such a system. Neely et al. (1995) have categorized the large number of performance measures into some categories. These categories include quality, time, flexibility, and cost. The adoption of performance indicators should deal with th following questions (Beamon and Ware, 1998; Beamon, 1999): which aspects should be measured? How to measure these aspects?, and how to use the measures to analyze, improve and control the productive chain quality?, how and when to reevaluate these measures?

Supply chain council (2001) has presented its performance measurement model popularly know as Supply Chain Operations Reference Model (SCOR). This model provides guidance on the use of a balanced approach towards measuring the performance of one's overall supply chain.

Baiman et al. (2001) examined the relationship among product architecture, supply chain performance metrics, and supply chain efficiency. To evaluate the impacts of information sharing on supply chain performance, Zhao et al. (2002a and 2002b) have presented a simulation-based computer model. Bullinger et al. (2002) describes a supply chain analysis approach and proposes a measurement methodology integrating bottom-up and top-down performance measures.

2.8 MISCELLANEOUS ISSUES

There are numerous other issues such as e-business, supply chain strategy, organizational changes etc., which are involved in the effective management of a supply chain such as supply chain strategy, organizational changes etc., which are involved in the effective management of a supply chain strategy, organizational changes etc. All such issues, which have not been covered in the previous sections, would be covered in this section.

2.8.1 E-Business and Electronic Market

E-business has recently received much attention from entrepreneurs, executives, investors, and industry observers. This is due to the rapid evolutions in SCM and IT. Based on various types of trading partners, there are many categories of e-business activities, for example: business-to-business (B2B), business-to-consumer (B2C), consumer-to-business (C2B) etc (Phan, 2003). The benefits of transformation to the e-business-based supply chain network can be stated from two hierarchical levels: strategic and operational (Poirier and Bauer, 2001). At the strategic level, the benefits are:

- Information will replace inventory,
- Coordination will replace functional silos,
- Win-win will replace sub-optimization, and
- Knowledge will replace condemnation.

At the operational level, the possible benefits include:

(i) The highest possible fill rate,

(ii) On time delivery excellence,

(iii) Minimal inventory, and

(iv) Zero obsolescence.

B2B has been widely recognized as the most common form of e-business. McCaughey (2002) has noted that B2B is a new experience for most firms. Though some firms have entered into their third decade of EDI use, which is technically B2B, it is the World Wide Web (a relatively new phenomenon) that has been the catalyst for explosive B2B growth in the last decade. Similar to traditional commerce, B2B necessitates interaction among trading partners. In addition to that B2B also relies on the successful use of advanced IT tools as well as cultivation of good relationships with trading partners.

Decision-makers are often faced with the problem of choosing the appropriate e-business model for their business or supply chain. The process of fully researching each of these models can prove daunting. Hayes and Finnegan (2003) have developed a framework to exclude models that are incompatible with prevailing organizational and supply chain characteristics. Their characteristics assessed by this framework include: economic control, supply chain integration, functional integration, innovation and input sourcing.

Hunter et al. (2003) have listed the advantage of e-business in SCM. These are: (i) streamlining the procurement process, (ii) connecting buyers and sellers, (iii) coordinated supply chain management, (iv) better after-sales service, (v) better sales and marketing efficiencies, and (vi) improved inter-organizational efficiencies in the selling organizations.

Electronic market and e-procurement have a significant influence on e-business as well as on the way in which organizations manage their supply chains (Eng, 2004) has investigated the extent to which supply chain members in the retail sector for B2B supply chain management are using e-business tools of the e-market place. It is observed in a survey on UK retailers that the e-market supply chain applications enable the majority of companies to automate transactions-based activities. It is also indicated in the survey that for full participation in e-market companies should integrate their internal and external supply chain activities and share strategic information.

E-market can be categorized as hierarchical (biased) or market-driven (third party) (Malone et al., 1994). In a hierarchical e-market, the market marker is also a buyer or seller and biased toward the sponsor or market marker because of the advantages over competitors that conduct business in that market. In contrast, a third party (neither a buyer nor a seller) sponsors an unbiased market-driven electronic market and the market marker does not carry out transactions in the market.

Eng (2003) has observed that e-market offers many advantages compared to traditional supply chain process with real-time access to data, and reach to global market. The results of a survey (Eng, 003) indicate that the most popular use of e-market for SCM is in auctions and reverse auctions, followed next by processing as regards online ordering, payment non-technical negotiations, and customer or supplier information management. The e-market has also been used for listing products or making purchases from catalogues, searching for buyers or sellers, and an improved online communications and exchanges of information. These functions are procurement-related activities such as checking product availability and exchanging information on product specification. However, technical exchange and development is the least subscribed function of the e-market.

On e-market, Lambert and Cooper (2000) remarked that through e-market provides many benefits for supply chain management; firms must not overlook the time-consuming process of relationship development. Activities that involve technical exchange and relationship development have not yet been fully developed in the e-market. For instance, it takes more time to develop trust for sharing strategic information which is more likely to occur through face –to-face contact. Since the supply chain is a network of multiple business and relationships, the ultimate success of firms would depend on management's ability to integrate the company's intricate network of business relationships.

Internet has emerged as an important tool in supporting the e-business activities. Cagliano et al. (2003) have observed that companies are using Internet for different processes in their business strategies. Further, the degree of adoption of internet is also different companies according to the use of Internet in their business strategy. The four clusters obtained through analysis are:

(i) Traditional: Most companies belong to this group. These companies have no significant use of Internet in their supply chain.

(ii) E-sellers: The second largest group of companies belongs to this group. The use of Internet is mainly for sales and customers care.

(iii) E- purchasers: This group of companies uses Internet for the purchasing activities mainly in the upstream of the supply chain.

(iv) E-integrators: This is the smallest group of the companies, which uses Internet for all the above said activities.

2.8.2 Supply Chain Strategy

Postponement of the point of product differentiation is an important strategy in SCM.

Alderson (1957) was among the first to have proposed the concept of postponement. The objective of postponement is to minimize the risk of carrying finished product inventory at various points in the supply chain by delaying product differentiation to the latest possible moment before customer purchase. It has now emerged as an important strategy in SCM (Anderson et al., 1997; Metz, 1998; Mohanty and Deshmukh, 2001).

As there may be various supply chain strategies, Shapiro (1984) has provided a framework suggesting a good fit between the logistics system and competitive strategy of a company. Froehlich et al. (1997) remarked that there could be three different types of SCM strategies. All these strategies are customer focused. These are 'innovator', 'marketer', and 'caretaker' strategies.

Parlar and Weng (1997) investigated the relationship between the manufacturing and supply functions and suggested that the two functions should be coordinated because the costs associated with the second supply and production to meet unsatisfied demand is much higher than for the first production run.

Fisher (1997) developed a framework for successfully matching product and appropriate supply chain. He observed that functional products require supply chain that is efficient in performing the market mediation function while innovative products require chain responsive in performing the market mediation function. Fisher's framework is supported by the Morash and Clinton (1997), Dyer et al. (1996) has provided a simulation model.

Despite all the advantages of SCM, its implementation is not an easy-going process. In this regard, Lee and Billington (1992) have identified 14 pitfalls in the implementation of

SCM. Later, Cohen, and Mallik (1997) also observed that the majority of SCM models lack practicality and would be difficult to implement.

2.8.3 Vendor-Managed Inventory (VMI)

Recently, vendors and retailers have begun to forge cooperative agreements to manage inventory, which requires sharing demand information and setting mutually agreed upon performance targets for the supply chain. These cooperative agreements have resulted into the development of VMI system (Achabal et al., 2000). An early conceptual framework for VMI was provided by Magee (1958). However, interest in the concept has developed only during the 1990s (Disney et al., 2003).

Dong and Xu (2002) have developed a supply chain model of VMI. They evaluate how VMI affects a supply channel. They observed that VMI always leads to a higher buyer's profit, but supplier's profit varies. In the short-term, VMI is found to reduce total costs of channel system, but under certain cost conditions between buyer and supplier, it could decrease the purchasing price and supplier's profit. In the long run, it could more likely increase supplier's profit than in the short-run. They conclude that VMI is an effective supply chain strategy that can realize many of the benefits obtainable only in a fully integrated supply chain.

Disney and Towill (2002) have designed a VMI system for different ratios of production adaptation costs and inventory holding costs. Their system highlights how the VMI design parameters may be used within an industrial context.

Disney et al. (2003) have investigated the impact of a VMI strategy upon transportation operation 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. It is shown that VMI results in transport cost saving in both, the short and long term.

Specifically, VMI offers the following benefits (Achabal et al., 2000) for the retailer:

- More effective inventory management and less uncertainty regarding inventory turnover and customer service levels. The VMI system provides a way to set and achieve performance targets for both these goals.
- A cost-effective way to obtain sales forecasting and inventory management services. As the vendor's analysts implemented the system across many retailers, economies of scale were achieved in both the development and the customization of the models. This lead to a VMI forecasting system thet was more accurate and developed at a lower cost than could be realized by any individual retailer.

For the vendor:

- VMI provide a method for the vendor to increase the availability of their brand in stores, relates to competitors' brands, and still meet the retailers' budgetary open-to-buy constraints.
- Relying on actual sales data prevents the bullwhip effect thet occurs when time lags, coupled with batch orders from the retailer, tend to amplify demand fluctuations as they go up the supply chain.VMI also reduces the opportunity and incentives for gaming, for example, retailers sometimes intentionally inflate orders when product supplies are limited and proportionally allocated by the vendor.
- Disney and Towill (2003) compare the bullwhip properties of a VMI supply chain with those of a traditional supply chain. Their analysis shows that with VMI implementation, two sources of the bullwhip effect may be completely eliminated, i.e.

rarioning and gaming, and the order batching effect. However, the effect of VMI on demand signal processing include bullwhip is less clear. The authors conclude that a balanced I offers a significant opportunity to reduce the bullwhip effect in rest-world supply chains.

Kuk (2003) has empirically tested how some of the acclaimed of VMI were subjected to some of key barriers, which are common in any IT implementation and reengineering initiatives. He observed that lack of trust among supply chain members is a major barrier to the success of VMI.

2.8.4 Change Management

SCM allows the organizations to realize the advantages of vertical integration. However, favorable organization condition must be present for effective SCM (Tan, 2001). In this regard, a change in the corporate culture of all members in the value chain is essential to make it conductive. The importance of change management is even greater in the context of IT-enable supply chain environment. McMullan (1996) has suggested that many firms will have to change their organizational structures, SCM relationship, and performance measures to successfully implement SCM. On change management in IT-enable environment , Pant et al. (2003) have cautioned the managers that IT-enabled supply chain systems are likely to disrupt the current practices and organizational structure, thereby requiring a big change management effort. The authors have suggested taking similar change management efforts in the partner firms, over which a firm may have little or no control. Novicevic et al. (2000) have discussed the changing role of managers within the supply chain networks. They observed that as firms shift from hierarchical to network governance, it has become necessary to clearly define the evolving role set of a manager within supply networks.

They introduced a strategic choice perspective into the SCM domain, which provides insights about the changing role of managers.

2.8.5 Trust among the Partners in a Supply Chain

Trust is defined as the binding force in most buyer-supplier transaction (Ba, 2001). Many researchers have proposed that trust is essential for understanding interpersonal behavior and economic exchange (Hirsch, 1978). Lack of trust is a major inhibitor in supply chain integration efforts (Agarwal and Shankar, 2003). It may exist due to past problems or due to fear. Mariotti (1999) says that it may exist because of a lack of leadership and communication among group of people. Additionally, resistance to change in the form of confusion, denial, deflection, or even sabotage can torpedo SCM initiatives between organizations or within organizations.

2.8.6 Forecasting in Supply Chains

Forecasting has an important role in SCM. Selection of a forecasting process significantly influences the performance of the supply chain and the value of the information sharing (Zhao et al., 2002a and 2000b). Collaborative forecasting is one of the supply chain integration initiatives being adopted by many supply chains. In 1995, the concept 'Collaborative Planning, Forecasting and Replenishment (CPFR)' was introduction (Skjoett et al., 2003) to increase the accuracy of the forecasting. In CPFR, more information has to be exchanged and the collaboration meetings are more frequent.

Barratt and Oliveria (2001) have discussed the benefits of CPFR. These benefits are: more predictable order cycles, reduced costs, more receiver-friendly loads, reduced product damage, smaller shipments, daily download of information, more frequent deliveries, accuracy of information, shorter production runs, timeliness of information, delayed final production, information formatted to facilitate usage, increased customer service, availability of information, fewer stock-outs, internal connectivity/compatibility, improved reliability of deliveries, information formatted on an exception basis, faster inventory turns, real-time information, reduced overstocks, external connectivity/compatibility and reduced inventory holding. The authors have also found some gaps in literature on CPFR. They say that very little information is available on some issues such as a practical guide to the implementation of CPFR.

McCarthy and Golicic (2002) noted that several barriers prohibit the widespread use of CPFR. Aviv (2001) observes the impact of collaborative forecasting on supply chain performance. He has developed two models that observe the impact of collaborative forecasting on supply chain performance. The underlying assumption for each model is a cooperative, two-stage supply chain consisting of two members, a buyer and a supplier.

Zhang (2003) investigated the impact of forecasting methods on the bullwhip effect for a simple replenishment system. The findings indicate that different forecasting methods leads to bullwhip effect measures with distinct properties in relation to lead-time and underlying parameters of the demand process.

2.8.7 Reverse Logistics

Reverse logistics and green issues are the emerging dimensions of SCM (Marien, 1998). This area examines both, reverse logistics issues of product returns (Padmanabhan and Png, 1995; Rudi and Pyke, 2000) and environmental impact issues (Herzlinger, 1994). Growing regulatory pressures in many countries are forcing managers to consider the most efficient and environmentally friendly way to deal with product recovery. Buxbaum (1998) observed that reverse logistics has different meaning for different linkages in the supply chain. For example, retailers and suppliers refer to reverse logistics as the process of getting sold goods eturned by the customers. Carter and Ellram (1998) have concluded a review of literature on the topic of the traditional logistics.

Direct shipment from products ordered over the web has created many new and important problems in economically handling customer returns. For products such as home furniture, management of product returns has proven to be the most vexing facing on-line retailers (Pyke, Johnson and Desmond, 2001).

2.9 REPORTED SURVEYS ON SCM PRACTICES

Many researchers have conducted surveys in the area of technology-enablement of SCM. Some have also addressed to the specific needs of manufacturing industries. A chronological review of relevant survey paper on SCM and AMT issues has been presented in Table 2.5.

Table 2.5: Surveys in the Area of AMT and SCM

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
		Logistics related survey		
1	Australia 3PL use by large Australia firms	84 Largest non- service firms	Logistics outsourcing had a positive impact on logistics cost reduction, customer satisfaction and employee moral.	Dapiran et al (1996)
2	Europe and Pacific region Relationship between the logistics information and logistics competence	111 General (supposed to be world –class firms)	(i) Firms have upgraded their internal capabilities but have been less successful in external co-ordination, (ii)It capabilities significantly influence overall logistics competences.	Closs et al (1997)
3	New Zealand current state of SCM activities in New Zealand	69 Largest manufacturing organization in new Zealand	Though there is awareness of the SCM concept , the adoption of the newer concept s is limited. In SCM , companies are more concerned with on time delivery from the immediate suppliers and to the immediate customers.	Basnet et al (2003)
4	Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) To report and reflect on the characteristics of the academic discipline concerned with logistics and supply chain management.	144 Researchers of supply chain management	Characteristic of research issues pursued by Nordic researchers the focus on supply chains and networks and the use of dyads, chains or networks of organizations as levels of analysis	Arlbjorn et al. , (2008)
5	Singapore The use of IT by manufacturing companies I SCM	148 Electronics an chemical companies	Main barriers in developing IT are: (a) retraining and education of employees (b) financial justification of IT (c) lack of IT compatibility of partners	Kwan (1999)
6	Taiwan Investigating whether there is significant difference in the explanatory power of dimensions of core competence both for High tech firms and Traditional Manufacturers in Taiwan	81 Machine tools and Electronics products manufacturers	The capabilities of supply chain management and logistics management for T-Ms significantly affect core competence, because these businesses must focus more on services.	Chen and Wu, (2007)
7	USA Implementation of the integrated logistics	127 Logistics executives	Integrated logistics lead to improved performances.	Daugherty et al. (1996)
8	USA Business arrangements between manufacturing firms and international 3PL	154 Manufacturing companies international business	Environmental factors such as capacity , concentration , diversity and volatility influence the decision regarding the formation of relationships with international logistics providers	Stank and Daugherty (1997)
9	USA Current practices and trends in logistics	92, Top retailing executives with logistics responsibilities	Tremendous potential for retail logistics.	Ellram et al (1999)
10	USA Selection of logistics service provider.	463 Diversified with 70% manufacturing companies	Companies rank financial stability , customer service capability, and price as the most important criteria in the selection of logistics service provider.	Boyson et al (1999)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
11	USA Perception of small and large international logistics logistics service providers on the importance of the logistics service attributes.	301 Respondents from 'Journal of Commerce Directory of US Importers and Exporters	Reliability .transit time and cost are the three most important attributes in the same order for small order for small and large firms.	Pearson and Semejn (1999)
12	USA Logistics outsourcing	372 Subscribers of transportations & distribution (T&D) magazines who had logistics outsourcing experience & decision making authority	Firms can improve customer service and reduce costs by outsourcing multiple logistics Functions.	Rabinovich et al (1999)
13	USA Ethical issues in international buyer- supplier relationships	132 Purchasing managers	Buyers and their suppliers identify the same sets of activities as being unethical .Culture does not influence ethics associated with the interactions of US purchasing managers and their foreign suppliers	Carter (2000)
Technology related survey				
14	25 countries in all the principal regions of the world Supply chain practices in these countries supply chain	500 Diversified	(i) IT is a major enabler for SCM (ii) Suppliers and customer involvement is relatively low among all regions and industries (iii)Overall level of outsourcing is low	Freeman (1998)
15	Asia –Pacific SCM practices	43 Largest companies I Asia-pacific region	(i) Cost competitiveness and control are the key SCM issues. (ii) Reengineering of the SCM component of their operations is considered a priority. (iii)IT was identified as a key management concern.	McMullan (1996)
16	Australia Practices related to IT implementation	81 Manufacturing companies	IT is still being a strong positive relationship between implementation of cooperative relationships and quality to internal and external costumers	Sohal et al (2001)
17	Australia Role of Web –based technology in construction supply chain	Not disclosed Australian construction companies	Web –based information system has proved to be beneficial to all participants in the construction supply chain.	Mohamed (2003)
18	Canada EDI integration in Canadian firms	140 Generalized	EDI integration both internally and externally leads to strategic advantage.	Bergeron and Raymond (1992)
19	Canada Impact of EDI and outsourcing on people involved in logistics activities.	209 Members of Canadian association of logistics management CALm	(i) No significant link between outsourcing and more cooperative relation (ii) No significant link between use of EDI and more cooperative relation	Larson and Kulchitsky (1999)
20	Europe To investigate on an empirical basis the relationship between two supply chain integration dimensions – the integration of information flows and the integration of physical flows	297 Manufacturing companies	Results show that the adoption of the lean production model has a strong influence on the integration of both information and physical flows along the supply chain, while no significant influence emerged from the adoption of ERP..	Cagliano et al. (2008)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
21	France Relationship between technology and third party logistics service providers	99 Managers of Logistics firms	Technology constitutes a crucial strategic orientation for logistics service providers gradually take on the role of key interface in the functioning of information systems,	Sauvage (2003)
22	Global Benefits and barriers of EDI	98 International freight forwarders and their customers	(i) The advantage of EDI to freight forwarders decreases order are quick access to information, better customer service, reduced paperwork and better communication and increased productivity. (ii) The advantage of EDI to user are quick access to information reduced paperwork, good communication and better customer service. (iii) The barriers to EDI for freight forwarders are high setup cost, incompatibility of hardware and software, Lack of standard formats.	Murphy and Daley (1999)
23	Global SCM practices in various countries	967 Reader of supply chain and logistics magazine across various countries	Bar coding is the single most widely used IT tool in a supply chain. only 20% of the sample has implemented ERP .15%have opted to install SCM software and 11 % use APS software	Fordor (2000)
24	Hong Kong Relationship between supply chain environments and Manufacturing Planning Control (MPC) systems	116 Senior manger s in manufacturing industries	MPC system performance is positively related to organizational performance.	Chan and Burns (2002)
25	India Current supply chain practice	32 Manufacturing companies	The weak IT infrastructure outside the organization is a major inhibitor in having and enabled supply chain. The next major inhibitor was the small size of the suppliers and distributors. These two inhibitors are related.	Kadambi (2000)
26	India IT applications and management practices in Indian manufacturing organization	78 Indian manufacturing companies	The quality delivery , participants identified inventory reduction and capacity ululation as the important objectives of IT usage	Saxena and Sahay (2000)
27	Spain relationship between the dimensions of supply chain flexibility and firm performance	126 automotive suppliers	Results indicate that flexibility capabilities are enhanced in supply chains with higher environmental uncertainty, technological complexity, and mutual understanding	Sánchez and Perez (2005)
28	Sweden SCM practices and studies in Swedish manufacturing g companies	128 Members of Swedish production and inventory management society	(i) the overall objectives for the design of supply chain are resources utilization and cost minimization (ii)Quality is the single most important criteria in choosing partners for supply chain. (iii) Forecasting is the prime area for collaborative efforts,(iv)Companies are prepared to expand the span of their supply chain operation (v)Companies show relatively high awareness of modern supply chain planning and control tools. Agile companies are customers focused and involve supplier s in their process to attaining high levels of customer's satisfaction. the less agile groups are characterized as more internally focused.	Olhager and Selldin (2003)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
29	Turkey Buyers –supplier relationship and advanced manufacturing technology (AMT)	83 Automotive component firms	The greater the extent of AMT implementation by a firm, the more collaborative is the relationship with their supplier.	Gules and Burgess (1996)
30	Turkey investigate the relative effects of supply chain integration, supply chain information sharing and supply chain design on supply chain performance	125 Manufacturing firms.	Only significant effects on resource and output performances belong to supply chain design. Integration and information sharing are correlated with performance measures.	Bulent Sezen, (2008)
31	UK Virtual Team working	70 Auto components supplier to rovers group.	(i) Fax , e-mail and phones were the most common means of communication in the supply chain of Rovers. (ii) Time and cost savings were the two advantages ahead of others in virtual team –working	Bal and Gundry (1999)
32	UK Electronics trading in the supply chain	141 General	Electronics commerce is slowly growing .The task up rate of EDI has been much slower in UK than in USA	Pawar and Driva (2000)
33	UK Information related issues in the construction supply chain.	78 Construction supply chain	The role of information in the construction supply chain needs to be branded to encompass its active management as a strategic resource.	Edum-Fotwe et al (2001)
34	UK SCM tends in small medium sized enterprises	288 UK based small medium sized enterprises	lack of effective adaptation from traditional adversarial relationships to the modern collaborative IT –enabled supply chains.	Quayle (2003)
35	UK,USA, Canada, Germany , Japan and some European countries. Comparison of buyer-supplier relationship between Japanese and non Japanese carmaker	98 Automotive component firms	Buyer –supplier relationships with Japanese car assemblers as regarded by component suppliers are better then their relationship with Japanese car assemblers n passing information about new working practices and creating better relationships through the supply chain	Pickernell(1997)
36	USA EDI implementation in JIT and non –JIT firms	50 Manufacturing	(i) The EDI related benefits achieved by JIT firms are higher than that by non –JIT firms. (ii) The main problem for EDI implementation is lack of standards. (iii) Customer request is a significant reason implementing EDI.	Banerjee and Gohlar (1993)
37	USA Relationship between buyer-supplier cooperation, quality and costs	712 Members of National Association of Purchase Management (NAMP),	A higher level of buyer-supplier Co-operation is linked to higher product quality and lower total costs.	Larson (1994)
38	USA EDI implementation related issues	128 Member firms of NAMP using EDI	Merely investments in resources such as EDI do not automatically leads to success	Angeles et al (1997)
39	USA, Role of information and communication technologies (ICT) in postponement in a supply chain.	80 Manufacturing industries	ICT greatly facilitate customer responsiveness and the application of postponement in a supply chain.	Van-Hoek (1998)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
40	USA Importance of the customers in a supply chain	99 Buyers and distribution personnel of a leading S manufacturers of personnel products	Strong relationships were found between satisfaction and the formal collection of the customer feedback as well as between loyalty and the formal collection of costumer feedback.	Ellinger et al (1999)
41	USA Assessment of supply chain practices	228 Wide range of manufacturing an services industries	(i) Supply chains must be managed differently in differently in different industries. (ii)Top barriers in SCM are resistance to change , poor availability of data ,complexity of supply chain , organizational structures and poor alignment of objectives .in the top five 4 are organizational issues (iii)Automotives industry is a shinning examples of sophisticated SCM (iv) ICT is a key enabler to SCM	Arthur D. Little (1999)
42	USA Firm level and industry level changes in the automotive supply chain	175 North American Auto Industry	At mainly upon agency theory and transaction cost economies .At the industry level, explanations are grounded primarily in the increasing competition and Globalization.	Senter and Flynn (1999)
43	USA Collaboration among firms for utilizing inventory replenishment	98 The manufacturing & retailing firm	Moderate levels of CPFR across al firms in the sample. A positive association exists between CPFR and process inputs , performance outcomes and IS tools used for implementation	Stank et al .(1999)
44	USA Effect of environmental purchasing on a firm's performance	437 Purchasing executives from NAPM, USA	Environmental purchasing is positively related to a firm's performance	Carter et al (2000)
45	USA Effects of EDI on the automotive supply chain	93 First tier automotive suppliers	(i) the transaction standard of big auto manufactures are different from each other, (ii)Most respondents use VAN for EDI transmission, few have also started using Internet for sending EDI. (iii) EDI integration is proportional to frequency information exchanged between a firm and its suppliers.	Rassameeth es et al (2000)
46	USA EDI's impact on customer service	106 Purchasing managers in automobile and pharmaceutical industry	EDI contributes to the following customers service components: order cycle time, product availability , distribution flexibility , distribution information and distribution malfunction	Lim and Palvia (2001)
47	USA Relationship between use of IT and buyer-s supplier Relationship	175 NAMP members representing 8 different industries	More research is needed to understand the relationship between the use of IT and buyer- supplier relations	Carr and smeltzer (2002)
48	USA Identification of potential antecedents of information exchange	248 CLM members belonging to five different industries namely food, clothing, office supplies , paper and pharmacy and loitering	Information quality and relationship commitment are both significantly related to strategic information exchange.	Moberg et al (2002)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
49	USA IT use I common purchasing activates	261 Purchasing professionals associated with the institute for SCM.	More research is needed to understand how IT can better facilitate purchasing and supply activities.	Ellram and Zsidin (2002)
50	USA Use of EDI in supply chain	185 Food industry	Most firms use EDI for the operational activities and its use is lesser in coordinating activities of supplying cabin	Hill and scudder (2002)
51	USA Antecedents of technology adaptation in SCM	50 Revere Group consultants	Firms within large number of employees adopt more technologies .Supply chain partners successfully pressurize other supply chain organizations to adopt new technologies	Patterson t al (2003)
52	USA Use of internet as a purchasing medium	416 Customer of a major Internet retailers	Internet –based some significant benefits but there is scope for further improvement.	Olson and Boyer (2003)
Integration and agility related survey				
53	USA and Canada Impact of purchasing s role , industry context and purchasing organizational structure , on the use of various forms of purchasing teams	236 Large service and manufacturing firms	Purchasing's strategic role was positively related to the great use of internal teams and councils, but mot customer teams. Industry context also played a role in the usage of teams, with internal teams and councils more extensively used by the firms	Johnson et al (2002)
54	19 developed & developing countries Effect of supply chain complexities on delivery performance.	469 textile and machine tools industries.	Complexities in the product /process and uncertainty of the management system s adversely affect the supply chain delivery performance.	Vachon and Klaseen (2002)
55	23 countries from Asia pacific, Europe , north and south America Supplier and customers integration strategies	322 manufacturing companies	There were different supply chain integration strategies that manufactures followed .These supply chain strategies namely inward , periphery , suppliers , costumers .and outward facing have not intuitive appeal and statistical validity in a reasonably large international database	Frohlich and Westbrook (2001)
56	China SCM in Chinese manufacturing firms	100, Shangai based large Chinese manufacturing firms	These firms are not as advanced in SCM practices as western firms	Pyke et al (2000)
57	Europe To identify the underlying factors of supply chain integration in European firms with particular emphasis on the role of information sharing and inter organizational collaboration	149 Manufacturing Industries	The significant negative correlation between the length of relationship with suppliers and performance measures such as total logistics costs, on-time delivery and rate of return	Bagchi et al (2005)
58	Germany Supplier selection and their involvement inter –company activities	268 Member from NAMP	The following hypotheses were supported : H1: When firms implement supplier selection criteria and consider these criteria as important, supplies performance increases. H2: suppliers participation in the manufacture 's product design process and continuous improvement program improves supplier performance	Tracey and Vonderemble(2000)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
59	Germany and UK Supplier policies of manufactures	220 Electronics process and engineering sector	(i) In the process sector the plants mainly intend to keep their supplier base constant while the electronics and engineering sector intend to reduce it .(ii) Benefits of reduced suppliers are lower price , lower administration cost , and easy to manage and improved relations	Szwejczewski et al (2001)
60	India relationship with organizational supply chain agility and performance	128 Manufacturing companies	Result shows the significant effect of strategic sourcing and its dimensions on supply chain agility and firms' performance	Khan and Pillania (2008)
61	India current practices of SCM in india	156 Indian companies from diversified industries range	(i) About one third of the companies have no SCM policies. (ii) Customer service and order –fulfillment were the areas for which maximum time was allocated by the SCM personnel .Surprisingly inventory management was low in agenda. (iii)Transportation .warehousing, manufacturing and information systems were the most outsourced activity. (iv)SCM solutions are used by the only 17.1% of the respondents whereas ERP package is being used by about 40%of the respondents.	Sahay et al (2003)
62	India investigation of supply chain performance measurement in the Indian automotive sector	40 Managers of Manufacturing firms.	Concept of supply chain performance is not fully embraced by the Indian automobile sector and highlights the difficulties associated with its implementation.	Saad and Patel (2006)
63	India and USA Purchasing practices of Indian and US managers	105 (56 from US and rest from India) Manufacturing companies	There exist a serious difference in the purchasing practices of Indian and US managers	Motwani and Ahuja (2000)
64	Italy Integrated management of logistics chains	194 Companies , shops and final costumer belonging to the white goods industry	There does not seem to much integration among various actors within the white goods a logistics chain regarding the exchange of the sales data.	Perona et al (2001)
65	North America ,South America and Europe Complexities of SCM	161, Five broad industry groups (life sciences, oil, and gas. Consumer products, utilities and manufacturing high tech electronics and automotive.	Buyers tend to be reluctant players and far more skeptical about the benefits of SCM. Buyers are more likely to highlight the risks associated with heightened dependence on a smaller number of suppliers.	Spekman et al. (1998)
66	North and south America and Europe Difference between innovative-product supply chain and functional product supply chains	188 22 extended supply chains from board industries groups	The practices and reasons for SCM that distinguish high performers from low performers are different for functional and innovative – product supply chains	Ramdas and Spekman (2000)
67	South East Asia Greening of supply chains in south east Asia	52, ISO 14001 Certified companies in south east Asia	South East Asian countries are conscious about the greening of the supply chain. More than 70% of the sample companies have taken various steps about SCM.	Rao (2002)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
68	Spain Supporting the notion that implementing a standardized quality management system is beneficial.	400 ISO 9000 Certified companies	Improvements in the SCM have been found but also those aspects in which the companies themselves recognize their limitations.	Casadesus and De-castro (2005)
69	Spain Supporting the notion that implementing a standardized quality management system is beneficial.	400 ISO 9000 Certified companies	Improvements in the SCM have been found but also those aspects in which the companies themselves recognize their limitations.	Casadesus and De-castro (2005)
70	Sweden Vulnerability in the supply chain	118 Three different industries namely retail suppliers pre fabricated houses , and furniture manufacturer	The sources and categories and universally applicable in the context of vulnerability in a supply chain.	Svesson (2000)
71	Sweden, Perceived trust of companies toward s suppliers an d customers in a supply chain.	215 Automotive industry	There are high levels of companies perceived trust towards the suppliers and the customers differ from each other.	Svensson (2001)
72	Turkey Supply chain collaboration and technology implementation	83 Automotive firms	The majority of respondents indicated that their relationships with suppliers were becoming more collaborative.	Burgess et al (1997)
73	UK Supply chain collaboration in construction industry.	40 Construction contractors	Construction supply chain managements is still at its infancy .Improved production planning and purchasing are the key target s for the application of SCM in construction	Akintoye et al (2000)
74	UK Collaborative relationships in the supply chain	100 All industries with in experiences in supply chain partnership	Few practices accounted for most of the differences between successful and unsuccessful organization s. Many conventional change management prescription s had no statically significant effect on the outcome of collaboration	Boddy and Macbeth (2000)
75	UK Internet enabled supply chains interaction strategies	890 Diversified manufacturing and service firms	Demand Chain Management (DCM) is currently the most powerful web based integration strategy that a manufacturer can adopt	Frohlich and Westbrook (2002)
76	UK Shared learning between firms in a supply chain	6 supply chains Supply cabinets belonging to following industries ; (i) Semiconductor (ii)Oil and Gas,(iii) computing equipment,(iv) two cabins in chemical. industry, and (v) aerospace industry	Continuous learning within and between organizations will be a key strategic requirement for building and sustaining compositeness	Basnet et al (2003)
77	UK Evaluation of retailers understanding of quick response concept a nd the implementation of relevant technologies	30 Fashion retailers	IT is being utilized by the large multiple retailers. However. there may be some reluctance by the supplier to invest the capital required to be able to share information in real time due to the dynamics and adverbial nature of the fashion retailers’ relationships	Birtwistle et al (2003)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
78	UK Impact of human resource factors on competitive advantage of SCM	358 Large US manufacturing And service companies	A sustainable competitive advantage must exhibit four dimensions: value added , rareness, imitation cost barrier, organizational structure for implementation .This research demonstrate s that these dimensions are activated by HR factors such as employee training and managerial /employee support.	Gowen III and talon (2003)
79	UK Barriers in supply chain partnership	100 Private and public sector companies with largest group of manufacturing companies	The main barriers in partnership are identified as: underestimating the turbulence surrounding partnering, priority conflicts left unresolved, over reliance on good interpersonal relation, cost, benefit and value adding models not defined, and insufficient long –term focus.	Boddy et al (1998)
80	UK Role of control mechanisms in the development of supply chains	78 Telephonic survey on logistics and transport companies	Expansion of horizontal third party alliance s , through the offering of supplementary services Is not a common practice in this sector.	Van –Hoek (2001)
81	UK SCM relationships in construction	118 Construction organization	Construction industry is moving to adopt SCM . Partnering is mainly being adopted up stem and essentially between clients, consultants and main contractors.	Saad et al(2002)
82	UK and Benelux Agility in supply chain	35 General	Introducing agility in Supply chain might raise customer sensitivity capabilities but might also call for project like management approaches.	Van – Hoek et al (2001)
83	USA Supplier development through strategic and reactive process.	84, Members of global procurement and supply chain electronic benchmarking network (GEBN) initiative at Michigan state University	Firms tend to use supplier development as a reactive tool and later .as suppliers performance and capability levels improve , use it as a strategic weapon .This approach seems justified	Krause et al.(1998)
84	USA Role of closeness in buyer supplier relationships	163 Diversified	Closeness (of views) is essential for success between business partners.	Nielson (1998)
85	USA Strategic role of purchasing in buyer-supplier relationships	739 Member of NAPM	Five hypotheses were presented and validated .The first and third hypotheses link strategic purchasing to suppliers olution systems, buyers –supplier relationships and firm's cial performance respectively. The fourth hypothesis links aluation systems to buyer-supplier relationships. The fifth thesis links buyer –supplier relationships to firm's finance.	Carr and Pearson (1999)
86	USA Role of SCM in developing operational flexibilities as a measure of acquiring agility	68 Purchasing managers of various companies who are also the members of NAPM	(i) Early supplier involvement in product design is significant and positively associated with delivery flexibility. (ii) A positive correlation was found between volume flexibility and suppliers' ability to respond to the order volume changes and modify products	Narsimahan and Das (1999)
87	USA Trends in SCM	38 Four sector namely equipment manufacture , automotive high tech and consumer good companies.	Joint planning is a very unusual in all fields in industry. High –tech industry is noticeably open in this respect as compare d with other branches	Brabler (2001)

S. N.	Country/ Region Focus of survey	Sample size Respondents/ Industry profile	Remarks	Reference
88	USA Impact of SCM on Performance	313 of Members Americans society of quality control	SCM initiatives alone cannot improve profitability and market show. Firms must pursue new market .new technologies and improve cost and delivery performance	Tan et al (1999)
89	USA Cooperative and competitive approaches on buyer and supplier relationship	292 Suppliers to fortune 500 electronics and aerospace firms	Analysis of the survey data indicates that buyers and suppliers have s better shared understanding with in the completive relationship than with in the cooperative relationship	Forker and stannack (2000)
90	USA Automatics replenishment programs and their effectiveness	98 Manufactures and retailer in the auto supply chain	Higher levels of success in these programs are likely either because of management's persuasive capability or by mandate	Myers et al (2000)
91	USA Buyer –supplier operational links and supplier development	52 Electronics and machinery plant	The design link seems to be most important factor in the supplier development action s set in motion by the buyer firm	Toni and Nassimbeni (2000)
92	USA Supplier selection criteria and their involvement I buyers' process	249 Subscribers of the publication Industry Week	Manufacturing firms select and evaluate suppliers based on quality , reliability and product performance but involve suppliers in the supply chain to a much lesser extent	Tracey and Tan (2001)
93	USA impact of supply-chain management (SCM) capabilities on business performance	474 Manufacturing firms in USA	Results indicate significant positive relationships exist among three types of SCM capabilities (outside-in, inside-out, and spanning) and business performance (perceived customer value, customer loyalty, market performance, and financial performance)	Tracey et.al (2005)
94	USA to examine the link between supply chain management (SCM), market orientation, and organizational success	80 Large manufacturing companies	Result suggest that a manufacturing firm's SCM strategy mediates the relationship between its market orientation and organizational success	Green Jr. et al. (2006)
95	USA To analyze the state of supply chain quality management in manufacturing companies	107 manufacturing companies	Provides information about the results of each hypothesis, their implications, and how these findings relate to the previous literature	Sila et al. (2005)
96	USA to examine the impact of supply chain lead-time averages and variability on an organization's financial performance.	210 Manufacturing firms	Result shows that as variance in supply chain lead-times increases, the financial performance of the organization decreases	Christensen et al. (2007)
97	USA understand the supply base reduction approaches and processes utilized by organizations	13 OEM of different products	A basic supply base reduction process is developed and outlined based on the similarities observed.	Ogden and Carter (2008)
98	World wide twenty three countries to present empirical results of an analysis of the strategic alignment between order winners selection and external supply chain integration strategies.	646 Manufacturing companies	Firms choosing to use price as an order winner do not show any significant difference in the extent of external supply chain integration.	Quesada et al. (2008)

2.10 STRENGTH OF CONTEMPERARORY RESEARCH

Based on the review of reported literature, following strength can be cited.

- Many research journals such as *International Journal of Operations and Production Management, International Journal of Manufacturing Research, International Journal of Agile Manufacturing, International Journal of Advanced Manufacturing System, International Journal of Agile Manufacturing, International Journal of Computer Integrated Manufacturing. International Journal of Flexible Manufacturing Systems, International Journal of Production Research, International Journal of Physical Distribution and Logistics, European Journal of operation Research, Supply Chain Management: An International Journal, international Journal of Logistics Research and application, Business Process Management Journal and Journal of Advances in Management Research etc.*.have given significant importance and thrust to the research on the various issues related to SCM and AMS. The concepts related to the AMT enabled supply chain like integration, flexibility, agility are given importance in aforesaid Journals. Some of these Journals have come out with special issues on agility and integration. Such support appears to be one of the major reasons for the boost in research in this area.
- Recent technological advances in tools used for information sharing, among trading partners have led to the sudden and sustained scope of improvement in supply chain activities. This accompanied by many technical and managerial issues, have drawn attention of researchers.
- Companies are now recognizing the importance to enhance their manufacturing capabilities and its effectiveness in the purview of the supply chain for their survival in the competitive environment. Workshops and seminars are frequently held to keep

Table 2.6: Some identified Gaps in Literature

S.N.	Author(s)	Gaps Identified	Remarks
1	Gunasekaran and Ngai, (2003)	Most of the literature on use of technology in SCM discussed only the implications of one or two aspects of supply chain, for example strategies, tools and techniques but not in entirety. Design and implementation of technological system for an effective SCM have not received adequate attention from both researchers and practitioners. However a comprehensive survey of technology in SCM will be useful to identify the critical success factor of technology for an integrated supply chain.	A comprehensive survey focusing use of technological tools in SCM has been conducted in this research
2	Kadambi, (2000), Sahay et al., (2003)	Few empirical studies on SCM have been conducted in India; these are either based on case studies or descriptive studies	Some hypothesis have been formulated and tested in this research.
3.	Bruce (2004)	There is need to deal with a network of companies in a business to understand and manage partnership through out its supply chain and ensure that whole supply chain should agile.	Variables related to integration and agility of supply chains have been identified and modeled using ISM.
4.	Zhao et al.(2002)	The value of information sharing depends on several conditions; he showed that demand sharing has no significant benefits for a manufacturer under tight capacity. They found that demand information sharing has more value if demand is highly correlated over time, highly variable, or the lead-time is long.	Various kind of information sharing has been investigated. Through a questionnaire based survey a relationship has been developed between type of information sharing and competitive strength acquired by the manufacturing enterprises
5	Gunasekaran et al.(2001)	Highlight the need of performance measurement system, a greater need to study the measures and metrics in the context of following reasons • Lack of a balanced approach, • Lack of understanding on deciding on the number of metrics to be used, • Lack of clear distinction between metrics at strategic, tactical, and operational levels.	Using a questionnaire with BSC approach a distinction has been made among different performance metrics. Each Performance metrics has been given value based on three criteria, Perceived usage value, frequency of use and Ease of measurement using three

the managers updated with agility, integration and flexibility related issues. The literature is dominated by empirical, case and conceptual studies so that managers are able to understand the dynamics of supply chain.

2.11 GAPS IN CONTEMPORARY RESEARCH

The identified gaps in literature provide opportunity for research in the area of SCM. There is vast scope of research in this area due to the fact that SCM encompasses a wide range of activities, where integration reflects the reality of business activities. Effectiveness of SCM is highly dependent on technological inputs such as use of IT tools, use of AMT tools etc. It is always possible to improve the supply chain performance as these technologies continually grow and mature. Besides technology, other issues such as social, behavioral, cultural relational etc. are major ingredients for the success of SCM. There is a vast scope of research in these areas also. Table 2.6 provides a list of identified gaps in literature. The identified gaps provide motivation for the present research. Issues related to technological enablement, integration and agility variables are widely attempted.

Earlier surveys of Indian supply chains are not focused towards assessing the agility and integration of the supply chain of advanced manufacturing systems.

2.12 CONCLUSION

In this chapter, a review of literature related to SCM has been reported. An issue based literature review has also been presented in this chapter. Due to nature and scope of the present research, technological enablement, information sharing, performance measurement system, integration and agility related issues in supply chain management are the main focus areas of the literature review Research papers related to state of art survey, case study etc., have also been studied and gaps have been identified and reported. Identified gaps have provided direction and motivation for the present research, which are reported in the subsequent chapters.

CHAPTER 3

AMT PRACTICES AND THEIR IMPACT IN INDIAN ORANIZATIONS

3.1 INTRODUCTION

Indian manufacturing enterprises were working in a protected environment, lacking in modern technology and facing less competition. After the liberalization of economy, they faced global competition. Several multinational companies, entered into Indian market, and brought new technologies and management practices. Since then different advanced manufacturing technologies have been implemented along with compatible management practices.

To provide best products and services to the customer, the holistic concept of supply chain management also implemented by the organizations, in which all the entities of the value chain are working together and deliver their competence to make the end product and services more competitive. The purpose of supply chain management (SCM) is to obtain the benefits of vertical integration without the associated costs.

In last one and half decade of development in industrial and service sector, SCM and AMT have become complementary to each other. The success of SCM depends to a large extent as the success of incorporating AMT in their supply chain. Also AMT has created many opportunities for the management of supply chain by providing information and automating the processes with the ability to produce large variety in small quantities with frequent new product introduction without incurring cost or delivery time.

In this chapter, the results of a questionnaire based survey of Indian manufacturing organizations are reported. Various other aspects of the survey such as questionnaire development, its administration, validity, descriptive statistics, and summary have also been discussed.

3.2 QUESTIONNAIRE DEVELOPMENT

To address the issues related to Technology-enablement of supply chains and also to assess the status of SCM in Indian industries, a questionnaire-based survey was undertaken. The questionnaire was designed keeping in view the available literature and the previous surveys. The practicing managers and academicians in the area of SCM were also consulted during the development of the questionnaire.

As the response rates of such surveys are not enthusiastic and the respondents are generally reluctant to spare time in responding to these questionnaires, the questions were set close ended, so that lesser time and efforts are needed in filling the questionnaire. It was designed on a five-point Likert scale. However, some of the questions contained objective type of options as well. In order to perform statistical analysis the individual responses were coded 1 through 5 according to their weight. The questionnaire was divided into three sections, Section I dealt with the organizational profile, Section II with supply chain management and advanced manufacturing technologies related issues, and Section III with performance measurement related issues in SCM.

3.2.1 Structure and Content Validation of the Questionnaire

The questionnaire was tested for two main types of validity (i) content validity, and (ii) construct validity. Content validity represents the adequacy with which a specified domain of content is sampled (Nunally, 1978) and that the instrument has items that cover all aspects of the variables being measured. Content validity cannot be determined numerically. Its determination is subjective and judgmental. It primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978). The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and detailed evaluations by academicians and practicing managers during pre-testing. The content validity was further tested during pilot survey as per the guidelines given by Forza (2002). After a careful review of the respondents' answers to the questionnaire during pilot survey, some questions were modified to convey their intended meaning, and few questions were deleted from the questionnaire as the suggestions received from the experts. The construct validity was verified through exploratory factor analysis. Factor analysis was conducted to test the uni-dimensionality of the multi-items perceptual measures. As per the suggestion of Kim and Mueller (1978) only items with a factor loading of more than 0.40 were used in the questionnaire.

3.3 QUESTIONNAIRE ADMINISTRATION

3.3.1 Target Industries for Questionnaire Administration

Four sectors from the Indian manufacturing industry were selected for the administration of the questionnaire. These are: (i) auto (ii) machine tools (iii) machinery and (iv) electrical and electronics.

These four sectors from the manufacturing industries are quite diversified in nature and it may be assumed that these are the representative sectors of the entire manufacturing industry. Though no specific supply chains were targeted in this study, the sample companies together constituted many diversified supply chains. For example, in the auto sector the sample consists of the OEM, and the first tier suppliers such as electronic components, steering, brakes, clutches, fasteners, glass suppliers etc. Some other first tier suppliers are part of the auto supply chain but due to the nature of manufacturing operations these have been put in the other sectors such as machine tools and electrical sector. Among the electrical and electronics sector companies, they import key components mainly from China/ Japan/ Korea and other East Asian countries. However, for the plants machinery and its maintenance it is dependent on the engineering sector.

The machinery industry is characterized by long lead time in manufacturing and product development and low level of participation by suppliers (Dangayach 2001). Machinery sector is the key supplier for establishing the set up for all manufacturing facilities. Machine tool industry has involvement of various advanced manufacturing tools like CAD/CAM/CAE and modern machining processes. Machine tool sector is the major supplier of different vendors, supplying the components to the OEM.

Among these, auto sector is seen as a flagship. It is also frequently regarded as a barometer measuring the current wealth of a nation’s economy (Childerhouse et al., 2003). Though it has similarity with the machinery and machine tools sector as far as the manufacturing processes are concerned yet the companies in this sector mainly use mass production, which is not always true in the case of other sectors. The extreme complexities and large bill of materials further makes it and ideal case for the study of SCM practices. The companies selected for the survey in this sector include both-the auto manufacturers and the auto component suppliers. On the basis of above observations, it may be said that though the respondent companies in these four sectors do not constitute four separate supply chain these are certainly the parts of many different supply chains. Therefore, a study of the perceptions and practices of these companies on SCM related issues might provide a fair assessment of the Indian manufacturing industry.

3.3.2 Method of Questionnaire Administration

The postal survey method was used for the administration of the questionnaire. Companies for survey were taken form the Directory of ISO 9000, 14000 and QS 9000 Certified Companies in India (Indian Promotion Center, 2006), Exhibitor catalogue (7th Auto Expo 2006 N Delhi)., ENGIMACH Souvenir (India Machine Tool Show 2007 New Delhi) companies in India and India's 500 largest wealth creator companies (Gandhok et al., 2000). In order to assess the SCM issues of advanced manufacturing systems in India, it was tried to ensure that the sample companies fulfill three minimum criteria: (i) the annual turnover is more than Rs 5 Crores and (ii) the employee strength is more than 50 (iii) using computer aided devices in manufacturing activities.

One thousand two hundred companies operating in India were identified for the survey. The survey was conducted during February-October 2007. In most cases only one questionnaire was sent to each of the sample company. Questionnaires, including a covering letter and a self-addressed stamped envelop were mailed to the senior executives such as chief executive officer/ managing director/vice- president/ general manger/ personnel manager etc. To encourage the response rate, the addressees were assured that they would be given the findings of the survey as soon as it is completed. Wherever needed, re-reminders followed the reminders. Personal visits, Phone calls and e-mails were also extensively used in promote the responses to the questionnaire. In most cases, the addressees filled the questionnaire at their own; however, in some cases other executives filled the questionnaires on behalf of the addressee. The respondents profile and the results of the survey are discussed in the next section.

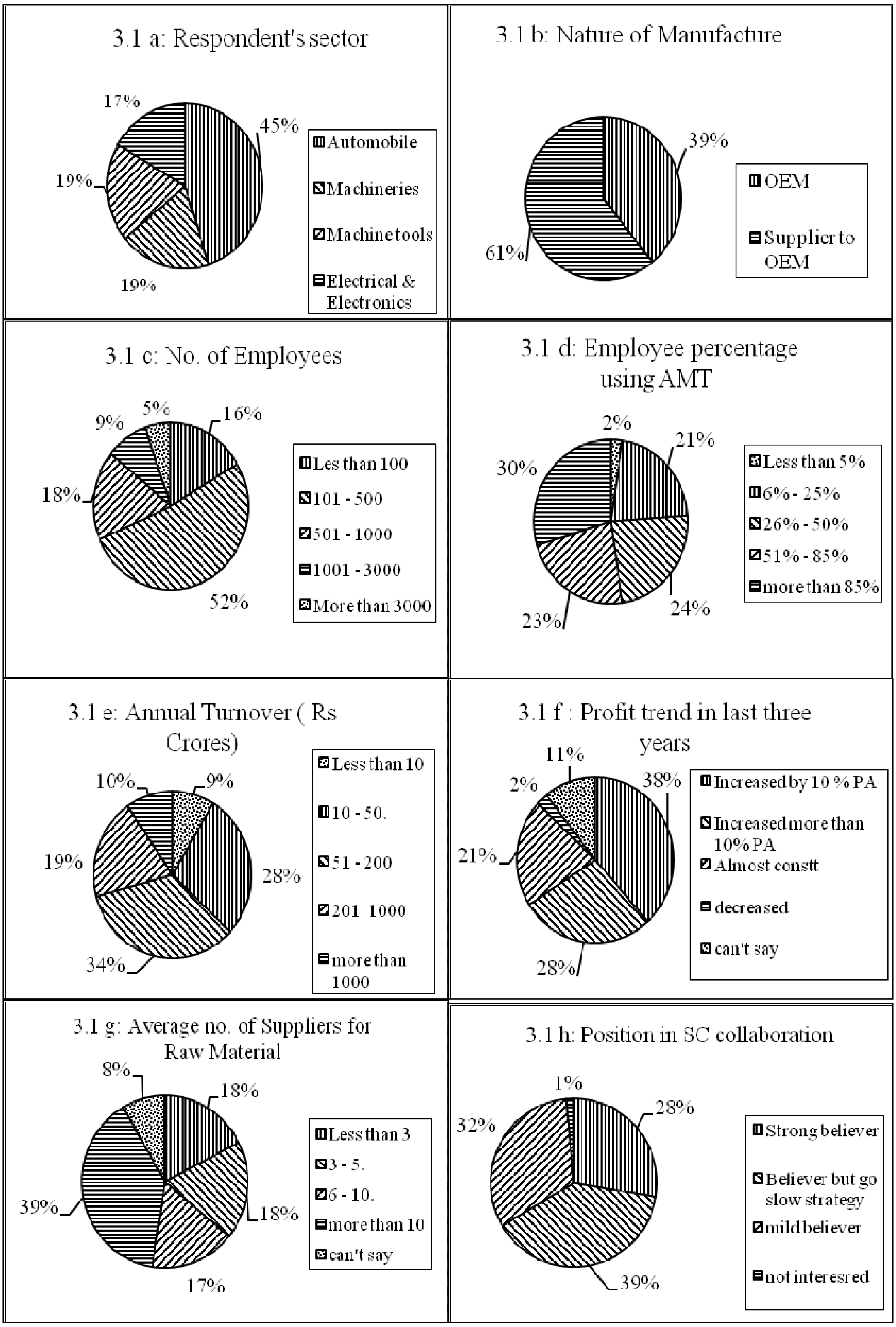


Figure 3.1: Respondents Profile

3.4 SURVEY RESPONSE AND RESPONDENTS PROFILE

Of the 206 usable responses, automobile and related industries comprised 45.1 % , Machine tools industries 19.4 % , Machinery 18.9 % and electrical & electronics 16.6 %. 60.7 percent are supplier to OEM and 39.3 percent are OEM. Other information like number of employees in the organization, annual turn over, average number of suppliers for raw material, use of AMT by employees, position/stand on supply chain collaboration, profit trends of last three years are given in (Figure 3.1).

3.4.1 Non-response bias

One test for non-response bias is to compare the answers of the early and late respondents (Lambert and Harrington, 1990). The logic behind this is that the late respondents are more likely to answer the questionnaire like non-respondents than the early respondents (Armstrong and Overton, 1977). Therefore, non response bias was assessed by comparing the responses, which were received late after sending two or more reminders (total 45 respondents in this case) with the early respondents do not significantly differ from the late responses. Therefore non-response bias in this study is ruled out.

3.4.2 Reliability of the Questionnaire Survey

For each question, wherever applicable, coefficient (Alpha α) was calculated to test the reliability and internal consistency of the responses. Alpha, with a value of more than 0.5 is considered adequate for such exploratory work (Nunally, 1978). The values of α for all the questions have been found to be more than 0.5 with an average value of 0.7347 (Table 3.1). It implies that there is a high degree of internal consistency in the responses to the questionnaire. The question numbers in Table 3.1 refer to the administered questionnaire, put as Appendix A1 of this thesis.

Table 3.1: Internal Consistency of the Responses

Que. no.	Question area	No. of items	Cronbach coefficient (α)
9	Competitive strength	11	.6056
10	Reasons of delays	5	.5715
11	Level of information sharing with suppliers	8	.8085
12	Level of information sharing with customer	9	.7364
13	Mode of correspondence	5	.5715
14	Use of AMT Tools	17	.8602
15	AMT information sharing	4	.7386
16	Problems in S C integration	5	.5736
17	Benefits of AMT enabled supply chain	17	.7386
18	Barriers in AMT enabled S C	10	.8354
19	Reasons of Adoption of AMT	9	.7079
20	Activities where AMT are used	8	.7300
21	Weightages of factors in AMT enabled S C	11	.6259
22	Degree of investments in AMT tools	10	.8830
27.1	Customer service related performance issues	10	.7555
27.2	Financial Measures	8	.5318
27.3	Internal business measures	14	.7626
27.4	Innovations and Other measures	11	.4889

3.5 RESULTS AND DISCUSSIONS

3.5.1 Supply Chain Strategy

Supply chain management (SCM) focuses on how firms utilize their suppliers; processes, technology, and capability to enhance their competitive advantage. It also promotes the coordination of manufacturing, logistics, and materials management functions within the organization (Lee and Belington, 1992). In order to the individual companies effectively work in a supply chain, proper coordination and planning among the linkages of the chain is necessary (Cartwright, 2000).

It has been found that 28.4 % of the respondent companies are strong believer in collaboration and are actively extending their supply chain. 38 % of the respondent companies believe in collaboration but use a go-slow strategy. 32 % of the respondents are interested in collaboration but have other priorities before entering into any such collaboration.

The results are similar to Sahay et al. (2003), they have observed that about one-third of the companies had no supply chain policies. Jharakharia and Shankar, (2004) have observed in their survey about Indian enterprise that more than half of the companies are strong believer in supply chain collaboration. They have included FMCG sector in their survey. The comparison of these two results indicates that FMCG sector have more willingness in supply chain collaboration as compare to manufacturing sector. Though the companies appear to be enthusiastic collaboration in their supply chain, it also appears that these collaborations are more on one-to-one basis as the companies are not in practice of regular joint meetings with all the partners of their supply chain.

3.5.2 Competitive Strengths of Respondent Organizations

The respondents are asked to rank the competitive strengths of their organization and the results are presented in Figure 3.2. Most of the respondents ranked the quality (4.18) as the major strength of their organization. Other competitive strengths like cost-effectiveness (3.85), manufacturing technology (3.46), product customization (3.42), innovativeness (3.38), service level (3.07) emerges as major competitive strength of the respondents.

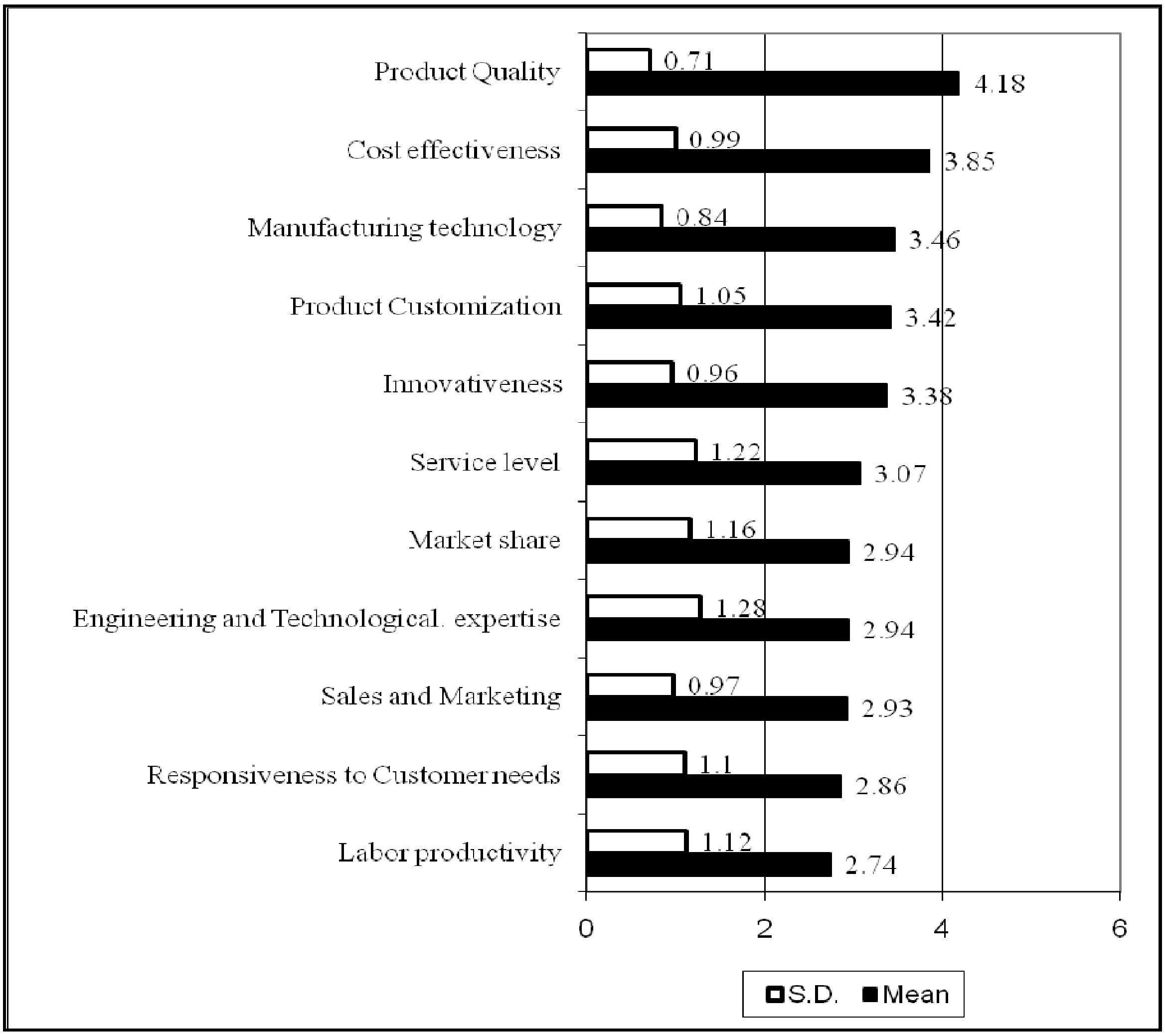


Figure 3.2: Competitive Strengths of the Organizations

Though manufacturing enterprises of neighbor country China produces stiff competition in terms of cost effectiveness (IPF annual report 2007). The parameters like labor productivity, engineering expertise and responsiveness to customer needs have low mean score, that shows the below average growth in manufacturing and related technologies in India. Human resource related issues may also the reason behind it. It can be observed that there is maximum variation in the engineering and technological expertise with standard deviation of 1.22 that indicates the significant variation in adoption of advanced technologies by manufacturing enterprises in India

Many companies are still lagging in expertise of engineering and technology. On the other hand Sahay et al (2003) reported about lack of adoption in IT related technologies.

3.5.3 Delays in SCM Processes

While everybody agrees that wasting time is undesirable, consensus on what constitutes wasted time is far from unanimous. High speed is not always synonymous with better use of time, but attacking and eliminating delays invariably improves throughput and customer services (Tersine and Hummingbird, 1995) Eliminating delays and improving product flow involves creativity, specialized skills, capital investments and behavioral changes.

Respondents are asked to rank the areas where majority of delays takes place in their organization (Figure 3.3). The maximum delay takes place in the order finalization (3.44) followed by manufacturing / operation (3.07) and material service procurement (2.98).

Figure 3.3: Delays in SCM Processes

It seems that still there is lack of trust building along the supply chain of Indian manufacturing organization. Agrawal and Shankar (2003) also reported about lack of trust among Indian manufacturers. Major thrust of their work is to promote on line trust building in Indian conditions through IT enablement.

3.5.4 Level of Information Sharing with Suppliers

In this survey an attempt has been made to explore the types of information, which supply chain partners usually share. For this purpose, eight widely used domains of information sharing were identified from the literature and discussions with academicians and practicing mangers. Respondents were asked to indicate their level of information sharing with the supply chain linkages on a 5-point Likert scale. Three most widely used areas of information sharing (Figure 3.4) have been identified. These are related to inventory status (3.83), company's production costs (3.45) and technology know-how

(3.34). The magnitude of this information sharing, as shown within the bracket, is an indicator of only moderate level of information sharing. Therefore, it may be inferred that there is enough scope of further collaboration.

The survey results indicate the involvement of supplier in the manufacture's processes (Freeman, 1998). This may be attributed to the time gap between these two surveys and due to the increasing awareness among the manufacturers about the constructive involvement of suppliers in their supply chain.

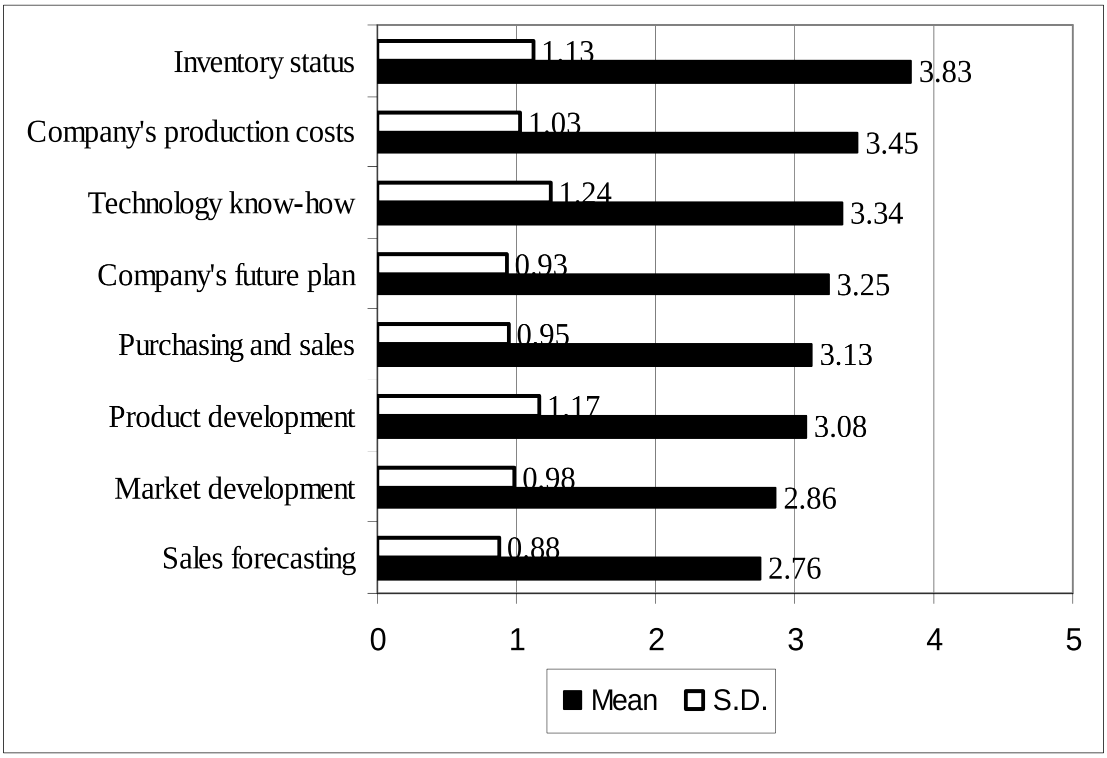


Figure 3.4: Information sharing with supplier

3.5.5 Level of Information Sharing with Customer

Same domains of information sharing as with suppliers are used in the questionnaire to know the status of information sharing with customers (Figure 3.5). It has been observed that information sharing with customer related to company's future plan is found to be in top with mean value of 3.60 followed by information sharing related to purchasing and sales, product development and order tracking. It shows their main focus on projecting their best image in front of customer. Information sharing related to company's production cost and technology know how are found to be low.

Figure 3.5: Information sharing with customer

There is maximum variation in the sharing of information related to purchasing and sales and technology know how. Several advanced manufacturing enterprise are sharing this information in top priority and many are traditionally conservative. It can be perceived that organizations are reluctant to share information related to technology know-how (2.84).

3.5.6 Mode of Information Sharing

To know the status of mode of information sharing being used in the supply chain, it has been asked to indicate the level of utilization of different mode of information sharing. Telephonic conversations are extensively being used by Indian manufacturers. Use of Internet, EDI and websites are more as compare to traditional mode of correspondence like fax and post/ courier. The details of the survey results regarding the mode of information sharing are shown in Figure 3.6

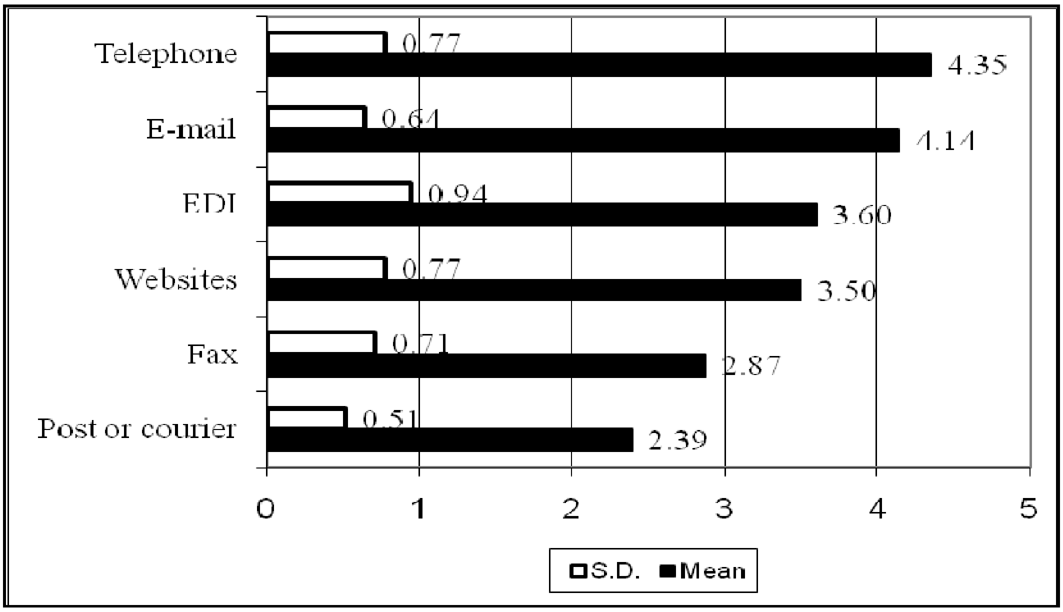


Figure 3.6: Mode of Information Sharing

3.5.7 Use of AMT Tools

As for use of AMT is concern, firms may use a number of AMT tools such as CNC technology, PLC's, automated inspection technologies, automated data capture devices, LASER oriented facilities, EDI, rapid prototyping, automated material handling devices, flexible manufacturing systems etc. Respondents were asked to indicate the level of use of these AMT tools in their organization.

It is observed from the survey that PLC's are the most widely used AMT tool, which is being used by 66% of the companies. ERP and CAD/CAPP software are also emerging as favorite AMT tools among the companies. Fifteen percent of the companies have planned to install ERP within next 6 months but 38% of the companies have no plan to use it in near future. However, the applications of FMS, robots, ASRS, CMS, rapid prototyping and SCM software are limited in the Indian manufacturing enterprises (Figure 3.7).

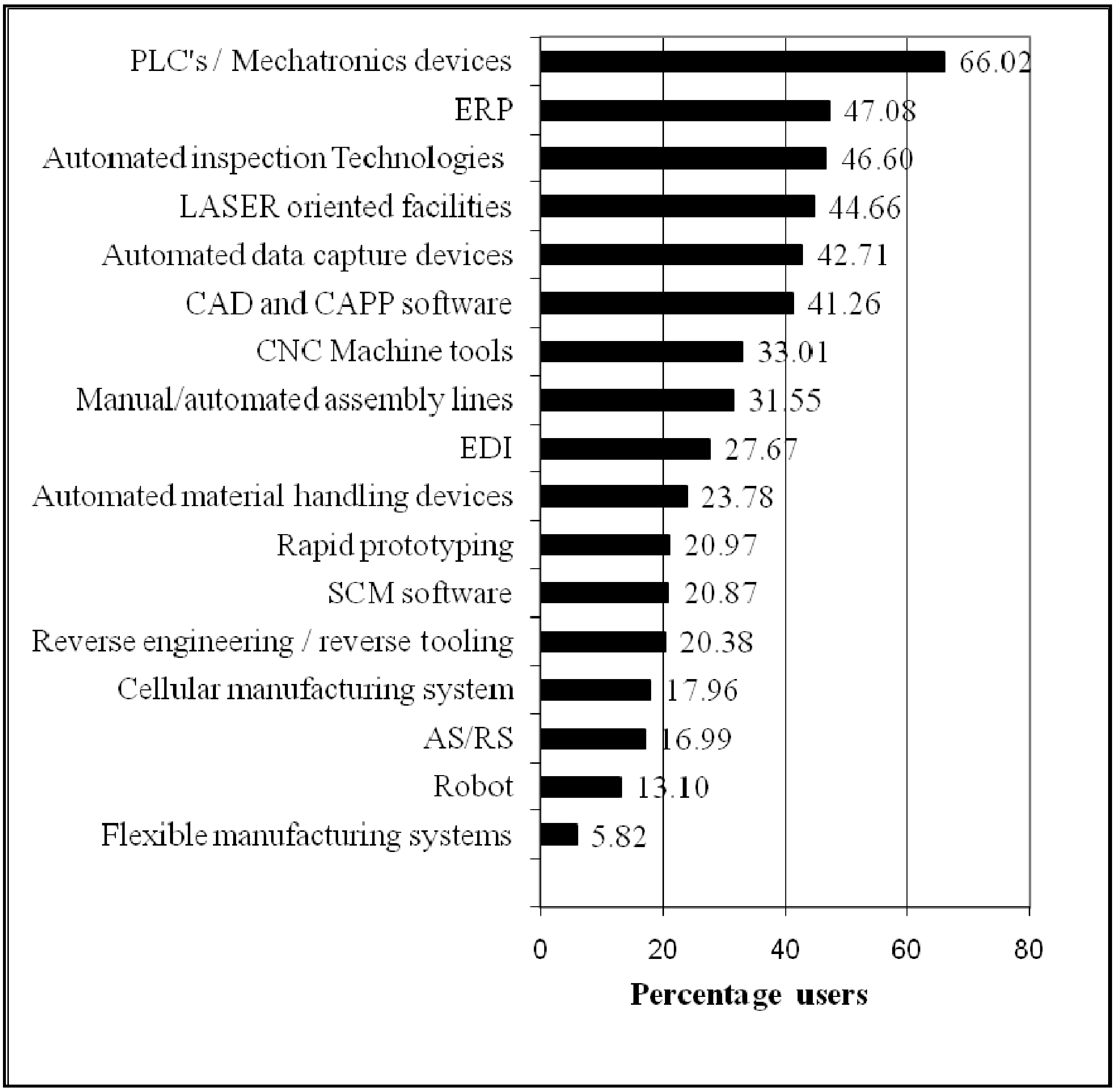


Figure 3.7: Use of AMT Tools

SCM software's are not much used automation tool, being used by only 20.87% of the companies. Jharakharia and Shankar (2003) reported 16.5% in their survey. Twenty nine percent of the companies intended to use it within next six month but about 50% of the companies had no plan to use it in the near future. In KPMG's global supply chain survey (Freeman, 1998), nearly all companies expected a dramatic increase in the requirement of EDI by their suppliers and customers in the years ahead. However, it does not seem to be valid in the Indian context. The application of bar coding is likely to increase in the coming years but EDI does not seem to be taking ground in the Indian companies. Though EDI is being used by 27% of the companies, more than 60% of the respondent companies have no plan to use it in the near future. ERP implementation has been reported in 47% of the surveyed companies, which is significantly higher than the 40% and 20% figure given by Sahay et al. (2003), and Saxena and Sahay (2000) respectively. However, Jharakharia and Shankar (2003) have reported the ERP implementation in 49%. Kadambi (2000) has reported the ERP implementation in 60% of the responding companies in India but it may also be recalled that his observation is based on only 32 responses.. Fodor (2000) has reported in his survey that 20% of the sample companies have implemented ERP software and 15% have opted to install SCM software. These results are almost similar to the past Indian surveys in terms of SCM software. The difference in the level of ERP implementation in India and in other countries of the globe may be attributed partially to the time gap between these surveys and partially to the local conditions and some other factors.

PLC's are still in use in most of Indian manufacturing companies, that indicates that Indian manufacturing enterprises are still adhere with relatively old technologies and they refrain to scrap such devices for adopting relatively modern control devices in their operations.

3.5.8 AMT Related Documents / Information Sharing

AMT related information sharing is very crucial in the supply chain. It has strategic impact on several areas of the supply chain management. Generally OEM use to provide technology related information to their supplier for their benefits. Technology related information sharing inherit long term benefits for all the supply chain partners (Zhou et al. 2002). In the survey, respondents are asked to indicate level of AMT related information sharing with the supply chain partners. The results of the responses are shown in Figure 3.8. From the results it appears that sharing of technology related information is unidirectional. Manufacturers are more interested to share such information with their suppliers (3.98). Technology related information sharing with customers is found to be low (2.69).

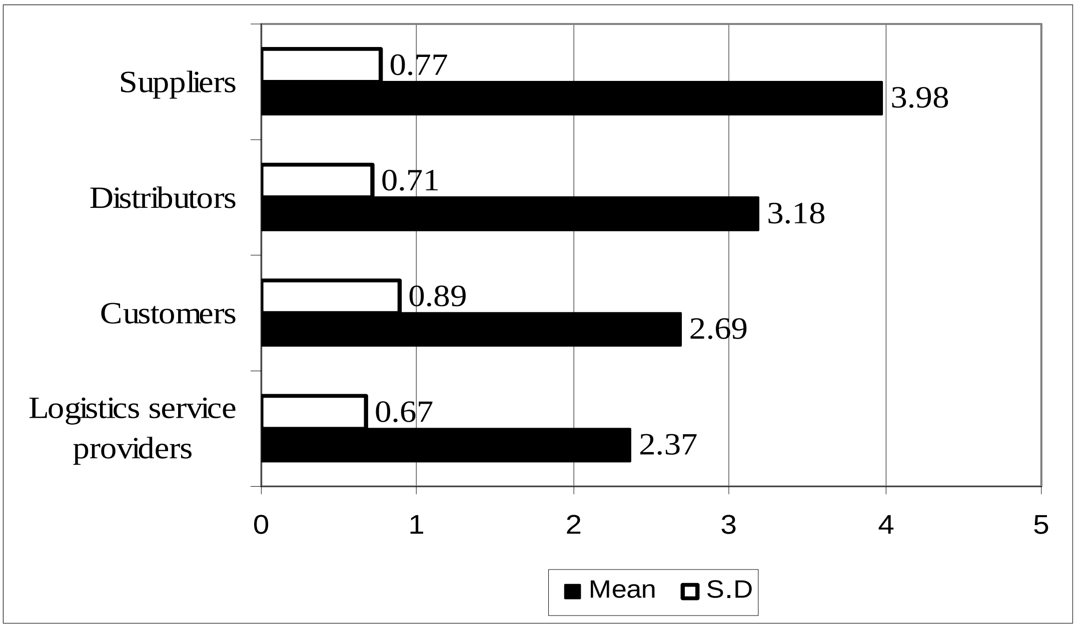


Figure 3.8: Level of AMT Related Document Sharing

3.5.9 Use of AMT in SCM Processes

In response of the question about use of AMT in different SCM processes; Design and process planning with score of (3.99) is at the top. This indicates that in planning and design, software's have almost replaced tradition ways of planning and design in Indian conditions (Figure 3.9).

Earlier Mukundan, 2003, reported the ease in penetrating the design and planning software's to replace tradition way of design and planning. Due to lack of enough use of SCM software's, there is lack of collaborative information sharing in Indian manufacturing conditions. Other areas where respondents are using AMT's are data sharing for design purpose (3.92), manufacturing scheduling (3.63), measurement and quality control (3.60), operation and material handling (3.52) and purchasing (3.14).

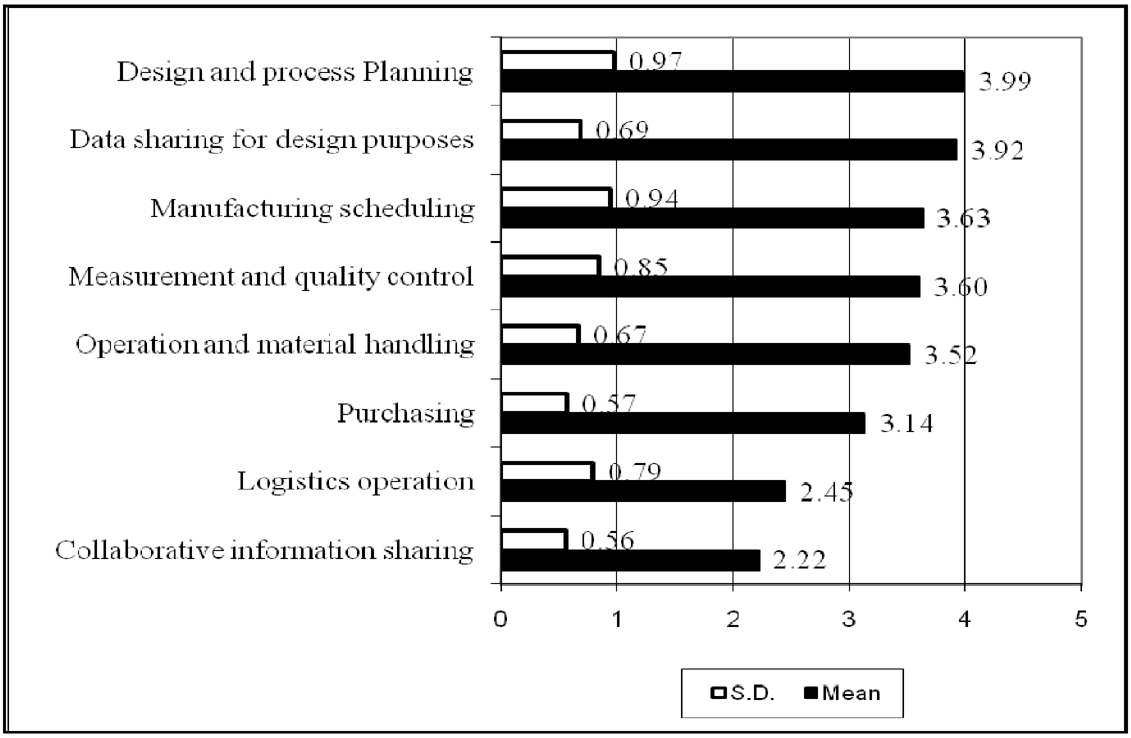


Figure 3.9: Use of AMT in SCM Processes

3.5.10 Reasons for Adopting AMT-enabled Supply Chain

The adoption of AMT has direct implications for the relationships with customers in at least three areas. Hayes and Jaikumar (1988) suggest that with the adoption of AMT there is a need to shift the manufacturing emphasis from a product orientation to a service orientation. Consequently, firms should foster tighter links with customers, with the emphasis being on achieving quick response to customer demand. To achieve this, customers should, wherever possible, be allowed to participate in product development. Second, the adoption of AMT production allows the manufacturer to reduce set-up times and produce in smaller lot sizes. Customer response to such capabilities might be to adopt a just-in-time (JIT) approach, changing demand patterns by reducing order sizes and increasing the number of orders. The resulting instability in demand patterns might place severe strain on the manufacturing system (Hill and chambers, 1991). Third, since the implementation of AMT could create an entire new market for the firms (Meredith, 1988), so that the firms should be more aggressive in using AMT as a competitive weapon.

Respondents are asked to indicate the reasons for adopting AMT enabled supply chain. The responses from Indian manufacturers are quite close to erstwhile surveys (Hayes and Jaikumar, 1988; Hill and Chambers 1991).

Top five reasons to adopt AMT's comes out from the responses are reduce throughput time (4.04), quick response to customer needs (3.95), quality of the product (3.89), facilitate early entry in the market (3.79) and pressure of the trading partner (3.68). Other possible reasons like consolidation of market share, improvement of overall efficiency, short product life cycle and reduced inventory costs scores with average of 3.3 (Figure 3.10).

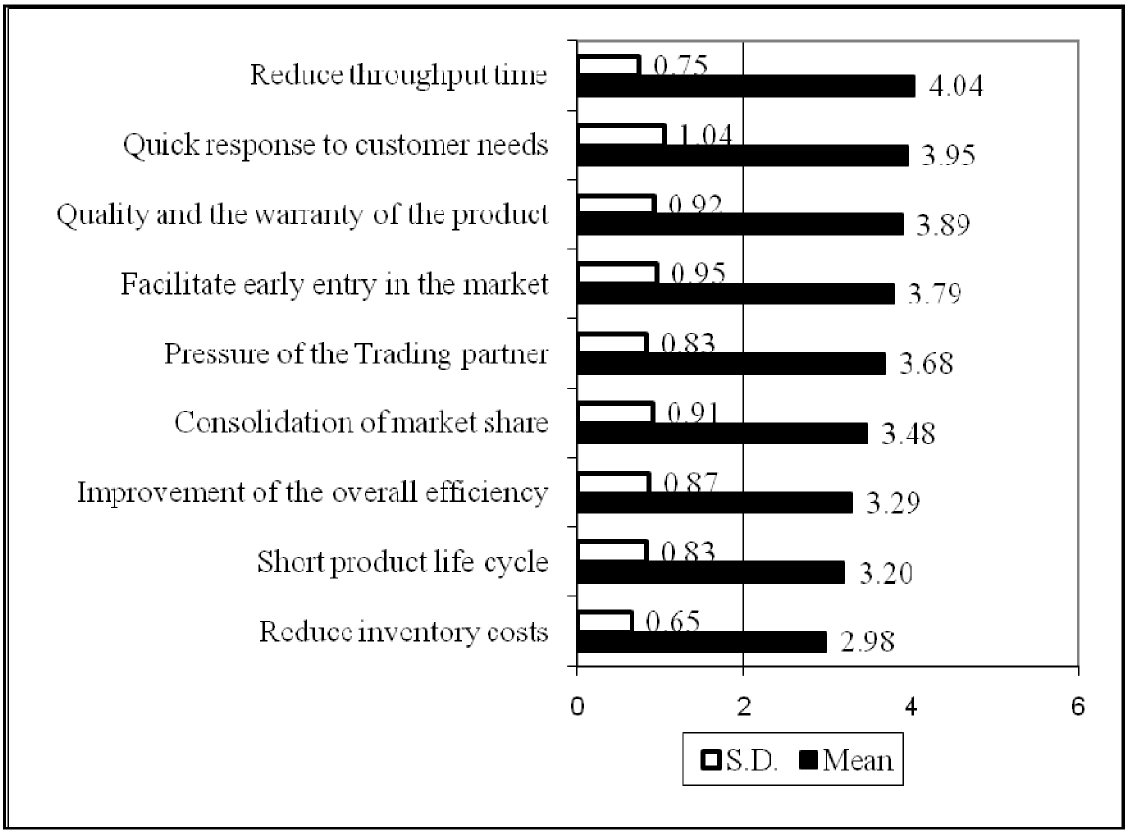


Figure 3.10: Reasons for Adopting AMT enabled Supply Chain

3.5.11 Benefits Perceived due to AMT-enabled Supply Chain

The AMT-enablement of supply chain offers several advantages to the users over the conventional supply chain where AMT is not predominantly used among the partners. In the present survey, most important benefits of AMT-enabled supply chain, are identified as order fulfillment time reduction (4.22), better customer service (4.17), product quality (4.13), responsiveness (4.08), better capacity utilization (3.99), access to world class service provider (3.91), an edge over new entrants in the industry (3.82), increase in turnover (3.78), improved relations in the supply chain (3.65) and inventory reduction (Figure 3.11).

The present survey endorses the view that improved customer service can be achieved through AMT-enablement as there is a possibility of significant reduction in lead times. It is also observed from the survey that, in the case of manufacturing companies, AMT-enablement of the supply chain does not much impact on the reduction in material acquisition cost, unit cost of production and unit transportation costs.

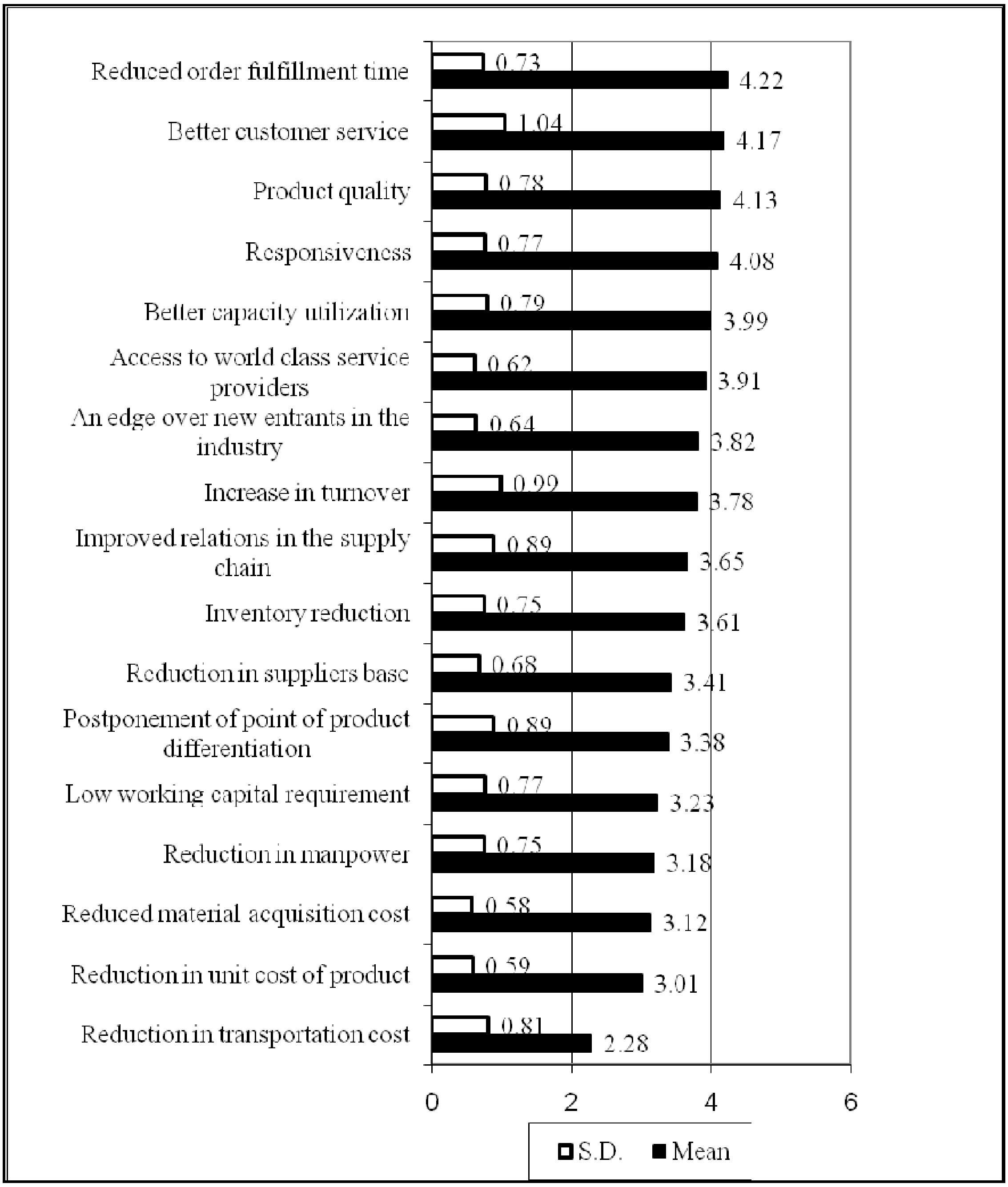


Figure 3.11: Benefits perceived due to AMT enabled Supply Chain

3.5.12 Barriers in the AMT enablement of Supply Chain

Barriers which can adversely affect the AMT-enablement of the supply chain were identified. Respondents were asked to indicate their option on these barriers. It is observed from the survey that a majority of the barriers, on which opinion of the respondents were sought, are of moderate intensity. Top three barriers comes out from responses are resistance to change/ innovation, low priority by the management and disparity in trading partners' capabilities (Figure 3.12).

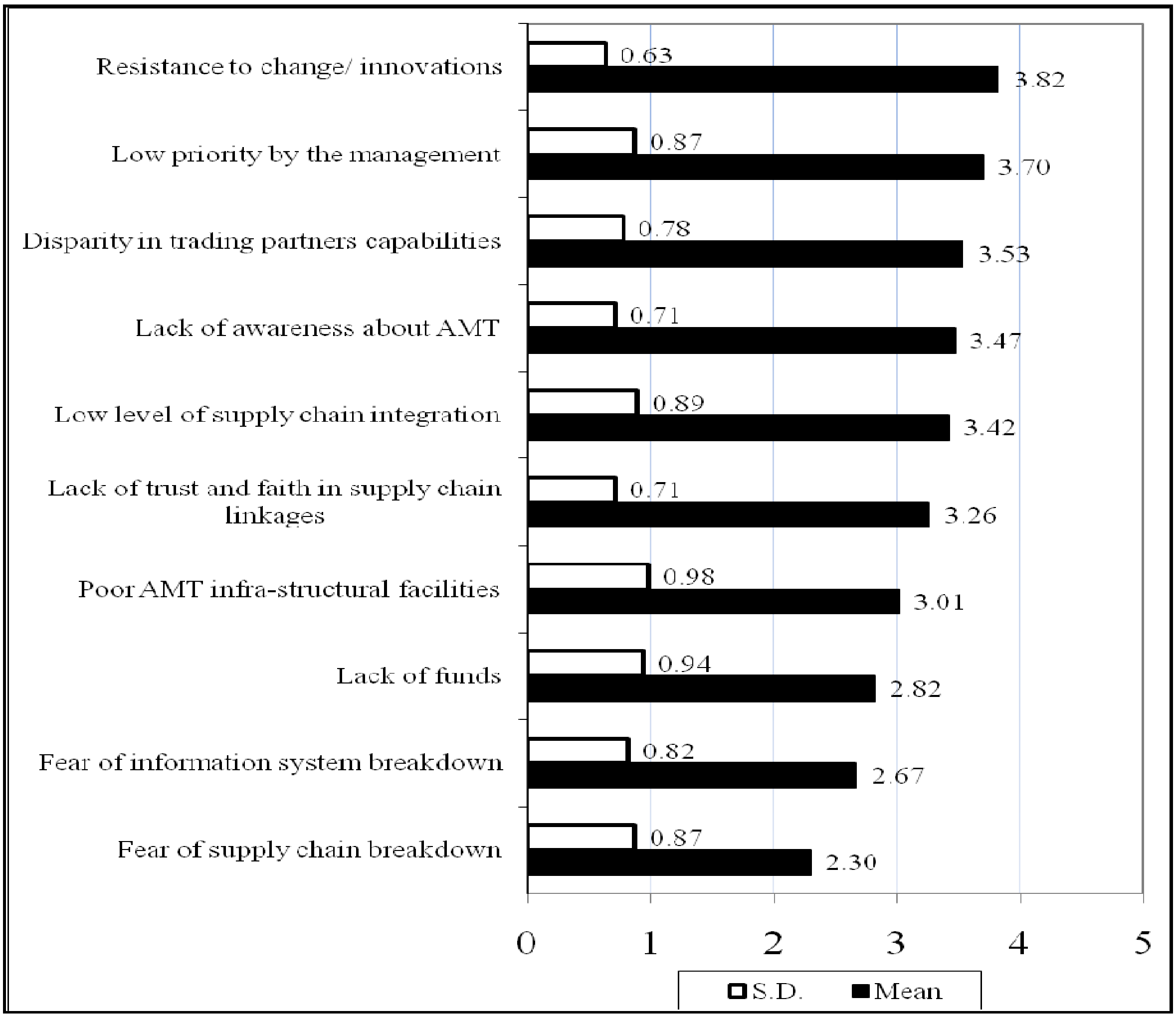


Figure 3.12: Barriers in the AMT Enablement of Supply Chain

These results indicate that the disparity in trading partners' AMT capability is one of the major barriers in the AMT-enablement of the supply chains. These results, when compared with the past survey in Indian context (Kadambi,2000), indicate that there is a similarity in these two surveys as Kadambi (2000) has also reported weak infrastructure outside the organization and small size of the trading partners as the inhibitors in the technology-enablement of the supply chains. Prior to that, Sohal et al. (2001) and Kwan (1999) have identified financial factors and lack of compatibility of partners as the barriers in the technology-enablement of manufacturing companies.

From these surveys, it may be inferred that the disparity in trading partners' capability is a major barrier in the AMT-enablement of the supply chain. This observation is in line with the observation of Angeles et al. (1998), who found that implementation of high level of technology alone do not automatically lead to success. These observations imply that though companies may put individual efforts to integrate their organization through technology but the integration of supply chain requires some minimum compatibility with the trading partners, and then only the potential of technology can be fully tapped.

3.5.13 Problems in Integrating Internet in SCM

The Internet is a tool that allows supply chain activities to be carried out in a synchronized, instantaneous manner, facilitating supply chain performance. The positive benefits of integrating the internet into management of the supply chain generally outweigh the risks and associated costs, and firms who have completed such integration hold a competitive advantage over those that have not. Internet deployment is rather a supply chain management tool that can be used to improve customer satisfaction, reduce costs, smooth production flows and shorten cycle times.

Use of internet has been spread all over India. It is expected that using internet, the Indian manufacturers will get better connectivity in the supply chain that results in an integrated supply chain. McCormack and Kasper (2002) have reported a significant relationship between Internet usage and supply chain performance, however, from the present survey, it appears that the use of Internet in Indian companies is mainly confined to communication through e-mails.

Other applications of internet like e-business, online ordering and order confirmation, online quotation, tracking of EPOS etc are not widely used by the respondent companies. In this survey, respondents were also asked to rank the problems in integrating their supply chain with Internet and it is observed that the poor service level (3.78), higher operating costs (3.57) and lack of trained manpower (3.21) are the main problems in integrating supply chain with Internet (Figure 3.13).

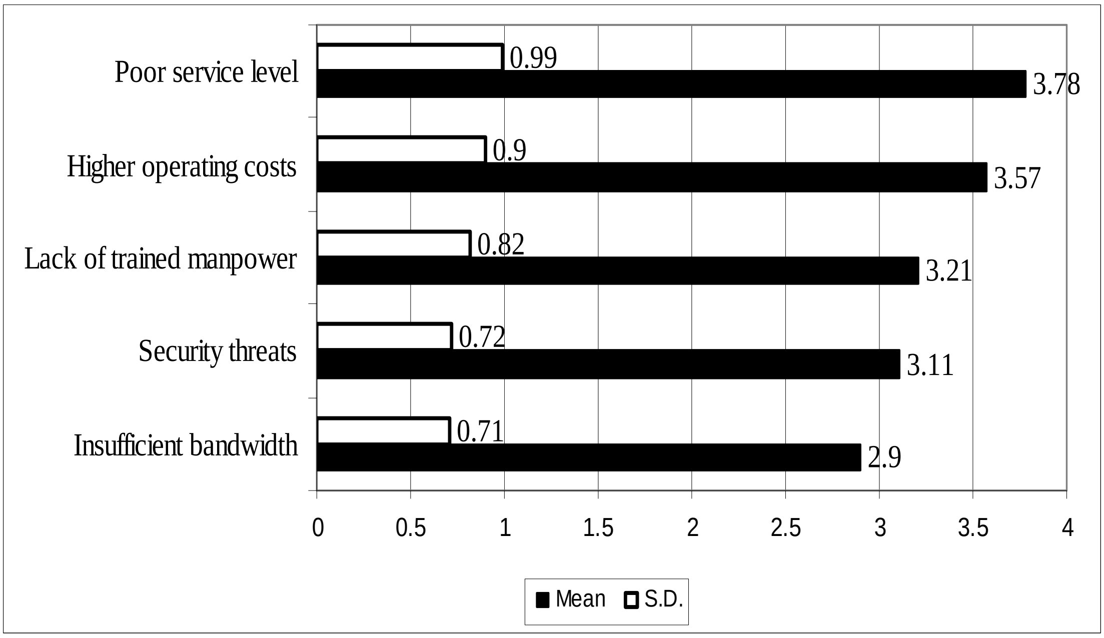


Figure 3.13: Problems in Integrating Internet in SCM

However, these problems are likely to get phased out with time as the rate of technology advancements in the recent years. Moreover, the mean value of respondents answer is around three, which represents a moderate level problem.

3.5.14 Degree of Investments in Automation Tools

Respondents were asked about the degree of investment made by their companies in various AMT tools, which support the smooth functioning of their organization and supply chain. It is observed from the survey that companies have made maximum investment in the computer aided design (3.57) and ERP (3.54) software (Figure 3.14). However, the companies have invested much less in SCM software (2.01), AS/RS and other storage devices (1.95), automated material handling devices (2.12) and employee training (2.21). Jharakharia and Shankar (2003) observed from their study that the investment in SCM software and extranet are likely to increase in future but the investment in EDI is not likely to significantly increase as instead of using extranet, the companies are now using Internet to send the information through e-mail and attachments.

Less investment in employee training is the issue that also reported by the (Sahay et al 2003). There is not much improvement as for as investment in research and development and employee training in last few years in Indian manufacturing scenario. This might be an area where Indian manufacturing companies need to focus upon. Investment on CNC technology is not done by all the respondents, so standard deviation is found to be high (Figure 3.14).

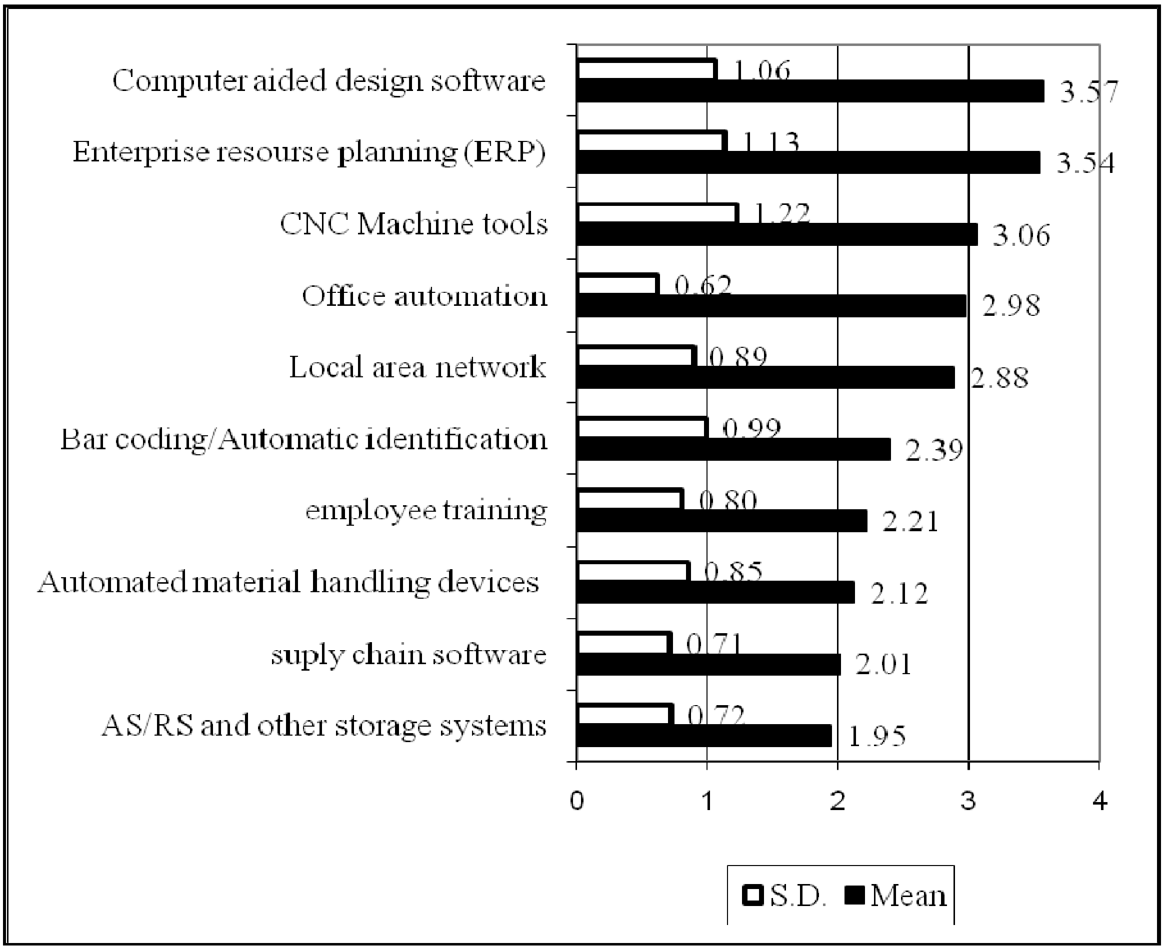


Figure 3.14: Degree of Investments in Automation Tools

3.5.15 Use of Performance Measurement Indicators

Respondents were asked to identify the most important performance indicators of a supply chain, relevant to their organization from the list of given indicators. The 15 most important performance indicators, as identified from the survey are shown in the Figure 3.15.

In the overall ranking of performance indicators, it is observed that on-time delivery (4.51); return on investment (4.48) and better product quality (4.4) are the three most important indicators for the performance evaluation of a supply chain. Among the top measures, three belong to financial measures and two belong to innovation and other measures. These findings indicate that the business managers accord a very high priority to the customer service and internal business measures. This result is justified also because it is the customer who is the ultimate evaluator of the supply chain by purchasing the products delivered through a supply chain and therefore customers' satisfaction level should figure in the performance of the supply chain.

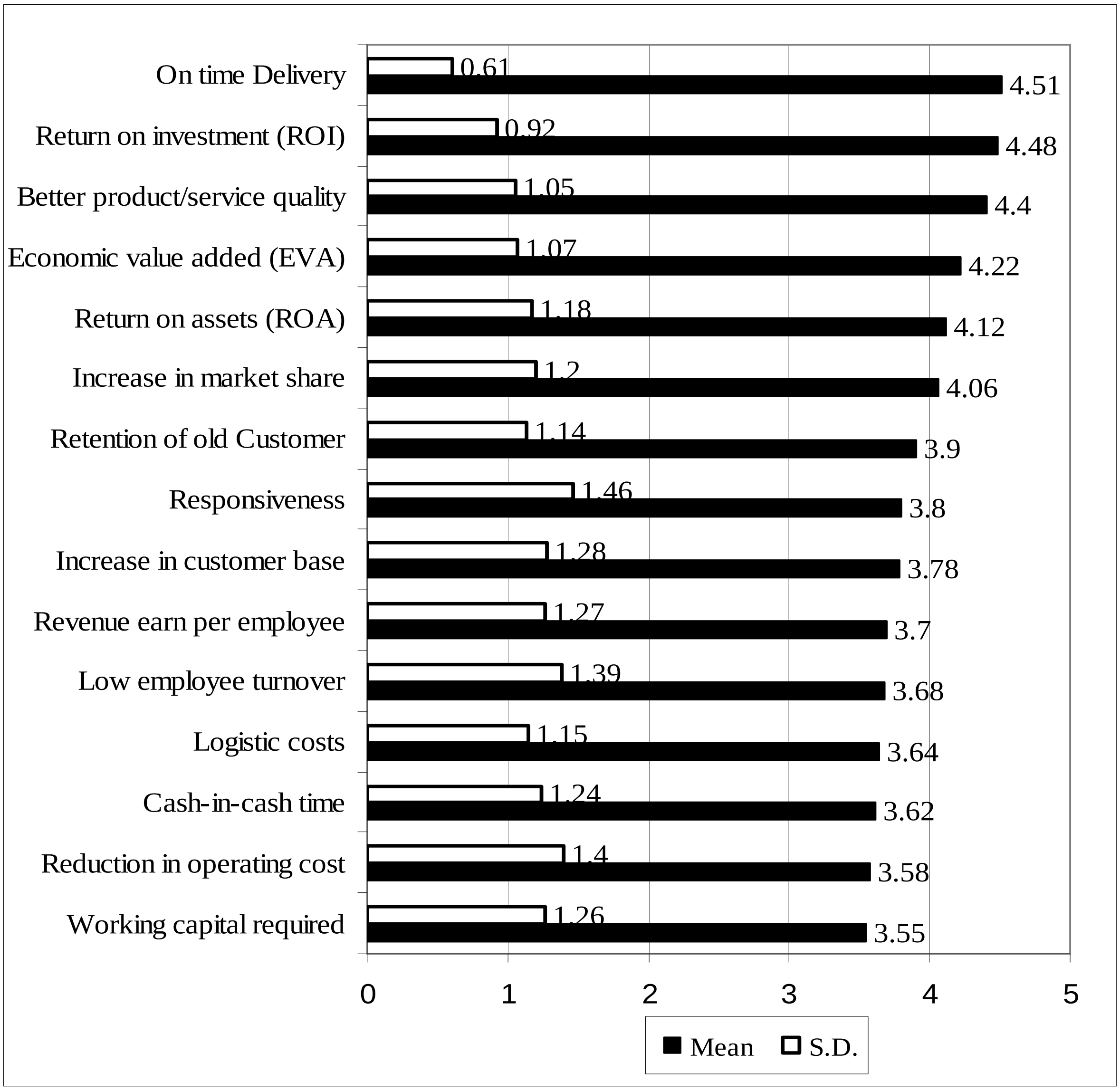


Figure 3.15: Top 15 Performance Indicators

3.6 DISCUSSION

The status of AMT-enabled SCM and the related issues in Indian manufacturing companies have been examined through a questionnaire-based survey. The findings indicate that Indian companies are moving ahead to adopt the supply chain practice and these are in line with the practices elsewhere. The benefits observed due to AMT-enablement have also been discussed in this study. The supply chain managers have to decide which AMT tools offer the greatest strategic values to their supply chain. The financial impact of AMT on the supply chain can be quantified only in certain areas like inventories, working capital and costs of communication but its impact on intangibles such as goodwill and the responsiveness of the company to react to situations is far greater. As more companies emphasize on responsiveness, the importance of AMT in SCM is going to be increasingly important in the days to come. It is observed from the survey that firms have upgraded their internal capabilities in terms of CNC technologies, computer hardware, internet, intranet, extranet, ERP etc but have been less successful in utilizing their capabilities for external co-ordinations, be it in terms of purchase process, design data sharing or inventory control etc. These figures indicate that though companies have developed individual AMT capability to a large extent, the integration and information sharing in the supply chain is still much lower than desired. Therefore, there is need to remove the barriers in the AMT-enablement in the supply chain. The observation of Close et al. (1997) is also valid in the context as the companies have developed their internal capabilities but substantial improvement is needed to make the supply chain integration a reality.

The strategic practices of VMI, 3PL, and cross docking are not widely used by the Indian companies and hence in the supply chain. This is an indication that there is a gap in the practices in the area of SCM. The disparity in trading partner's AMT capability, resistance to change to AMT enabled SCM, and level of supply chain integration need to be taken seriously as these are found to be the main barriers in the AMT enablement of the Indian supply chains.

3.7 CONCLUSION

The survey presented in this research empirically examines the SCM practices in the Indian manufacturing industries. Results from the study further indicate that information sharing and AMT have a pivotal role in SCM, whether it is the issue related to inventory reduction or buyer-supplier relationships. Therefore, long-term strategies should be developed to boost the information sharing across the supply chain. AMT is a facilitator to information sharing therefore, a high priority should be accorded to build up the AMT capability in supply chain organizations.

CHAPTER 4
SECTORAL ANALYSIS ON AMT IN SCM

4.1 INTRODUCTION

The Indian industry has started taking some initiatives towards improving agility, flexibility and responsiveness of their supply chains in order to survive in the highly competitive global market. In the last chapter, descriptive analysis of the survey has been considered. In this chapter, through a questionnaire based study, the various facets of SCM and AMT are analyzed to find the most frequently used elements and technologies. The respondents are categorizes into four sectors based on their association with the product. The other classification is based on type of manufacture, i.e. OEM and supplier to OEM.

The objective in this chapter is to understand the similarity/ dissimilarity with respect to the issues related to adoption of AMT-enablement between original equipment manufacturer (OEMs) and suppliers, and among different sectors within the Indian Industries, namely auto, machinery, machine tools, and electrical and electronics. We used the survey response of 206 respondents whose profile is already presented in chapter 3.

4.2 HYPOTHESIS FORMULATION

Two sets of hypotheses have been formulated. The first set of hypotheses belongs to the similarity/dissimilarities in use of technology by OEM and supplier to OEM in the supply chain, whereas the second set contains the hypotheses on similarities/ dissimilarities among sectors of Indian manufacturing industry in their SCM issues, aiming at establishing a relationship among these issues. In the second set of sector specific hypotheses, the aim is to test the dissimilarities if any among the sectors with respect to their supply chain practices.

4.2.1 Use of Technology in Supply Chain

4.2.1.1 Use of AMT

For the effectiveness of a supply chain the use of advanced manufacturing technology (AMT) plays an important role. Technology related issues play vital role in reducing various types of delays in the organization. In broader perspective AMT represents a wide variety of modern computer-based systems devoted to the improvement of manufacturing operations and thereby enhancement of firm competitiveness (Lei and Goldhar, 1991; Meredith, 1987)**.**

Advanced manufacturing technologies are a set of advanced and emerging manufacturing technologies and skills that can be deployed to increase the efficiency, productivity and profitability of the modern manufacturing industry (Marri et al. 2007). These technologies may include a number of elements in an integrated environment. The main objectives of advanced manufacturing technologies are to enhance manufacturing efficiency and productivity by improving flexibility of manufacturer's, equipment utilization, effectiveness of skilled labor, effectiveness of adaptation, to changing demand, the effectiveness of management, quality of products and work life, lead times and costs of manufacturing.

The main objective of the hypothesis formulation related to AMT use, is to checkout the benefits perceived by Indian Manufacturing Industries, especially in reduction of various delays that adversely affects the organization and supply chain as well.

IT enablement of supply chain results the elimination of several delays and helps in trust building (Agrawal and Shankar, 2003). To explore, how the managers perceives in considering the use of AMT and their benefits following hypothesis is formulated

Hypothesis 1a: *OEMs and suppliers have similarity in their perception in considering that use of AMT reduces the order fulfillment time.*

4.2.1.2 Use of ERP and automation tools

Enterprise resource planning (ERP) solution is an increasingly popular category of enterprise software that organizes and interconnects most day-to-day tasks of a business, such as entering orders, tracking product shipments, scheduling production, and updating sales forecasts and balance sheets (Donovan, 1999).

The movement towards B2B, e-commerce and SCM has ultimately forced ERP system providers to reevaluate their models. ERP venders would have to shift toward more flexible systems to compensate for the need to adapt to changing business cultures. Point and click systems are also a near-term direction to support more user-friendly operation and thus reduce training cost. Perhaps ERP venders' strongest assets are the large customer bases they possess. In the 1980s TQM was the business fad, then business process reengineering in 1990s, now companies are looking at ERP and SCM as the solution. The trend indicates that ERP will adapt through the incorporation of modular upgrades to current systems and the exploitation of the small- to medium-sized markets.

Accordingly, the industrial trend between ERP and SCM is that the integration of supply-chain capabilities with ERP systems will continue to be enhanced in the near future. One of the main reasons is that cross-enterprise integration will continue to be one of the major organizational goals, especially for those whose business success is directly dependent upon the success of their supply chain. Driven by the market forces such as shifting channel power and demand for fast cycle-time-to-market, SCM has created a critical and influential business success. Consequently, organizations begin to rely on SCM systems as a new source of competitive advantage. To explore the comparison of Indian manufacturing organization with difference in type of manufacture (OEM and suppliers) and how they perceives the use of ERP and automation tools, following hypothesis are formulated.

Hypothesis 1b*: OEMs and suppliers have similarity in their perception in considering that use of ERP and automation tools in the supply chain reduces the product/ material acquisition cost.*

Hypothesis 1c*: OEMs and suppliers have similarity in their perception in considering that use of ERP and automation tools in the supply chain helps inventory reduction.*

4.2.2 Information Sharing in Supply Chain

Auto sector have relatively more complex bill of materials. In this sector, many of the components and materials are outsourced from various suppliers. Outsourcing demands for active collaboration between the manufacturers and the suppliers in product development. These collaborations ensure the quality and reliability of the finished product. Due to these reasons the manufacturers in the auto and engineering sectors frequently share information with their suppliers. Some of the observations of the Arthur D. Little’s survey (1999) on SCM put auto sector as a leading user of SCM software. The companies in the auto sector involve suppliers in the forecasting and product development activities. It is reported that in sharing product design and strategic use of IT have made a global impact (Saxena and Sahay, 2000). These observations lead to the formulation of hypothesis as follows.

Hypothesis 2a: *Auto sectors more frequently share the product related information with the suppliers in comparison to other sectors.*

Hypothesis 2b: *Compared to other sectors, auto sector makes more use of AMT in design data sharing.*

4.2.3 Internal Business Activities

The increased competition and globalization have been the source of motivation to the business managers in paying more attention towards internal business activities such as inventory turnover, assets utilization, operating cost, manufacturing lead-time, just-in-time environment etc. The improvements in these activities result in lean and responsive supply chains. Auto supply chains are the examples of such lean and agile supply chains (Kehoe and Boughton, 2001; Svensson, 2001). These supply chains are considered as a network with both, high complexity and relativity high uncertainty in terms of variation in product level demand (Kehoe and Boughton, 2001).

Due to highly competitive environment in the auto industry, managers are motivated to adopt the latest tools and techniques of industrial engineering. The automotive industry thus defines the industry standards in any country (Bhateja and Banwet, 1999) and its study enables one to study the emerging trends in the developing countries (Dangayach and Deshmukh, 2005). Under such situations it may be assumed that the auto sector pay relatively more attention to internal business activities. Hence the next hypothesis is formulated as follows.

Hypothesis 2c*: The auto sector pays more attention to the internal-business performance measures of the supply chain compare to others.*

4.2.4 Customer Related Issues

Customers generally, concern to lead-time, quality of products and services, company's performance service and the cost effectiveness. But on long term basis and more importantly in the era of globalization any firm's competitiveness lies on different customer related issues (Gunasekaran et al. 2001). Automobile companies are facing tough competition in last decade. Since India has a big market with 1200 million people. So a global competition can be observed in days to come.

Our next hypothesis is dedicated to test the level of concern of the auto sector for customer related issues in comparison to other sectors.

Hypothesis 2d*: The auto sector pays more attention to the Customer service related* ***measures*** *of the supply chain compare to others.*

4.2.5 Financial Issues

Financial performance measures indicate whether the company's strategy, implementation and execution are effectively contributing to the bottom line improvement of a firm. Financial objectives include achieving profitability, maintaining liquidity and solvency both short term as well as long term, growth in sales turnover and maximizing wealth of shareholders. In simplicity, financial goals are to survive, succeed and prosper. Survival is measured by cash flow, success by growth in sales and operating income and prosperity by increased market share and return on equity and capital employed. Machinery and Machine tools industries are understood as key to entire manufacturing. From power generation to commissioning a plant this sector plays a vital role. The leading enterprises in India belong to this sector are quite old and financially sound.

So our next hypothesis is dedicated to this sector. Since the leading players of this sector have long life and survived in several decades. All aforesaid reasons are sufficient to formulate next hypothesis as follows:.

Hypothesis 2e: *The machinery and machine tools sectors pay more attention to the financial measures of the supply chain compare to other sectors.*

4.2.6 Investment for the AMT-enablement of Supply Chains

Use of technology in supply chains has become a necessity for the survival and growth of the companies (Sahay et al., 2003). The technology-enablement of a supply chain not only improves the responsiveness but also brings accuracy in communication. For the automation of their supply chain, firms may use a number of technological tools such as bar coding, extranet, EDI, SCM software, ERP etc. It is observed from the KPMG supply chain survey that the automotive sector has integrated its technological systems more than any other sector (Freeman, 1998). Similar observations were made by Fodor (2000): his survey indicates that automotive sector is the leader in adopting and investing in technological tools. Other sectors are also much aware to adopt and invest in AMT enabled supply chain but auto sector is known to adopt AMT for several reasons. These observations lead to the formulation of the last hypothesis as follows.

Hypothesis 2f: Auto *sector has made more investments towards the Technology -enablement of its supply chain as compared to other sectors.*

4.3 HYPOTHESIS TESTING

Statistical tests like t-test, correlations and ANOVA have been used to test the hypothesis on the SPSS version 15.00 software. For quick reference of the proposed hypothesis, each of the hypotheses is reproduced before it is tested for its validity.

4.3.1 Perceived Benefits of AMT

First hypothesis is dedicated to compare the OEM and supplier to OEM in terms of benefits perceived by the use of AMT. The respondents were asked to tell the benefits observed/ perceived due to AMT- enabled supply chain. Three important benefits have been taken namely reduction in order fulfillment time, product/material acquisition cost and inventory.

Hypothesis 1a: *OEMs and suppliers have similarity in their perception in considering that use of AMT reduces the order fulfillment time.*

The relevant descriptive statistics are shown in Table 4.1. Independent sample t-test has been carried out on the data collected from OEM's and suppliers to OEM's.

Table 4.1: Effect of AMT Tools in Order Fulfillment Time

Total (N = 206)		OEM (N = 81)		Supplier (N = 125)		Independent t Test	
Mean	S.D.	Mean	S.D.	Mean	S.D.	t	Sig.*
4.22	0.73	4.54	0.71	4.01	0.79	1.12	0.26

Where t value is not assumed for equal variance. Value with superscript * is significant at 0.05 level.

The Table 4.1 shows the 2-tailed significance values for the delay in manufacturing and operation. High significant value (more than 0.05) for the t-test indicates that there is no significant difference between the group means. This implies that hypothesis "*OEMs and suppliers have similarity in their perception in considering that use of AMT reduces the order fulfillment time"* can be accepted at the significance level of 0.05.

Hypothesis 1b*: OEMs and suppliers have similarity in their perception in considering that use of ERP and automation tools in the supply chain reduces the product/ material acquisition cost.*

The Table 4.2 shows the 2-tailed significance values for the reduction in product/ material acquisition costs. High significant value (more than 0.05) for the t-test indicates that there is significant difference between the group means. This implies that hypothesis "OEMs and suppliers have similarity in their perception in considering that use of ERP and supply chain automation tools in the supply chain reduces the product/ material acquisition cost" cannot be accepted at the significance level of 0.05.

Table 4.2: Effect of ERP and Automation Tools in reduction of Product / material acquisition cost

Total (N = 206)		OEM (N = 81)		Supplier (N = 125)		Independent t Test	
Mean	S.D.	Mean	S.D.	Mean	S.D.	t	Sig.*
3.12	0.78	3.42	0.73	2.92	0.91	3.18	0.001

Where t value is not assumed for equal variance. Value with superscript * is significant at 0.05 level.

Hypothesis 1c*: OEMs and suppliers have similarity in their perception in considering that use of ERP and supply chain automation tools in the supply chain helps inventory reduction.*

The Table 4.3 shows the 2-tailed significance values for the reduction in inventory level has High significant value (more than 0.05) for the t-test indicates that there is not significant difference between the group means. This implies that hypothesis "*OEMs and suppliers have similarity in their perception in considering that use of ERP and supply chain automation tools in the supply chain reduces the inventory level."* can be accepted at the significance level of 0.05.

Table 4.3: Effect of ERP and SCM Tools on Reduction in Inventory Level

Total (N = 206)		OEM (N = 81)		Supplier (N = 125)		Independent t Test	
Mean	S.D.	Mean	S.D.	Mean	S.D.	t	Sig.*
3.61	0.69	3.76	0.53	3.51	0.71	1.83	0.067

Where t value is not assumed for equal variance. Value with superscript * is significant at 0.05 level.

4.3.2 Sectoral Analysis in Sharing of Information

Second set of hypothesis have been formulated to demonstrate sectoral dissimilarity in types of information sharing in the supply chain. The responses have been categorizes based on the sector from they belong to, in four categories. The hypothesis has been reproduced as follows:

Hypothesis 2a: Auto *sectors more frequently share the product development and future requirements related information with the suppliers in comparison to others.*

Table 4.4: Sectoral Comparison on Information Sharing Related to Product Development

Information sharing related to product development	Sectors	N	Mean	S.D.	ANOVA	
					F	Sig*
with the supplier	Auto	93	3.48	1.09	11.91	.002
	Machinery	39	2.99	1.27		
	Machine tools	40	2.35	0.95		
	Electrical	34	2.98	1.11		

Where value with superscript * is significant at 0.05 level

From Table 4.4 it has been observed that mean value of information sharing related to product development is highest for Auto sectors followed by Machinery, Machine tools, and Electrical and electronics sectors, ANOVA test has been conducted to test the difference among the sectors. The results of the test point out of the group means differ significantly (less than 0.05). Therefore hypothesis can be accepted.

The Mean of Auto sectors and other sectors has been compared using Independent t-test. The results from Table 4.5 suggest the significant difference between the Auto and other sectors hence hypothesis will be accepted. So using ANOVA and Independent t-test both favors the hypothesis, therefore the hypothesis is accepted.

Table 4.5: Information Sharing related to Product Development with Supplier

Sample		Auto (N = 93)		Others (N = 113)		Independent t Test	
Mean	S.D.	Mean	S.D.	Mean	S.D.	t	Sig.*
3.08	1.17	3.48	1.03	2.76	1.21	3.24	0.001

This Indicate that Auto sector is leader in successfully exploiting SCM practices in Indian manufacturing Scenario. While other sectors are in process of adopting SCM practices especially information sharing through which SCM integration is possible.

Hypothesis 2b: *Compared to other sectors, auto sector makes more use of AMT in design data sharing.*

Table 4.6: Sectoral Comparison on Use of AMT in Design Data Sharing

Sectors	N	Mean	S.D.	ANOVA	
				F	Sig*
Auto	93	4.11	0.55	4.91	.06
Machinery	39	3.99	0.73		
Machine tools	40	3.78	0.85		
Electrical	34	3.51	0.91		
Total	206	3.92	0.69		

Where value with superscript * is significant at 0.05 level

To test this hypothesis the respondent were asked to indicate the level of use of AMT in design data sharing with their supply chain partners. The respondents were asked to indicate their answer on a five-point Likert scale. The relevant descriptive statistics is shown in Table 4.6.

The descriptive statistics indicate that auto and machinery sectors are ahead of others in using AMT for design data sharing. An independent sample t-test is conducted to test the hypothesis is shown in Table 4.7. The mean of Auto Sector has been compared with the other sectors. Since p-value is more than 0.05 in Tables 4.6 and 4.7 respectively. Therefore hypothesis is not accepted.

Table 4.7: Use of AMT in Design Data Sharing

Sample		Auto (N = 93)		Others (N = 113)		Independent t Test	
Mean	S.D.	Mean	S.D.	Mean	S.D.	t	Sig.*
3.92	0.69	4.11	0.55	3.77	.65	1.34	0.18

***Hypothesis 2c**: The auto sector pays more weight age to the internal-business performance measures of the supply chain compare to others.*

To test this hypothesis the respondents were asked about the importance given by their organization to some internal business activities for the purpose of supply chain performance measurement. The mean values of the importance assigned by the different sectors to internal business measures on a five point scale shown in Table 4.8.

Table 4.8 Sectoral Comparison on Internal Business Performance Measures

Weightage to Internal business measures	Sectors	N	Mean	Standard Deviation
Inventory Turnover ratio	Auto	93	3.26	1.14
	Machinery	39	3.07	1.09
	Machine tools	40	2.99	1.12
	Electrical	34	2.89	0.93
Assets utilization	Auto	93	4.41	0.89
	Machinery	39	4.07	0.94
	Machine tools	40	3.85	0.79
	Electrical	34	3.57	0.99
Reduction in throughput time	Auto	93	3.59	1.32
	Machinery	39	3.16	1.22
	Machine tools	40	3.32	1.19
	Electrical	34	3.03	1.14
Reduced waste	Auto	93	4.08	1.17
	Machinery	39	3.06	1.28
	Machine tools	40	2.89	1.22
	Electrical	34	2.93	0.98
Just in time environment	Auto	93	3.86	1.14
	Machinery	39	2.78	1.23
	Machine tools	40	2.82	1.09
	Electrical	34	2.65	1.01
Cash to cash cycle time	Auto	93	3.41	1.11
	Machinery	39	3.45	1.21
	Machine tools	40	3.68	0.99
	Electrical	34	3.46	0.87
Purchase lead time	Auto	93	2.76	1.10
	Machinery	39	2.83	0.79
	Machine tools	40	3.68	0.98
	Electrical	34	2.46	0.88
Manufacturing lead time	Auto	93	3.81	0.72
	Machinery	39	3.45	0.99
	Machine tools	40	3.18	1.09
	Electrical	34	3.45	1.13
Plant productivity	Auto	93	3.34	1.21
	Machinery	39	3.67	1.16
	Machine tools	40	3.68	1.08
	Electrical	34	3.53	0.89

The Table 4.9 indicates a difference between auto and other sectors on internal business measures. The importance assigned by the respondents to internal business measures in measuring the performance of a supply chain is compared on independent sample t-test. The results of the t-tests indicate that for nine items, which belong to internal business measures, the mean values of importance assigned by auto sector is more than the rest of the sectors. Further, in seven of these nine items considered for internal business, the difference in the importance assigned between the auto and the rest of the respondents are significant (at a p value of 0.05 or less) therefore the hypothesis is accepted (Table 4.9).

Table 4.9: Internal Business Performance Measures

Item	t-value	p-value	Mean Auto	Mean others
Inventory Turnover ratio	2.09	0.04	3.26	2.98
Assets utilization	2.54	0.01	4.41	3.84
Reduction in throughput time	3.66	0.00	3.59	3.17
Reduced waste	1.95	0.05	4.08	2.94
Just in time environment	3.14	0.00	3.86	2.74
Cash to cash time	0.94	0.35	3.41	3.53
Purchase lead time	2.86	0.00	2.76	3.01
Manufacturing lead time	1.78	0.07	3.81	3.35
Plant productivity	2.98	0.00	3.34	3.63

Hypothesis 2d: The *auto sector pays more attention to the Customer service related measures of the supply chain compare to others.*

To test this hypothesis the respondents were asked about the importance given by their organization to select customer service related activities for the purpose of supply chain performance measurement. The mean values of the importance assigned by the different sectors to customer related measures on a five point scale shown in Table 4.10

Table 4.10: Sectoral Comparison on Customer Service Related Performance Measures

Weightage to Customer service related Issues	Sectors	N	Mean	Standard Deviation
On time Delivery	Auto	93	4.56	0.98
	Machinery	39	3.81	1.01
	Machine tools	40	3.96	1.13
	Electrical	34	4.08	1.05
Order fill rate	Auto	93	3.74	1.13
	Machinery	39	3.34	1.07
	Machine tools	40	3.21	0.89
	Electrical	34	3.5	1.25
After sales service	Auto	93	3.48	1.1
	Machinery	39	3.01	1.26
	Machine tools	40	2.88	0.89
	Electrical	34	3.18	1.13
Increase in customer base	Auto	93	3.71	1.11
	Machinery	39	4.08	1.04
	Machine tools	40	3.86	1.09
	Electrical	34	3.95	1.19
Retention of old Customer	Auto	93	4.18	0.94
	Machinery	39	3.97	0.89
	Machine tools	40	3.95	0.82
	Electrical	34	4.09	1.01
Product customization	Auto	93	3.94	1.12
	Machinery	39	3.32	1.03
	Machine tools	40	3.18	0.94
	Electrical	34	3.48	1.16
Better product quality	Auto	93	4.76	0.72
	Machinery	39	4.09	0.82
	Machine tools	40	4.14	0.67
	Electrical	34	4.28	0.75
Ease in tracking customer order	Auto	93	3.67	0.99
	Machinery	39	3.35	1.28
	Machine tools	40	3.51	1.19
	Electrical	34	3.49	1.32
Increase in market share	Auto	93	4.24	1.03
	Machinery	39	3.7	0.89
	Machine tools	40	3.86	0.93
	Electrical	34	4.09	1.04

The table indicates a difference between auto and other sectors on customer related measures.

The importance assigned by the respondents to customer related measures in measuring the performance of a supply chain is compared on independent sample t-test (Table 4.11). The results of the t-tests indicate that for nine items, which belong to customer related performance measures, the mean values of importance assigned by auto sector is more than the rest of the sectors in eight out of nine measures. Further, only two of these nine items considered for customer related performance measures, the difference in the importance assigned between the auto and the rest of the respondents are not significant (at a p value of 0.05 or less) therefore the hypothesis is rejected

Table 4.11: Customer Service Related Performance Measures

Item	t-value	p-value	Mean Auto	Mean others
On time Delivery	1.78	0.07	4.56	3.94
Order fill rate	1.43	0.15	3.74	3.33
After sales service	1.27	0.20	3.48	3.00
Increase in customer base	0.91	0.36	3.71	3.96
Retention of old Customer	0,85	0.39	4.18	3.99
Product customization	2.38	0.02	3.94	3.32
Better product quality	1.98	0.05	4.76	4.15
Ease in tracking customer order	1.61	0.11	3.67	3.45
Increase in market share	1.77	0.09	4.24	3.87

Hypothesis 2e*: The machinery and machine tools sectors pay more attention to the financial measures of the supply chain compare to auto and electrical sectors.*

To test this hypothesis the respondents were asked about the importance given by their organization to select financial issues for the purpose of supply chain performance measurement. The mean values of the importance assigned by the different sectors to financial measures on a five point scale shown in Table 4.12

Table 4.12: Sectoral Comparison on Financial Performance Measures

Weightage to financial issues	**Sectors**	**N**	**Mean**	**Standard Deviation**
Cost per unit of product	Auto	93	3.69	1.27
	Machinery	39	4.15	1.15
	Machine tools	40	4.03	1.32
	Electrical	34	3.99	094
Net profit per unit sales	Auto	93	4.45	0.82
	Machinery	39	4.65	0.93
	Machine tools	40	4.69	0.85
	Electrical	34	4.39	0.79
Turnover	Auto	93	4.75	0.58
	Machinery	39	4.84	0.52
	Machine tools	40	4.86	0.59
	Electrical	34	4.74	0.72
Return on investment (ROI)	Auto	93	4.34	1.1
	Machinery	39	4.64	1.06
	Machine tools	40	4.6	0.97
	Electrical	34	4.36	1.04
Economic value added (EVA)	Auto	93	3.34	1.17
	Machinery	39	4.13	1.04
	Machine tools	40	4.03	1.10
	Electrical	34	3.49	1.23
Working capital required	Auto	93	3.53	1.46
	Machinery	39	4.1	1.26
	Machine tools	40	4.14	1.29
	Electrical	34	3.36	1.17
Logistic costs	Auto	93	3.74	1.15
	Machinery	39	3.9	1.21
	Machine tools	40	3.87	1.19
	Electrical	34	3.69	1.07
Revenue earn per employee	Auto	93	3.33	1.27
	Machinery	39	3.92	1.13
	Machine tools	40	4.01	1.25
	Electrical	34	3.48	1.19

The table indicates a difference between Machinery and Machine tools and other sectors on financial measures. The importance assigned by the respondents to financial measures in measuring the performance of a supply chain is compared on independent sample t-test (Table 4.13). The results of the t-tests indicate that for eight items, which belong to financial performance measures, the mean values of importance assigned by machinery and machine tools sector is more than the rest of the sectors in all measures. Further six of these eight items considered for financial performance measures, the difference in the importance assigned between the machinery and machine tools sector and the rest of the respondents are significant (at a p value of 0.05 or less) therefore the hypothesis is accepted.

Table 4.13: Financial Performance Measures

Item	t-value	p-value	Mean (M/c and M/c Tools)	Mean others
Cost per unit of product	2.35	0.02	4.09	3.76
Net profit per unit sales	2.57	0.01	4.67	4.42
Turnover	0.89	0.37	4.85	4.75
Return on investment (ROI)	3.04	0.003	4.62	4.34
Economic value added (EVA)	2,85	0.005	4.08	3.38
Working capital required	3.38	0.00	4.12	3.48
Logistic costs	0.98	0.32	3.88	3.73
Revenue earn per employee	3.61	0.00	3.96	3.37

Hypothesis 2f: Auto *sector has made more investments towards the Technology -enablement of its supply chain as compared to other sectors.*

Regarding investments towards AMT-enablement of supply chains, nine commonly used AMT tools were included in the questionnaire. The items used for the comparison are: investments in CAD Softwares, CNC Machine Tools, automated material handling system, Office Automation, bar-coding, Local area Network (LAN), automated storage and retrieval system (AS/RS), SCM software, and ERP software (Table: 4.14) .

Table 4.14: Sectoral Comparison on Investment on AMT- enabled Supply Chain

Investments towards the AMT Tools	Sectors	N	Mean	Standard Deviation
AS/RS and other storage systems	Auto	93	2.46	0.94
	Machinery	39	1.74	0.88
	Machine tools	40	1.32	0.46
	Electrical	34	1.53	0.50
Automated material handling devices	Auto	93	2.26	0.98
	Machinery	39	2.51	0.66
	Machine tools	40	1.85	0.83
	Electrical	34	1.63	0.45
Bar coding/Automatic identification	Auto	93	2.98	1.16
	Machinery	39	1.76	0.93
	Machine tools	40	1.69	0.87
	Electrical	34	2.35	0.79
CNC Machine tools	Auto	93	3.32	1.32
	Machinery	39	3.29	0.89
	Machine tools	40	3.65	0.77
	Electrical	34	1.38	0.51
Computer aided design software	Auto	93	3.62	0.93
	Machinery	39	3.65	1.25
	Machine tools	40	4.27	1.12
	Electrical	34	2.52	0.82
Enterprise Resource Planning (ERP)	Auto	93	3.7	1.14
	Machinery	39	3.71	1.19
	Machine tools	40	3.08	0.95
	Electrical	34	3.46	1.24
Local area network	Auto	93	2.67	0.94
	Machinery	39	3.39	0.82
	Machine tools	40	2.83	1.04
	Electrical	34	2.91	1.01
Office Automation	Auto	93	2.88	0.81
	Machinery	39	3.09	0.73
	Machine tools	40	3.32	0.65
	Electrical	34	3.19	0.76
Supply chain software	Auto	93	2.54	0.95
	Machinery	39	1.69	0.77
	Machine tools	40	1.39	0.82
	Electrical	34	1.66	0,55

Respondents were asked to indicate the degree of investments made by their organization on these tools. They were asked to answer in reference to the annual turnover of their organization. The descriptive statistics for the use of these items in the surveyed sectors is shown in Table 4.14.

To test this hypothesis, auto sector is compared with rest of the sectors covered in the questionnaire (Machinery, machine tools, and electrical and electronics) on independent sample t-test. The comparison is made for the degree of investment made by these sectors on these AMT tools. The results of the t-tests are shown in Table 4.15.

The results of the t-test indicate that six out of nine AMT's have p-value more than 0.05. So the hypothesis may be rejected

Table 4.15: Investments on AMT enabled Supply Chain

Item	t-value	p-value	Mean (Auto)	Mean others
AS/RS and other storage systems	3.28	0.002	2.46	1.53
Automated material handling devices	1.73	0.08	2.26	2.01
Bar coding/Automatic identification	2.88	0.004	2.98	1.90
CNC Machine tools	1.27	0.20	3.32	2.85
Computer aided design software	1.49	0.137	3.62	3.52
Enterprise Resource Planning (ERP)	1.09	0.27	3.70	3.40
Local area network	0.95	0.34	2.67	3.05
Office Automation	.0.89	0.37	2.88	3.06
Supply chain software	2.78	0.006	2.54	1.57

4.4 DISCUSSION

The research conducted in this chapter is important because through hypotheses, it establishes the relative importance of two or more independent variables, which influence a key issue in SCM. For example, use of AMT tools is an important aspect in SCM, and may promote several SCM processes. However, a manager would be more interested to find out the issues, which play a dominating role in improving these relationships. It is observed from the first hypothesis that OEM and suppliers in Indian manufacturing enterprises have similar perception in considering the effect of AMT reduces the order fulfillment time. At the same time OEM and Suppliers have difference in opinion about use of ERP in hypothesis 1b. Significant difference has been found between their mean value as for as the use of ERP and supply chain automation is concern. This may because of suppliers are often fail to utilize the benefits of ERP systems which may be often OEM.s friendly. Other reason in Indian context may be the poor connectivity of up stream partners of suppliers with ERP and other automation tools. It shows that in Indian manufacturing enterprises ERP and automation systems need to be improve for connecting upper stream partners also.

Hypothesis regarding the effect of ERP and automation tools on inventory reduction has been accepted. Since the advent of several Japanese concepts like JIT and other inventory reduction approaches Indian managers are much aware and focused on inventory reduction strategies hence able to utilize automation tools to do so. Both OEM and suppliers are found equally competent in utilizing ERP and automation tools in order to inventory reduction.

Results from the study further indicate that information sharing related to product development with supplier is more common in Auto sector compare to other sector. There is tough competition in Auto sector as compared to others in Indian scenario. Auto sector is quicker in product development and launching new product more rapidly. The existing nature of this industry promotes information sharing with the suppliers in order to rapid product development and to remain competitive in Indian markets. Compare to others machine tools sectors has been found less mean value compare to other sector. Indian machine tools Industry still rely on imports of electronics and soft wired systems, so the information sharing level with supplier has been found to be low.

A similarity is observed between auto and other sectors in use of AMT in design data sharing. This may be because of growing software industries in India in terms of software development and skilled users. Most of Indian companies has been switch over to modern way of design data sharing from traditional way. Computer is going to be common tool for every industry. So there is not much difference among different sector in use of AMT in design data sharing. Still mean value of Auto sector is more than others with a slender margin.

Auto sector pays more weightage to internal business performance measures as compared to others. The Auto sector is ahead with others in mean value on most of the internal business performance measures. The main reason behind it may be dedicated to level of competition in this sector. Auto sectors witnesses, frequent adoption of AMT's, hence able to focus more effectively on their internal business related issues. It can be observed that Electrical and electronics sector is next to auto sector as for as mean value is concern. Machinery and machine tools sector is still have a long way to give weightage to internal business performance measures.

A similarity is observed between auto and electrical and electronics sector towards the focus on customer related issues. Increasing growth in communication and growing competition in cellular phones and electronics components this sector is going to be closer partner of Auto sector. In several customer related performance measure electrical and electronics sector is ahead of machinery and machine tools sectors. Hypothesis has not been accepted because high p-value in majority of issues. This may be due to growing awareness about customer related measures among all the sectors

The conventional nature of machinery and machine tools sector have been explored in hypothesis 2e, where it has been found that these sectors pay more attention towards financial performance measures. Mean value for various financial measures are high as compared to internal and customer related measures for almost every sector. Machinery and machine tools sectors are generally supplier to variety of industries like Auto, process, consumer items, so they may have disadvantage in their position towards upstream of the supply chain. Much focus on financial issue may be results of insecurity they posses, as largely depends on other sectors.

It is observed from hypothesis 2f that of all the tools which are commonly used for the AMT-enablement of a supply chain, machinery and machine tools sector has made lesser investments as compared to any other sectors in the study. Among the discussed AMT tools, the investment made by the machinery and machine tools sector is significantly low for extranet, ERP and SCM software. The machinery sector is known for longer lead-time in new product development and also the large manufacturing lead-time Therefore, it is suggested that by investing in these automation tools, lead-time may be reduced, It may also result in concurrent new product development, responsiveness and better customer service.

The hypothesized findings indicate that SCM has its own importance but different sectors are adopting it as per their own requirements and working environments. From a practical perspective, the analysis reveals that there is some fundamental dissimilarity in the operations and working of some sectors and this might be the cause of dissimilarities in their supply chain practices.

4.5 CONCLUSION

Testing of two sets of hypotheses has been presented in this chapter. These hypotheses are concerned with the use of AMT's as well as the sectoral similarities and dissimilarities. It is observed from the first set of hypotheses that manufacturing enterprises perceives the benefits of use of AMT that ultimately reduces the inventory level, hence cost effectiveness and profits. Further, inventory reduction is another important issue in SCM. Proper information sharing among the supply chain members may help in reducing the inventory level within an organization and hence within the supply chain. Among the sectoral hypotheses, it is observed that auto sector is more conscious about implementation of SCM performance measures in more effective way with advanced managerial approaches. This has apparently led to the focus of industry and academia to study the various issues, related to SCM in the auto sector.

CHAPTER 5

AMT ENABLED SUPPLY CHAIN

5.1 INTRODUCTION

India has achieved high economic growth rate in recent years, and is likely to perform well in future. The growth is largely due to the fast growing software exporting industry and outsourcing service business from developed countries. The implementation of Information technologies and software can be perceived more in banking and financial sectors than manufacturing sector. Manufacturing sector is yet to explore the use of software technologies to the extent of global standards. As a result, Indian manufacturing industry is not as competitive as East Asian and Chinese manufacturing industry. Nevertheless, having more than 1 billion people and a big market, India has high growth potential in manufacturing sector too. Adoption of suitable Advanced Manufacturing Technologies to consolidate SCM by Indian firms is a critical issue that may determine how quickly and how widely Indian manufacturing enterprises can grow to meet global standards and competitiveness. This chapter is focused on the strategic benefits that are significant in the adoption of AMT to consolidate supply chain management in Indian manufacturing industries. This chapter is focused to investigate

- The level of use of different manufacturing technologies in India, on scale ranging from the simple technologies to integrated technologies such as flexible manufacturing system and automated assembly lines.
- Different views are held by Indian manufacturing industry in the adoption of AMT as compared to other countries.
- Reasons for adoption of AMT’s.

- Benefits perceived due to AMT enablement of supply chain management.
- Identify critical reasons of AMT adoption.

In order to achieve some of these objectives, we surveyed of firms in India on their AMT implementation in their way to consolidate Supply Chain Management. Statistical techniques like factor analysis and discriminant analysis are used to identify important or significant interrelations among various AMT and their benefits to SCM.

Zhao et al. (1997) examined 27 “successful factors” important to the adoption of AMT in Singapore manufacturing industries. Discriminant analysis was used to identify “successful factors” that contributed positively to the adoption of AMT. Those significant are project team integrity, strategic planning, project championship, and technical knowledge. They also used Factor Analysis to help reduce 27 “successful factors” to 9 common features that were used in their Discriminant Analysis.

A comprehensive survey on the adoption of AMT was carried out by Statistics Canada (1998) (Statistics Canada is a Canadian central statistical agency and has the legislative responsibility for providing indicators of science and technology activity in Canada). In that survey, a total of 3702 companies completed survey questions. The questionnaire used in that survey has nine main sections, covering important factors of business strategy, current status of AMT implementation, shortage of various types of skilled personnel, results of AMT adoption, obstacles to AMT adoption, etc.

Pyke et. al. (2002) surveyed 120 manufacturing firms of different types of ownership (e.g., state-owned, privately-owned, joint-venture, and wholly-owned foreign subsidiaries) in the Shanghai area of China. They concluded that the differences among the ownership types are often insignificant. Their work provides a very good measure of the overall level of AMT adoption in Shanghai, one of the best developed regions in China.

A complementary survey in less developed region of China was conducted by Sun *et al.* (2001). They surveyed 30 state-owned enterprises (SOEs) in Northeast China, where heavy industries are located. They found that the level of AMT used in these Chinese SOEs is much lower than expected. One reasonable explanation might be that the Northeast region in China lags far behind China's southeast coastal region with reference to ongoing economic reforms.

Kotha et al. (1998) compared the use of 18 AMT in the U.S. and Japan in an exploratory study using data from 160 U.S. firm and 125 Japanese firms. AMT use is significantly different in the two countries. U.S. manufacturers use more scheduling and control technologies, their Japanese counterparts use more factory floor technologies. Swamidass *et al.* (2002) compared the use of 17 different technologies in similar industries in the U.S. (sample size 1025) and U.K. (sample size 166) using a common questionnaire. Largely, there are remarkable similarities between the two countries. U.S. manufacturers are ahead of the UK firms in computerized integration; more UK manufacturers reported the use of soft technologies such as just-in-time, total quality manufacturing and manufacturing cells.

Jharkharia and Shankar (2003) in their survey studied about IT-Enablement of the Supply Chain Management of selected Indian Industries. They surveyed 108 Indian firms, mostly in Northern and western part of India. They found that Indian Companies are moving ahead to adopt the supply chain practices and these are in line with practices elsewhere. They also found that firms have upgraded their internal capabilities in terms of computer hardware, Internet, Intranet, Extranet, ERP etc. but have been less successful in utilizing their capabilities for external co-ordination, be it in terms of purchase process, design data sharing or inventory control etc.

Thakur et al. (2007) in their survey found that the adoption of simple and less sophisticated technology in India is high. For large companies AMT adoption is more advantageous than small companies. Using Factor analysis on their survey they also concluded that implementation of AMT in technologies that demand extensive human interaction in India is highest and is lowest in technologies with heavy investments.

5.2 ELEMENTS OF AMT

The questionnaire used in Thakur et al. (2007) is the most comprehensive one we have found. We adopt major AMT's from that questionnaire. The questions from our questionnaire used in this chapter consist of *nine* major Issues with a total of 91items (Table 5.1).

Table 5.1: Description of the Major Issues in the Questionnaire

Q.No	Major Issues	No. of Items
1	Current Status and Future Status of AMT Implementation	17
2	Level of Advanced manufacturing related information sharing	4
3	Main problem in Integrating supply-chain with AMT	5
4	Benefits perceived due to AMT enabled supply chain	17
5	Rank of the barriers in the AMT – enablement of the supply- chain	10
6	Reasons of adopting AMT-enabled supply chain	9
7	Use of AMT in different manufacturing activities of the organization	8
8	Weight age of factors in formulating AMT-enabled supply chain strategy	11
9	Degree of Investments in automation tools	10
	Total	91

Table 5.2 gives a list of 17 advanced technologies with a brief description. Since benefits perceived by AMT adoption in the Supply Chain used in Jharkharia and

Shankar (2003) are useful in providing insights in the IT adoption process, we complement our questionnaire by most of AMT benefits on their list.

Most items on our questionnaire are close-ended with definitive responses. All the questions in the questionnaire require only appropriate check marks or circles except some that ask for text content. Most questions are designed to use a five point Likert scale, for instance, 1 represents low and 5 high. This helps us obtain comparable statistics in the data analysis stage.

Brief description of the AMTs included in the survey are given in following sections

5.2.1 **CNC Machine Tools**

In modern CNC systems, end-to-end component design is highly automated using CAD/CAM programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools, drills, saws, etc., modern machines often combine multiple tools into a single "cell". In other cases, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the complex series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design. This technology is well established and generally used as stand alone basis in India, so it can be put under simple AMT category (Yeung, 2003).

5.2.2 CAD/ CAPP Software

Computer-aided design (CAD) is the use of computer technology for the design of objects, real or virtual. CAD often involves more than just shapes. As in the manual drafting

Table 5.2: Description of the Advanced Manufacturing Technologies

Technologies	DESCRIPTION
1 CNC Machine tools	CNC technology uses the output produced by CAD systems to control the machines that manufacture the part or the product
2. Computer Aided Design (CAD) and CAPP software	Use of computer-based software for designing and testing new products. Use of software for process planning.
3. PLC'S and Mechatronics devices	Computer-aided manufacturing uses the output produced by CAD systems to control the machines that manufacture the part or the product
4. Flexible Manufacturing Systems	Collections of computer-controlled machine tools, serviced by robots and/or automated material handling systems and overseen by computers
5 Automated material handling devices	Use of computer-controlled equipment to handle and store goods and materials
6. Cellular Manufacturing System and Group	Grouping of similar parts into families for production in manufacturing cells for greater efficiency
7. Automated data capture technologies i.e. optical, magnetic, smart card, machine vision etc.	Automated Data Capture (ADC) refers to the methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems (i.e. without human involvement). Technologies typically considered as part of ADC include bar codes, Radio Frequency Identification (RFID), biometrics, magnetic stripes, Optical Character Recognition (OCR), smart cards etc
8. Manufacturing Resource Planning (MRP II), /Enterprise Resource Planning	Information systems used to keep track of machine loading, production scheduling, inventory control, and material handling
9.SCM software	Supply chain management software is a business term which refers to a range of software tools or modules used in executing supply chain transactions, managing supplier relationships and controlling associated business processes.
10. EDI	Electronic Data Interchange (EDI) refers to the structured transmission of data between organizations by electronic means. It is used to transfer electronic documents from one computer system to another, i.e. from one trading partner to another trading partner.
11. Robots	Robots with sensing capabilities: Robots programmed to alter their function based on input from sensors more sophisticated robots; Robots without sensing capabilities: Robots programmed to undertake simple tasks such as picking and placing, less sophisticated robots
12. Rapid prototyping systems	Systems capable of producing a prototype part from the output of a computer-aided design
13 AS/RS.	Automated Storage and Retrieval System (AS/RS) refers to a variety of computer-controlled methods for automatically placing and retrieving loads from specific storage locations
14. Reverse Engineering/ Reverse Tooling	Reverse engineering (RE) is the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation.
15. LASER oriented facilities	Lasers used for such processes as welding, cutting, treating, scribing and marking
16. Manual/ Automated Assembly lines	An assembly line is a manufacturing process in which parts (usually interchangeable parts) are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods
17. Automated systems used for inspection/testing	Automated systems used for inspecting/testing incoming materials or final products for inspecting products for defects, blemishes, color, orientation, etc

of technical and engineering drawings, the output of CAD often must convey also symbolic information such as materials, processes, dimensions, and tolerances, according to application-specific conventions. CAPP is a highly effective technology for discrete manufacturers with a significant number of products and process steps. Rapid strides are being made to develop generative planning capabilities and incorporate CAPP into a computer-integrated manufacturing architecture. The first step is the implementation of GT or FT classification and coding. Commercially-available software tools currently exist to support both GT and CAPP. As a result, many companies can achieve the benefits of GT and CAPP with minimal cost and risk. Effective use of these tools can improve a manufacturer's competitive advantage (Xu, and He, 2004).

5.2.3 Programmable Logic Controller (PLC) and Mechatronics Devices

A PLCs' is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or lighting fixtures. PLCs' are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

Mechatronics is an interdisciplinary area of engineering that combines mechanical, electrical and computer science. A typical mechatronics system picks up signals from the environment, processes them to generate output signals, transforming them for example into forces, motions and actions (Lee and Nicholls, 1999)

5.2.4 Flexible Manufacturing System (FMS)

FMS is a manufacturing system in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted. This flexibility is generally considered to fall into two main categories, which both contain numerous subcategories (Tiwari and Vidyarthi, 2000).

The first category, machine flexibility, covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part. The second category is called routing flexibility, which consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability. A typical FMS consists of organized integration of several technologies, so it can be put under the category of integrated technologies.

5.2.5 Automated Material Handling Devices

The techniques employed to move, transport, store, and distribute materials, with or without the aid of mechanical equipment The use of computers to control the moving and positioning of materials in a warehouse or factory. Automated handling may involve the use of automated conveyors, elevators, AGVs and robots etc. (Groover, 2005).

5.2.6 CMS and GT

Cellular Manufacturing is a model for workplace design, and is an integral part of lean manufacturing systems. The goal of lean manufacturing is the minimisation of waste, called *muda*, to achieve maximum efficiency of resources. Cellular manufacturing, sometimes called cellular or cell production, arranges factory floor labor into semi-autonomous and multi-skilled teams, or work cells, who manufacture complete products or complex components. Properly trained and implemented cells are more flexible and responsive than the traditional mass-production line, and can manage processes, defects, scheduling, equipment maintenance, and other manufacturing issues more efficiently (Singh, 1993).

Group Technology (GT) is a manufacturing philosophy in which the parts having similarities (Geometry, manufacturing process and/or function) are grouped together to achieve higher level of integration between the design and manufacturing functions of a firm. The aim is to reduce work-in-progress and improve delivery performance by reducing lead times. GT is based on a general principle that many problems are similar and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort. The group of similar parts is known as part family and the group of machineries used to process an individual part family is known as machine cell. The implementation of this technology needs knowledge based thinking and decisions so this technology may put under complex categories.

5.2.7 Automatic Identification and Data Capture (AIDC) Devices

These refer to the methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems (i.e. without human involvement). Technologies typically considered as part of AIDC include bar codes, Radio Frequency Identification (RFID), biometrics, magnetic stripes, Optical Character Recognition (OCR), smart cards, and voice recognition. AIDC is also commonly referred to as “Automatic Identification,” “Auto-ID,” and "Automatic Data Capture."

AIDC is the process or means of obtaining external data, particularly through analysis of images, sounds or videos. To capture data, a transducer is employed which converts the actual image or a sound into a digital file. The file is then stored and at a later time it can be analyzed by a computer, or compared with other files in a database to verify identity or to provide authorization to enter a secured system. Capturing of data can be done in various ways; the best method depends on application (Groover, 2005).

5.2.8 MRP/ ERP

Manufacturing Resource Planning (MRP II) is defined by APICS (American Production and Inventory Control Society) as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP. This is not exclusively a software function, but a marriage of people skills, dedication to data base accuracy, and computer resources. It is a total company management concept for using human resources more productively.

Enterprise **r**esource **p**lanning (ERP) is a business management system that integrates all facets of the business, including planning, manufacturing, sales, and marketing. As the ERP methodology has become more popular, software applications have emerged to help business managers implement ERP in business activities such as inventory control, order tracking, customer service, finance and human resources (Al-Mashari, 2002).

5.2.9 SCM Software

Supply chain management software (SCMS) is a business term which refers to a range of software tools or modules used in executing supply chain transactions, managing supplier relationships and controlling associated business processes. It commonly includes; Customer requirement processing, Purchase order processing, Inventory management, Goods receipt and Warehouse management (Shankar et al. 2008).

A requirement of many SCMS often includes forecasting. Such tools often attempt to balance the disparity between supply and demand by improving business processes and using algorithms and consumption analysis to better plan future needs. SCMS also often includes integration technology that allows organizations to trade electronically with supply chain partners.

5.2.10 Electronic Data Interchange (EDI)

It refers to the structured transmission of data between organizations by electronic means. It is used to transfer electronic documents from one computer system to another, i.e. from one trading partner to another trading partner. It also refers specifically to a family of standards, including the X12 series. However, EDI also exhibits its pre-Internet roots, and the standards tend to focus on ASCII (American Standard Code for Information Interchange)-formatted single messages rather than the whole sequence of conditions and exchanges that make up an inter-organization business process (Huang et al. 2008)

5.2.11 Robots

It is a virtual or mechanical artificial agent. In practice, it is usually an electro-mechanical machine which is guided by computer or electronic programming, and is thus able to do tasks on its own. Another common characteristic is that by its appearance or movements, a robot often conveys a sense that it has intent or agency of its own (Groover, 2005).

5.2.12 Rapid Prototyping Systems

It is the automatic construction of physical objects using additive manufacturing technology. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications and are even used to manufacture production-quality parts in relatively small numbers. Some sculptors use the technology to produce complex shapes for fine arts exhibitions (Lin and Liang 2002).

5.2.13 Automated Storage and Retrieval System (AS/RS)

This refers to a variety of computer-controlled methods for automatically placing and retrieving loads from specific storage locations.ASRS are categorized into three main types: single masted, double masted and man-aboard. Mast is supported on a track and ceiling guided at the top by guide rails or channels to ensure accurate vertical alignment, although some are suspended from the ceiling. The 'shuttles' that make up the system travel between fixed storage shelves to deposit or retrieve a requested load (ranging from a single book in a library system to a several ton pallet of goods in a warehouse system). As well as moving along the ground, the shuttles are able to telescope up to the necessary height to reach the load, and can store or retrieve loads that are several positions deep in the shelving (Manzini, et al., 2006).

5.2.14 Reverse engineering (RE)

It is the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation. It often involves taking something (e.g., a mechanical device, electronic component, or software program) apart and analyzing its workings in detail to be used in maintenance or to try to make a new device or program that does the same thing without copying anything from the original (Groover M.P. 2005).

5.2.15 LASER Oriented Facilities

These are the technologies that use a laser to process the materials. These are typically used for industrial manufacturing applications. Laser facilities work by directing the output of a high power laser, by computer, at the material to be process. The material then melts, burns, vaporizes away, or is blown away by a jet of gas leaving an edge with a high quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials. Laser oriented facilities are used in variety of ways in advanced manufacturing technologies (Pandey et al.2000)

5.2.16 Manual/ Automated Assembly lines

An assembly line is a manufacturing process in which parts (usually interchangeable parts) are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods. The assembly line developed by Ford Motor Company between 1908 and 1915 made assembly lines famous in the following decade through the social ramifications of mass production. However, the various preconditions for the development at Ford stretched far back into the 19th century, from the gradual realization of the dream of interchangeability, to the concept of reinventing workflow and job descriptions using analytical methods. Ford was the first company to build large factories around the concept. Mass production via assembly lines is widely considered to be the catalyst which initiated the modern consumer culture by making possible low unit-cost for manufactured goods (Groover M.P. 2005).

5.2.17 Automated Inspection and Testing

Automated inspection (AI) is an automated visual inspection of a wide range of products, such as printed circuit boards (PCBs), LCDs, transistors, automotive parts, lids and labels on product packages or agricultural products (seed corn or fruits). In case of PCB-inspection, a camera autonomously scans the device under test (DUT) for variety of surface feature defects such as scratches and stains, open circuits, short circuits, thinning of the solder as well as missing components, incorrect components, and incorrectly placed components. AI is a type of white box testing. It is commonly used in the manufacturing process due to the fact that it is a non-contact test method. AI is able to perform most of the visual checks performed previously by manual operators, and far more swiftly and accurately. AI systems are implemented at many stages through the manufacturing process. They are used for inspecting parts that have limited and known variations. For defect or flaw detection, the AI system looks for differences from a perfect part. There are systems capable of bare board inspection, Solder Paste inspection (SPI), as well as inspecting the component placement prior to reflow, the post-reflow component conditions, and post-reflow solder joints. These inspection devices all have some common attributes that affect capability, accuracy, and reliability.

Low costs and programming efforts make AI a practical and powerful quality tool for both prototypes and high-volume assembles. It is often paired with the testing provided by boundary scan test, in-circuit test, x-ray test, and functional test. In many cases, smaller circuit board designs are driving up the demand for AI versus in-circuit test.

Integrated technologies are newly emerged, knowledge based, sophisticated, requiring large capital and, knowledge based workforce and may demand several technologies to work together, thus developed countries may have a high degree of adoption. Simple technologies are well established, traditional, requiring small/medium capital, and can work on stand alone basis, require conventional skill based workforce and therefore they may have been highly adopted in developed countries as well as in developing countries. Lastly, complex technologies could be undergoing rapid adoption in developing countries currently. In following sections, we will investigate if there is any consistency between the data from our survey and our classification (Groover M.P. 2005).

5.3 CLASSIFICATION OFADVANCED MANUFACTURING TECHNOLOGIES

Classification and status of AMT

AMT have been classified into three levels based on their characteristics,

Table 5.3: Criteria and Classification of AMT in Three Categories

	Simple Technologies	**Complex Technologies**	**Integrated Technologies**
Capital Investment	Small or medium.	Medium	Large
History	Well established.	Well established / Newly emerged.	Newly emerged
Complexity	Simple or Moderate	Moderate or Sophisticated.	Sophisticated.
Interdependence	Stand alone, or based on another technology	Technologies that depend on different software and knowledge based workforce.	May demand several technologies i.e. to work together.
Technologies belonging to the group	1. CNC Machine tools 3. PLC's or Mechatronics 5. Automated Material handling 10. EDI 14. Reverse Engineering / Reverse Tooling 15 LASER oriented facilities 17. Automated data capture technologies i.e. optical, magnetic, smart card, machine vision etc.	2. Computer Aided Design and CAPP software 6. Cellular Manufacturing system or Group technology 8. Manufacturing Resource Planning (MRP II), / Enterprise Resource Planning ERP 9. SCM software 13. AS/RS	4. Flexible Manufacturing System 17. Automated systems used for inspection/testing 11.Robots 12 Rapid prototyping systems 16.Manual/ automated assembly lines

In India simple technologies should have a highest degree of implementation and integrated technologies may have lowest degree. As shown in Table: 5.3, the survey data are consistent with expectations. Simple technologies have average score of 2.84 in the survey, suggesting a high degree of implementation of these technologies in India. These technologies should have a high degree of implementation in all countries including developing countries due to relative easiness of adoption. Complex technologies have average score of 2.25, suggesting a modest degree of implementation. In developing countries such as India, integrated technologies are deemed to have a good but not high indicating a low degree of implementation in India Table 5.4.

Table 5.4: Current Status of Implementation of Three AMT's

(On scale from 1 to 4)	Simple	Complex	Integrated
Mean Score	2.84	2.25	1.44

The low adoption degree of integrated technologies 1.44 in developing countries can be contributed to the factors such as, less knowledge based workforce, lack of capital investment, lack of infrastructure, etc.

In order to know the degree of investment in the manufacturing technologies enabling supply chain. The mean of the different groups of technologies has been taken. The group with high mean will be the technology with highest investment by Indian firms. Still the investments in Simple technologies are more than other two. But it is quite encouraging that the investments on complex and integrated technologies are increasing in recent years. (Table 5.5)

Table 5.5: Status of Current Investments in Three AMT's

(On scale from 1 to 5)	Simple	Complex	Integrated
Mean Score	3.74	3.35	2.46

We try to identify technologies that have significantly higher potential in the future than their current adoption level. Table 5.6 has four technologies that have a future plans rank well above its current status rank. These are Rapid Prototyping, SCM software, Computer aided design and flexible manufacturing system. It can be predicted that these four technologies will have a higher rank among 17 AMT in future. Out of these four, two technologies are complex technologies and two technologies belong to integrated technologies, reinforcing our point of view that integrated and complex technologies will be adopted rapidly by Indian manufacturing enterprise.

Table 5.6: AMT Current Adoption Versus Future Adoption

Technologies	Rank of Current Status	Rank of Future Plans
1. CNC Machine Tools	7	9
2. Computer Aided Design	6	3
3. PLC.s and other mechatronics devices	1	1
4. Flexible Manufacturing systems	17	15
5. Automated Material handling devices	10	7
6. Cellular Manufacturing Systems and GT	14	12
7. Automated data capture technologies	5	6
8. MRP (II) / ERP	2	2
9. SCM software	12	8
10. Electronic Data Interchanger (EDI)	9	16
11Robots	16	17
12. Rapid Prototyping	11	5
13 AS/RS	15	14
14 Reverse Engineering/ reverse Tooling	13	13
15. LASER oriented facilities	4	10
16. Manual/ automated assembly lines	8	11
17 Automated Inspection/ Testing	3	4

It should be noted that there are some technologies that are highly implemented currently and will continue to be highly adopted in the future, such as PLC and Mechatronics devices which is ranked 1st in current implementation status and ranked 1st in future adoption plans also, and MRP (II) / ERP which is ranked 2nd in current implementation status also ranked 2nd in future adoption plans.

5.4 COMPARISON OF SMALL AND LARGE SIZE ORGANIZATIONS

All respondents are divided into two categories. The companies with annual turnover more than Rs 200 Crores (Approx $40 million) have been said to be large companies (Jharakharia and Shankar 2002). The data of small companies and large companies was examined based on three categories of AMT's. We expected that the difference in the degree of AMT adoption between small companies and large companies would increase as AMT moves to integrated category. Since in integrated category, AMT are more advanced and complicated, require more capital, etc. Large companies would have more relevant advantage in adopting integrated AMT than small companies. Our findings confirmed the expectations, as presented in Table 5.7

Table 5.7: Mean Scores and p Values for Three Categories of AMT

AMT	Current AMT Status			Future AMT Plans			AMT Investment		
	Small Company Mean	**Large Company Mean**	**P * Value**	**Small Company Mean**	**Large Company Mean**	**P * Value**	**Small Company Mean**	**Large Company Mean**	**P * Value**
Simple	2.35	2.60	0.09	2.00	2.28	0.02	2.65	2.63	0.16
Complex	1.33	2.02	0.11	1.65	2.45	0.12	1.61	2.67	0.30
Integrated	1.05	1.94	0.18	1.48	2.71	0.10	1.40	2.57	0.19

- P value from one tail *t test* of testing difference between two means.

Generally, the p value means that the mean score of large companies has 100*(1-p) percent probability to be statistically large than the mean score of small companies. For example, p value of 0.09 for simple AMT and Current AMT Status suggests the 91% probability that the mean score of large companies is statistically greater than the mean score of small companies.

It has been found that p-values of complex and integrated technologies are greater than p values of simple technologies, suggesting that large companies have more advantage in adopting complex and integrated AMT's.

Respondents were requested to give the current status of their implementation on each of 17 AMT on four point scale (4-using, 3- will be using in 6 months, 2- will be using in one year and 1- will not use . Some of the observations of their input are as follows:

PLC/Mechatronics device has the highest degree of implementation with a mean score of 3.60. Other technologies that have a high degree of implementation are Manufacturing Resource Planning/Enterprise Resource Planning (3.35), Automated

Inspection Technologies (3.33), LASER oriented facilities (3.23), Automatic Data Capture Technologies (3.13). Computer Aided Design and CAPP software (3.06) and CNC Machine tools (2.65) Table 5.8.

Table 5.8: Current Status of AMT Implementation

AMT	Mean	Std. Dev.	Rank
CNC Machine tools	2.65	0.52	7
Computer aided design and CAPP software	3.06	0.79	6
PLC's or mechatronics devices	3.60	0.38	1
Flexible Manufacturing system	1.29	0.33	17
Automated material handling devices	2.43	0.69	9
Cellular Manufacturing System or Group Technology	1.89	0.59	14
Automatic Data Capture Technologies	3.13	0.81	5
Enterprise Resource Planning (ERP)	3.35	0.71	2
SCM Software	2.04	0.73	12
EDI	2.38	0.79	10
Robot	1.65	0.64	16
Rapid prototyping	2.04	0.69	11
Automatic Storage and Retrieval System	1.84	0.54	15
Reverse Engineering / Reverse Tooling	2.01	0.66	13
LASER oriented facilities	3.23	0.82	4
Manual/ Automated assembly lines	2.57	0.77	8
Automated Inspection Technologies	3.33	0.71	3
Grand Average	**2.54**	**0.66**	**--**

5.5 FACTOR ANALYSIS ON CURRENT STATUS OF AMT IMPLEMENTATION

In factor analysis, some variables can have large loadings on several factors, making it difficult to interpret. Hence factor rotation is often used to make each variable to have few, ideally only one, large loadings. "Varimax" is one common criterion for orthogonal rotation which can improve loading pattern. And "promax" is one common oblique rotation criterion which can give more satisfactory results. We have chosen "promax" rotation method in our factor analysis. First we tried a two factors analysis and a three factors analysis for all 17

AMT. The loadings pattern is not clear. We were unable to assign all variables to two or three common components. At least four factors seem necessary to nicely group 17 AMT variables. After performing a four factor analysis, we can get an acceptable scheme of four groups.

Factor 1 seems to represent "expensive" technologies that require large amount of capital investment automated assembly lines, robotics, rapid prototyping and Flexible Manufacturing Systems are expensive technologies. These four technologies require not only heavy capital investment but knowledge based manpower too. Its maintenance and depreciation is also a costly affair to the enterprise. That's why these technologies are put into "expensive" category.

Factor 2 may be interpreted as "Integration" technologies that help in clubbing of all entities of manufacturing for all the inputs, necessary for production. In present manufacturing scenario ERP, SCM software and EDI becomes integral part of manufacturing, this is why these three have been termed as advanced manufacturing technologies in present study. So three AMT's ERP, SCM software and EDI has interpreted as "Integration Technologies"

Factor 3 technologies are "production" technologies that are used directly in manufacturing the products. Six technologies correctly classified into the "production" factor are Reverse Engineering / Reverse Tooling, CAD and CAPP software,, CNC Machine tools Cellular Manufacturing System or Group Technology, Automated material handling devices such as automated conveyors, PLC's or mechatronics devices. These Technologies in augmentation with traditional manufacturing processes leads the manufacturing competitive.

Lastly, factor 4 can be interpreted as "*quality*" technologies that relate to product quality improvement. Then computer controlled machine is often required to execute these findings. At the end, the bigger benefit is often not how much material is saved, but improved product quality because of more precise cutting by LASER oriented Technologies. Automated data capture devices dismiss any chance of mistaken identity in production and material handling improves product quality from the perspective that quality is conformance to customer requirement. Automate storage and retrieval system again a foolproof system to augment the product quality. Automated inspection devices are capable of searching even minute defects in the product. Hence four "quality" technologies include automated inspection devices, automated storage and retrieval system, automated data capture devices and LASER oriented facilities (Table 5.9).

Table 5.9: 17 Advanced Manufacturing Technologies in Four Groups

AMT	Loadings				Specific Variance
	Factor 1 "***expensive***"	Factor 2 "***Integration***"	Factor 3 "***production***"	Factor 4 "***quality***"	
16.Manual/ Automated assembly lines	0.90				0.19
11. Robot	0.79				0.29
4. Flexible Manufacturing system	0.66				0.54
12. Rapid prototyping	0.51				0.72
8. Enterprise Resource Planning (ERP)		0.82			0.14
9. SCM Software		0.70			0.34
10. EDI		0.57			0.51
5. Automated material handling devices			0.87		0.22
14.Reverse Engineering / Reverse Tooling			0.66		0.35
2. Computer aided design and CAPP software			0.59		0.38
1. CNC Machine tools			0.53		0.47
6. Cellular Manufacturing System or Group Technology			0.46		0.58
3. PLC's or mechatronics devices			0.29		0.71
13. Automatic Storage and Retrieval System				0.87	0.11
15.LASER oriented facilities				0.77	0.27
7. Automatic Data Capture Technologies				0.65	0.44
17. Automated Inspection Technologies				0.54	0.49

In summary, four common factors, "*expensive*", "*Integration*", "*production*", and "*quality*" are easy to understand and very helpful in interpreting 17 AMT. The division of 17 AMT into four groups is not perfect. For instance, the maximum loading of "PLC's or mechatronics system" is merely 0.29 whereas an ideal loading to classify a variable into a factor would be greater than 0.5. Two reasons can help to explain. Generally, the more variables (17 in this case) and the fewer factors (4 in this case), the less perfect the division will be. Further, all AMT are coming from bottom up approach, not from any top down planning. Therefore they might not be classified into a few common groups by nature.

We reexamined mean scores given by Indian companies we surveyed, for each of our four common factors. As a developing country, India can't afford expensive technologies Table 5.10. The mean score for factor 1 "*expensive*" technologies is the lowest. On the other side, India is a country where soft technologies and its manpower are now available in plenty. Accordingly, factor 2 "*integration*" technologies have a highest mean score. The mean scores for "*production*" and "*quality*" technologies are in the middle.

Table 5.10: Current Status of Four AMT Common Factors

(On scale from 1 to 4)	Factor 1 "***expensive***"	Factor 2 "***integration***"	Factor 3 "***production***"	Factor 4 "***quality***"
Mean Score	1.68	2.44	2.30	2.09

5.6 DISCRIMINANT ANALYSIS ON BENEFITS PERCEIVED DUE TO AMT-ENABLED SCM

We want to identify what factors out of 9 we surveyed encourage to adoption and implementation of AMT, See Table 5.11 for detailed data of 9 reasons for adopting AMT-enabled Supply Chain.

What companies should be labeled “successful” or “unsuccessful”? There may be many different criteria, innovation, profitability, market share, contribution to society, etc. What we are interested in is the “successfulness” of implementing AMT enabled supply chain management. Some existing criteria, such as financial performance, may or may not relate to how successfully companies adopted AMT enabled supply chain. Asking surveyed companies to indicate their success seems a quick remedy. Asking about the reasons to adopt AMT-enabled supply chain, the respondents dedicate the reasons are to reduce throughput time (4.04), quick response to customer needs (3.95), Quality of product (3.89), want early entry in the market (3.79) are among the top reasons to adopt AMT. The Success in AMT implementation can be dedicated to the benefits perceived by the companies and the company’s fail to perceive the enough benefits of the AMT’s are said to be unsuccessful in AMT implementation.

Table 5.11: Reasons for Adopting AMT-enabled Supply Chain

S.N.	**Item**	**Mean***	**Std. Dev.**	**Rank**
1	Pressure of the trading partners	3.68	0.83	5
2	To reduce inventory cost	2.98	0.65	9
3	Quick response to customer needs	3.95	1.04	2
4	Improvement of overall efficiency	3.29	0.87	7
5	Quality and warranty of product	3.89	0.92	3
6	Want early entry in the market	3.79	0.95	4
7	Short product life cycle	3.2	0.83	8
8	Consolidation of market share	3.48	0.91	6
9	Reduce throughput time	4.04	0.75	1

In the questionnaire, 17 questions were asked about benefits perceived after adopting AMT enabled supply chain such as product quality, profitability, worker safety. Answers are based on a five point scale, 1-Much Worse, 3-No Change, and 5-Much Better.. Hence 206 answers are usable. Each company has an average score over their answers to these 17 items.

Among 206 average scores, the mean is 3.58. We labeled "unsuccessful" to companies that have a below mean average score, and "successful" to other companies. We ended up with 76 "unsuccessful" companies and 130 "successful" companies. See Table 5.12 for detailed data of 17 benefits perceived due to AMT-enabled Supply Chain.

Table 5.12: Benefits Perceived by AMT-enabled SCM

Items	**Mean***	**Std. Dev.**	**Rank**
Increase in turnover	3.78	0.99	8
Inventory reduction	3.61	0.75	10
Order fulfillment time reduction	4.22	0.73	1
Low working capital requirement	3.23	0.77	13
Product quality	4.13	0.78	3
Reduction in manpower	3.18	0.75	14
Reduced transportation cost	2.28	0.81	17
Improved relations in the supply chain	3.65	0.89	9
Better capacity utilization	3.99	0.79	5
Responsiveness	4.08	0.77	4
Reduction in suppliers base	3.41	0.68	11
Reduced product/material acquisition cost	3.12	0.58	15
Reduction in unit cost of product/service	3.01	0.59	16
Access to world class suppliers/ service providers	3.91	0.62	6
An edge over new entrants in the industry	3.82	0.64	7
Better customer service	4.17	1.04	2
Postponement of point of product differentiation	3.38	0.89	12

* On scale from 1 to 5: 1-Much Worse, 3-No Change, 5-Much Better

Table 5.12 indicates the assessment of the respondent is as per AMT characteristics. For example, AMT enablement is characterized for higher responsiveness, better quality and higher productivity. These factors have higher mean as compared to rest of the factors. In the same way, reduction in material acquisition cost, reduction in manpower, reduction in logistics costs profitability have comparatively lower mean indicating lesser effect of AMT adoption. AMT adoption in India is fail to reduce manpower requirement, dismissed the fear of unemployment in India. It is dedicated to reduction in direct labor but increase in indirect knowledge based manpower to operate, assist and maintain these technologies.After dropping 76 unsuccessful companies 130 Successful companies remain from above analysis found suitable for discriminant analysis to find critical reasons for AMT adoption. Basically there are two approaches to run discriminant analysis with too many variables. One is to select a few variables that can reach the lowest possible error rate, the other approach is to reduce variables to a few common components via factor analysis and then use these common components in discriminant analysis. Nine variables (reasons to AMT adoption) have been reduced to 4 common reasons. These four reasons are used to run discriminant analysis. It has been found the error rate of 27.3% which is not a good one. So the error rate can be minimized using as few variables as possible. All combinations of four variables have been iterated. The Lowest error rate, 5.26%, has been found under following four variables; quick response to customer needs, reduce throughput time, want early entry in the market and quality of the product. Quality of the product is dropped from the list of four variables reduced four variables to three variables, the lowest error rate increased to 12.74%, under three variables; quick response to customer needs, reduce throughput time, want early entry in the market. Lastly using only two variables resulted error rate of 20.17%. So, the optimum number of variables to be used is four, with a 5.26% error rate, namely the discriminant function can correctly classify 130 companies out of 206.

We run a regression analysis on these four variables: to quick response to customer needs, reduce throughput time, want early entry in the market and quality of the product. The regression coefficients are given in Table 5.12. The coefficient of reduced throughput time is lowest, indicating a weak contribution to the AMT adoption. Quick response to the customer needs has a strong contribution to the adoption of AMT.

Table 5.13: Regression Coefficient of Four Critical reason of AMT adoption

Critical Reasons for AMT adoption	Coefficient
Quick response to the customer needs	0.2205
Want early entry in the market	0.1817
To reduce throughput time	0.1149
Quality of the product	0.1367

Further desire to early entry in the market and quality of the product are the other critical reasons to adopt AMT enablement of Supply Chain. Three out of four critical reasons to adopt AMT are related to reduction of lead-time in different stages. So it can be interpreted as Indian Manufacturers are adopting AMT for quick response that dominates to cost and quality.

5.7 CONCLUSIONS

From the present survey, it is concluded that in future, adoption of integrated technologies in India will be high. For large companies AMT- enablement of supply chains are more advantageous than small companies. Using Factor analysis on the present survey data we also concluded that implementation of AMT in integration and production technologies in India is highest and is lowest in "Expensive" technologies. Complex technologies adoption has grown up in recent years and will play vital role in AMT enabled supply chain. Using discriminant analysis four critical reasons of AMT adoption have been found these are, quick response to customer needs, reduce throughput time, early entry in the market and quality of the product.

CHAPTER 6
INFORMATION SHARING IN SCM

6.1 INTRODUCTION

In supply chain management (SCM) the co-ordination of products and information flows among suppliers, manufacturers, distributors, retailers and customers is vital (Simchi-Levi et al 2008). By appropriately sharing information between suppliers and retailers and co-coordinating their replenishment and production decisions under demand uncertainty, it is possible to reduce costs and improve customer service levels.

Information sharing is an important component of cooperation in supply chain management. It can be categorized according to operations areas such as inventory, sale, demand forecasting, order state, and production plan (Lee and Whang, 1999). Looking at the information flow direction, the inventory and production plan related information is a two-way communication between the downstream and upstream organizations in the supply chain (Frohlich and Westbrook, 2001). The sale information and demand forecasting information are the flows from downstream companies to their upstream partners. The order state information is provided by upstream organizations to their downstream partners. In addition, information sharing also includes performance criteria, such as production quality data and early complete date etc., and production capacities among the partners. The information sharing is often supported by an electronic data interchanger, internet and other communication devices between the partners (Handfield and Nichols, 1999).

Information sharing in supply chain context refers to the extent to which crucial and/or proprietary information is available to members of the supply chain. Shared information can be tactical (e.g. purchasing, operations scheduling, logistics) or strategic (e.g. long-term corporate objectives, marketing and customer information). Prior research on the importance of formal and informal information sharing between trading partners has shown that effective information sharing enhances visibility and reduces uncertainty (Handfield and Bechtel, 2002). It allows firms to access data across their supply chains, allowing them to collaborate in activities such as sales, production, and logistics. The extent to which information is shared can create opportunities for firms to work collaboratively to remove supply chain inefficiencies, and thus has a significant direct impact on the relationship between buyer and the supplier. The ability to access important information across the supply chain can also provide other opportunities. For example, when additional supply chain information becomes available, firms can take advantage of this increased visibility to modify existing actions or plan future operations. Lee *et al*. (1996) presented an analytical model to evaluate the benefits of information sharing and replenishment co-ordination to each partner in a supply chain. They found that:

- Sharing information alone would provide cost savings and inventory reduction for the supplier, but it would not benefit the retailer much;
- combining information sharing with replenishment co-ordination would result in cost savings and inventory reduction for the retailer and the supplier;
- the underlying demand process would significantly influence the magnitude of cost savings and inventory reductions associated with information sharing and replenishment co-ordination.

6.2 RESEARCH AGENDA

Based on the various issues presented in the literature, this chapter proposes a research agenda focusing on resolving how to deploy information sharing in the supply chain. The following major research questions are analyzed:

- With whom should information be shared?
- What information should be shared?
- Should information be censored?
- How the benefits of information sharing should be distributed?
- What are the implications for organizations?

There is strong preliminary evidence that information sharing can bring major benefits for supply chains. Improved information and communication technologies make information sharing easy. It is timely to reconsider these research questions especially in an environment dominated by globalization, increased consumer expectation and intensified competition.

6.2.1 With whom should information be shared?

This question can be approached from different perspectives. First, how far information should be shared both upstream and downstream in a supply chain? And which partners at each stage should be involved? These decisions are related to the structure of supply chain (D'Amours et al. 1999).

Supply chain structure is how companies are arranged to form a supply chain and how all activities are linked (Lambert et al. 1997; Cooper et al. 1998; Lambert and Cooper 2000). An individual company can participate in a number of supply chains (Lambert et al. 1997; Mentzer et al. 2001). Cooper et al. (1997) suggest that companies need to determine carefully with which partners of supply chains they should be closely integrated. Cooper et al. also point out that level of integration depends on various factors including firm capabilities, the complexity of products and corporate culture.

As information sharing is the foundation of supply chain integration (Lee 2000), decisions on the level of integration are strongly correlated with decisions on what information should be shared and how it should be shared. Cooper et al. (1997) contend that designing the configuration of the supply chain is not merely determining with whom companies should integrate but also designing .how a company's activities are linked to those of their partners and deciding what information should be made accessible by partners.

Research, determining with which partners in a supply chain a company should share information is very limited. Raghunathan (2003) examines demand information sharing in a supply chain comprising a manufacturer serving many retailers and analyses the optimal number of retailers that should be involved in information sharing. He found that the supplier will more likely to include more sharing partners when demands amongst retailers are independent, as the value of information sharing will increase significantly with the increasing number of sharing partners. This study confirms Cooper et al. (1997) argument that decisions on how many retailers should be involved in information sharing depends on product characteristics. The correlation of demand amongst retailers depends on the nature of products, consumer segments, and geographical location of partners (Raghunathan 2003). Lee et al. (2000) also found that benefits of information sharing increase with the number of retailers involved when the demand processes variance are correlated over time.

One approach is to consider how many stages up and down the supply chain should company share information with. This is particularly important as the implementation of information sharing is not costless (Lee and Whang 1999) and may requires significance changes in companies' business operations (Lee and Whang 1999). Lau et al (2002) examined various combinations of sharing between stages in a supply chain comprising a manufacturer, two distributors, and two retailers. Four combinations of sharing demand and inventory levels were studied: no information sharing; sharing demand and inventory level between retailers and distributors only; distributors and the manufacturer; and full information sharing. Counter- intuitively, the second mode of information sharing resulted in the highest total supply chain cost compared to other modes, even that of no information sharing. The lowest total cost was gained in the full sharing mode. All the firms may not be benefited from information sharing.

The next question is which partners in each stage should be involved and what factors affect that decision. Huang and Gangopadhyay (2004) studied various degree of information sharing in a four-stages supply chain comprises customers, retailers, distributors, wholesalers, and manufactures, in which each stage comprises several players. Three scenarios are analyzed: no information sharing; partial information sharing (only 50% of trading partners in each channel involved); and full information sharing. The simulation study found that increasing degree of information sharing resulted in decreased inventory levels at wholesalers. The benefits are higher when demand is highly variable. The study concluded that parties obtain different benefits from information sharing.

Walter et al. (1999) studied a supply chain comprising a manufacturer, distribution centers and retailers that used the vendor managed inventory (VMI) program, where a supplier is responsible for replenishing retailers' inventory. The study found that the manufacturer's inventory is reduced even by low level adoption of VMI and that even non-VMI partners gain benefits. Contrary to the previous study, demand variance did not significantly affect the benefits. Smaros et al. (2003) studied a three levels supply chain in which the manufacturer used a combination of order data from non-VMI customers and sales data from VMI customers in its production planning. The study showed that manufacturer benefited from even a partial increase of involvement of its partners. This study only considered products with stable demand but included twenty one products with different replenishment frequencies. Products with low replenishment frequency obtained more benefits with increasing information sharing.

The above discussion demonstrates that information sharing can be beneficial in at least some circumstances. However, the question of which partners should be recruited and recruitment criteria remain unclear. Partner selection in supply chains involves complex processes ranging from strategic to operational (Mentzer, Min et al. 2000). Companies must evaluate their partnering orientation which is the pattern of shared values and beliefs between partnering companies.

Mentzer (2004) further insists that it is not possible to include all supply chain members. Potential partners must be identified based on their importance to companies' competitive advantage. Shore and Venkatachalam (2003) proposed a method to evaluate partners' capabilities in information sharing. But this method only considers one aspect of partner selection. Therefore, the following research questions are proposed:

How far up and down should information be shared in a supply chain? What are the criteria for the partner selection process? How does the information sharing between two parties in a supply chain affect others who do not involve? Will a company's competitive positions affect the decision on selection of partners? Or will information sharing change a company's competitive positions amongst others who not been involved?

6.2.2 What Information should be shared?

The information in a supply chain can be classified in different ways e.g. strategic or tactical; logistical; or pertaining to consumers (Mentzer 2004). Lee and Whang (2000) discuss various types of shared information and their potential benefits. For example, sharing order status can improve the quality of customer service, reduce payment cycles, and reduce labor cost. Sharing retail sales data can mitigate the bullwhip effect. Huang et al (2003) sort information into six categories pertaining to product, process, resource, inventory, order, and planning (Table 6.1).

Table 6.1: Classification of Production Information (Huang, Lau et al.2003)

Category	Product Information
Product	Product structure
Process	Material lead time, Lead time variance, Order transfer lead time, Process cost, Quality, Shipment, Set-up cost
Inventory	Inventory level, Holding cost, Backlog cost, service level
Resource	Capacity, Capacity variance
Order	Demand, Demand variance, Order batch size, Order due date, Demand correlation
Planning	Demand forecast, Order schedule, Forecast Model, Time limits

The value of information sharing depends on several conditions. For example, Simchi-Levi and Zhao’s (2003) showed that demand sharing has no significant benefits for a manufacturer under tight capacity. Lee, So and Tang (2000) found that demand information sharing has more value if demand is highly correlated over time, highly variable, or the lead-time is long. The product’s characteristics also affect the value of different kinds of information. Sharing forecasts of demand of products that have high demand variability brings significant benefits (Angulo, Nachtmann et al. 2004). The relationship between trading partners also influences the selection of the type of shared information. For example, sharing production schedules with part suppliers can reduce part inventories without risking stock-outs. Sharing shipping information with logistics agents can improve customer service levels. Information sharing arrangements are dictated by circumstances (Mentzer, Min et al. 2000). Most of the existing studies only analyze the sharing of production information, but other information for example, market and consumer information can be important (Mentzer 2004). Lee and Whang (2000) showed that sharing market knowledge can improve promotion planning. Sharing information and close coordination between retailers and manufacturers may facilitate developing new products. The previous studies have analyzed a number of types of shared information (Table 6.2) however there is still a critical question that needs more investigation i.e. what information should be shared with supply chain partners that give most benefits?

6.2.3 Should information be censored?

An attribute of information is its timeliness. Delayed transmission of information exacerbates the effects of volatility afflicting the upstream level of a supply chain (Forrester, 1958). Chen (1999) examines the impact of delay of information transmission (also called information lead-times) between supply chain stages. Reducing lags in the transfer of information from downstream is highly beneficial. Bourland et al. (1996) found that timely demand information affects suppliers' inventory control policy and that sharing demand information daily can decrease suppliers' expected inventory cost especially when demand variability is high. Another attribute of information is the level of detail or completeness of information. If the information is transmitted every week, for example, there would be a question whether data should be provided on daily basis or aggregated per week. It is obvious that aggregate data has different variance than daily data and this could affect the operating decision of companies in a supply chain.

Table 6.2: Types of Shared Information in the Literature

Shared information	References
Pertaining to demand, forecast	Boone et al., (2002); Cachon and Lariviere, (2000); Raghunathan,(2003); Yu et al., (2002); Lee and Whang, (1999); Simchi-Levi and Zhao, (2003).
pertaining to inventory status	Cachon and Fisher, (2000); Lau et al., (2002).
Warehouse, consumer related	Kulp et al., (2004)
market development	Huang and Gangopadhyay, (2004)
company's future plans	Xu et al, (2001)
company's production costs	Owen and Levari, (2002), Smaros et al., (2003).
technology know-how	Narasimhan and Nair, (2005)
product development and future requirements	Koh et al., (2006)

There is possibility that some companies might not want to share their detail data with Partners, fearing that the data could leak to their competitors. As a result, those companies may only provide aggregated data. For example, they might share demand data on category level of products but not provide detail of size, color or other product attributes. On the other hand, suppliers might need those detailed information in order to predict the various trends of each type of product. Furthermore, providing comprehensive data might weaken a company's negotiating position.

6.2.4 How the benefits should be distributed

Numerous studies analyze the value of information sharing in a supply chain and factors that affect the value. The overall objective of information sharing is to achieve efficiency in the whole supply chain. However, it is apparent that different parties obtain different returns from information sharing (Table 6.3). Ideally, all members of a supply chain should share the benefits equally but members with monopoly power may obtain most of the benefits. Under intense competitions, savings may flow through to customers.

Table 6.3: The value of Information Sharing in the Literature

Authors	Benefits and allocation
Lau et al. (2002)	Inventory reduction All partners not obtain benefit
Simchi-Levi and Zhao (2003)	Manufacturers gain benefit
Mitra and Chatterjee (2004)	Only supplier gain benefit
Walter et.al. (1999)	All parties gain benefit Non-Sharing partners also gain benefit
Huang and Gangopadhyay (2004)	Not much benefit for retailer
Cachon and Fisher (2000)	No significant benefit from information sharing
Yu et al. (2001)	Manufacturer gain more benefit
Lee et al. (2000)	Only manufacturer gain benefit
Smaros et al. (2003)	Manufacturer gain benefit
Chen et al. (2000)	Reduce but not eliminate the bullwhip effect
Bourland et al. (1996)	Supplier gains more benefits

6.3 IMLICATIONS OF INFORMATION SHARING FOR ORGANIZATIONS

Realizing the benefits of information sharing depends on companies' ability to utilize shared information in their business processes. Kulp et al. (2004) did a survey to investigate the impact of information sharing on companies' performance. They found that the highest profit margin companies are not simply exchanging information but they combine it with close collaboration. Lee and Wang (2000) argue that information sharing is only enabler for achieving supply chain efficiency. Gavirneni (2002) showed that the benefits of information sharing can be obtained if companies change their operational policy. To take full advantages of information sharing, some significant changes in organization need to be implemented once information sharing in place. Companies should move toward collaboration with their partners to achieve common goals of supply chain efficiency that is built based on high level of trust between companies. Lee (2000) argues that collaboration and coordination can be achieved through exchanging decision rights, work and resources. Exchanging decision rights, such as in a VMI program, should not be considered merely to alleviate the bullwhip effects or to simply shift costs and responsibility to other parties, rather it should be noted that other parties are in the best position to accomplish such decisions. Work realignment is redistribution of physical activities amongst members of supply chain and may lead to reduce total supply chain costs. Work realignment can only be effective if information sharing is in place. This work realignment needs a cultural shift in organization to treat supply chain partners as if they are parts of Organizations.

Mentzer (2004) further argues that people can impede or facilitate collaboration. Information sharing will not bring significant benefits if people in organization still persist with past behaviors, exemplified by functional silos thinking. These considerations and the potential benefits suggest the following research questions:

- What are the barriers of implementation of information sharing?
- What are the critical success factors?
- How should information sharing be implemented?

6.4 OBJECTIVES OF THE EMPIRICAL STUDY IN THE RSEARCH

This section aims to overview the strategic benefits of the information sharing and to study the kind of information sharing in SCM, the manufacturing organizations are practicing in India. Strategic benefits accrue over an extended period of time, and capture the long-term benefits of information-sharing. It requires an assessment of the direct gains arising from collaboration, market share, conflict resolution, and new product introduction. Different information that can be shared with upstream and downstream partner that has been included in the study is as follows:

- related to purchasing and sales
- pertaining to inventory status
- product development and future requirements
- sales forecasting
- market development
- company’s future plans
- company’s production costs
- technology know-how

The main objectives of the study in the context of Indian organizations are as follows:

- To measure the competitive strengths of the organizations.
- To measure the intensity of information sharing with suppliers and customers.
- To explore the significant relationship between the level of information sharing and competitive strengths.
- To develop guidelines to share information under different conditions.

6.5 METHODOLOGY

In this section, questionnaire-based survey and statistical analysis have been used to achieve the research objectives outlined earlier in chapter 3 as given in Figure 3.1

6.5.1 Instrument Development

The questionnaire was tested for two main types of validity: Content validity; and Construct validity. Content validity primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978). The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and detailed evaluations by academicians and practicing managers during pre-testing. The construct validity was verified by factor analysis. All the items in the question related to barriers loaded with a minimum factor loading of 0.49. This is in agreement with Kim and Mueller (1978) who suggested the use of only those items, which have a factor loading more than 0.40 (Table 6.4).

6.5.2 Target Industries For Survey

Four sectors of industry from manufacturing were selected for the administration of questionnaire. These were:

i) **Automotive Sector:** automobile industry is seen as a flagship bearer frequently regarded as a barometer measuring the current wealth of a nation's economy (Childerhouse *et al.*, 2003). The extreme complexities and long lead-times of automobile manufacturing make it an ideal case for the study of SCM.

ii) **Machinery Sector:** The machinery industry is characterized by long lead time in manufacturing and product development and low level of participation by suppliers (Dangayach 2001).

Table 6.4: Constructs Variables, Factor Analysis and Internal Consistency

Q.N	Construct/ Variable	Factor loading	Percentage of variance	Internal consistency
A	**Competitive Strength**			
1	Quality	0.661		
2	Cost effectiveness	0.802		
3	Responsiveness to customer needs	0.774		
4	Service level	0.805		
5	Engineering expertise	0.510	46.938	$\alpha = 0.7921$
6	Product Customization	0.794		
7	Market share	0.720		
8	Sales and Marketing	0.672		
9	Manufacturing Strength	0.581		
10	Innovativeness	0.594		
11	Labor safety	0.662		
B	**Information Sharing with Supplier**			
a	Related to purchasing and sales	0.575		
b	Inventory status	0.619		
c	Product development	0.678		
d	Sales forecasting	0.757	48.168	$\alpha = 0.6583$
e	Market developments	0.796		
f	Company's future plans	0.700		
g	Company's production costs	0,717		
h	Technology know-how	0.815		
C	**Information Sharing with Customer**			
a	Related to purchasing	0.822		
b	Inventory status	0.729		
c	Product development	0.806		
d	Sales forecasting	0.689	57,6835	$\alpha = 0.8549$
e	Market developments	0.508		
f	Company's future plans	0.490		
g	Company's production costs	0.524		
h	Technology know-how	0.639		
i	Order tracking	0.868		

iii) **Machine Tools Sector ;** Machine tool industry has involvement of advanced manufacturing tools like CAD/CAM/CAE and modern machining processes (Dangayach, 2006)

iv) **Electrical & Electronics Sector:** The Electrical and Electronics industry is recognized as globally competitive in terms of cost and quality with shorter product cycle. Electrical and electronics manufacturer in India are the supplier of the automobile, machineries and machine tools industry and they import the various types of components from China, Japan, Taiwan and other east Asian countries. Electrical and Electronics industry is significantly different in terms of production processes.

6.6 RESULT AND DISCUSSION

To remain within the scope of this chapter, the relevant portion of the questionnaire survey, which pertains to the competitive strength of the company and level of information sharing with supplier and customer have been discussed and presented. One sample statistics of responses has been shown in Table 6.5 and 6.6. The t-value has been included in these tables. Pearson's variate two-tailed correlation test was conducted using SPSS (Version 15.00) software to find correlations among the various types of information sharing and different performance measures of competitive strength of the respondents.

Table 6.5: Competitive Strengths of the Respondent Organizations

Symbol	Competitive strength	Mean (rank)	Standard Deviation	t-value*
1	Product Quality	4.18 (1)	0.71	23.75
2	Cost effectiveness	3.85 (2)	0.99	12.36
3	Responsiveness to Customer needs	2.86 (10)	1.10	-1.70
4	Service level	3.07 (6)	1.22	0.91
5	Engineering and Technological. expertise	2.94 (7)	1.28	-0.65
6	Product Customization	3.42 (4)	1.05	5.74
7	Market share	2.94 (8)	1.16	-0.71
8	Sales and Marketing	2.93 (9)	0.97	-1.00
9	Manufacturing strength	3.46 (3)	0.84	7.81
10	Innovativeness	3.38 (5)	0.96	5.71
11	Labor productivity	2.74 (11)	1.12	-3.29

Notes: * Based on one sample t- test with test value 3.

6.6.1 Competitive Strength

Strengths parameters like quality, cost-effectiveness, product customization and innovativeness have high mean score as summarized in Table 6.5. This may be the results of constant adoption of managerial practices like TQM, TPM, and JIT etc. in last decade by Indian enterprises. The parameters like labor productivity, engineering expertise and responsiveness to customer needs have low mean score, that shows the below average growth in manufacturing and related technologies in India. Human resource related issues may also the reason behind it It can be observed that there is maximum variation in the engineering and technological expertise with standard deviation of 1.22 that indicates the significant variation in adoption of advanced technologies by manufacturing enterprises in India. The result for one sample t-test has been shown in the last column Table 6.5.

Table 6.6: Information Sharing with Customer and Supplier

Symbol	Type of information sharing	With supplier			With customer			$t_{P:I}$
		Mean	S.D.	t-value	Mean	S.D.	t-value	
A	Purchasing and sales	3.13*	0.95	1.97	3.47*	1.22	5.53	-3.42**
B	Inventory status	3.83*	1.13	10.55	3.05	0.92	0.83	7.84**
C	Product development	3.08	1.17	1.06	3.40*	1.11	5.20	-2.72**
D	Sales forecasting	2.76*	0.88	-3.80	3.05	0.93	0.82	-3.23**
E	Market development	2.86*	0.98	-1.98	3.12	1.05	1.72	-2.62**
F	Company's future plan	3.25*	0.93	3.94	3.60*	0.90	9.56	-3.61**
G	Company's production costs	3.45*	1.03	6.26	2.69*	0.98	-4.46	7.50**
H	Technology know-how	3.34*	1.24	4.03	2.84	1.15	-1.92	4.61**
I	Order Tracking	-	-	-	3.15*	0.81	2.72	-

Notes: * Significantly above moderate level at 0.05 level (Based on one sample t-test with test value 3); ** significant difference of 0.05 significance level between information sharing with supplier and information sharing with customer.

6.6.2 Comparison of Information Sharing with Supplier and Customer

It can be observed from Table 6.6 that information sharing is highest with supplier related to inventory status with mean value of 3.83 followed by information related to production costs, technology know-how and company’s future plan. It shows their main focus on tactical and operational issues. Information sharing related to sales forecasting and market development is found to be low and needs to be improved. Point of Sales (POS) information collected and shared using advanced technologies can fill the gap in this area. There is maximum variation in the sharing of information related to technology know how, product development and future requirements. Several Indian manufacturing enterprises are sharing this information in top priority and many are traditionally conservative. The result for one sample t-test are shown in the Table 6.6. It shows that except information sharing related to product development with supplier all other information sharing are found significant above the moderate level of 0.05.

It has been observed that information sharing with customer related to company's future plan is found to be high with mean value of 3.60 followed by information sharing related to purchasing and sales, product development and order tracking. It shows their main focus on projecting their best image in front of customer. Information sharing related to company's production cost and technology know how are found to be low. There is maximum variation in the sharing of information related to purchasing and sales and technology know how. Several advanced manufacturing enterprise are sharing this information in top priority and many are traditionally conservative

It can be observed that the level of information sharing differ for supplier and customer. Table 6.6 shows that the information sharing with the supplier is more on the issues like inventory status (3.83) compared to mean score of (3.05) with customer. Information sharing related to production cost is more with supplier (3.45) than customer (2.69), Information sharing related to technology know-how is more with supplier (3.34) compared to (2.84) with customer. Information sharing with customer is found more in the issues like purchasing & sales with the mean score of 3.47 compared to 3.13 with supplier. Information sharing related to product development and future requirement is found more with customer with a score 3.40 compared to 3.08 with supplier. Information sharing related to product customization is found to be more with customer 3.60 compare to 3.25 with supplier.

The last column of Table 6.6 shows the result of Paired sample t-test between the information sharing with supplier and customer. All values of the T_{PST} are found to be significant above the 0.05 level. The Negative values show that information has more shared with customer than suppliers. Such types of information in decreasing magnitude of

T_{PST} are company's future plan, purchasing and sales, sales forecasting, product development and market development. The positive T_{PST} suggest the information has been much shared by supplier such information in decreasing magnitude are inventory status, production cost and technology know how.

6.6.3 Information Sharing with Supplier and Competitiveness

The Pearson correlation coefficient is used to check the correlation of each set of paired dimensions. Pearson's bi-variate two-tailed correlation test was conducted for this purpose. The correlation coefficients between competitive strength of the enterprise and level of information sharing with supplier are presented in Table 6.7.

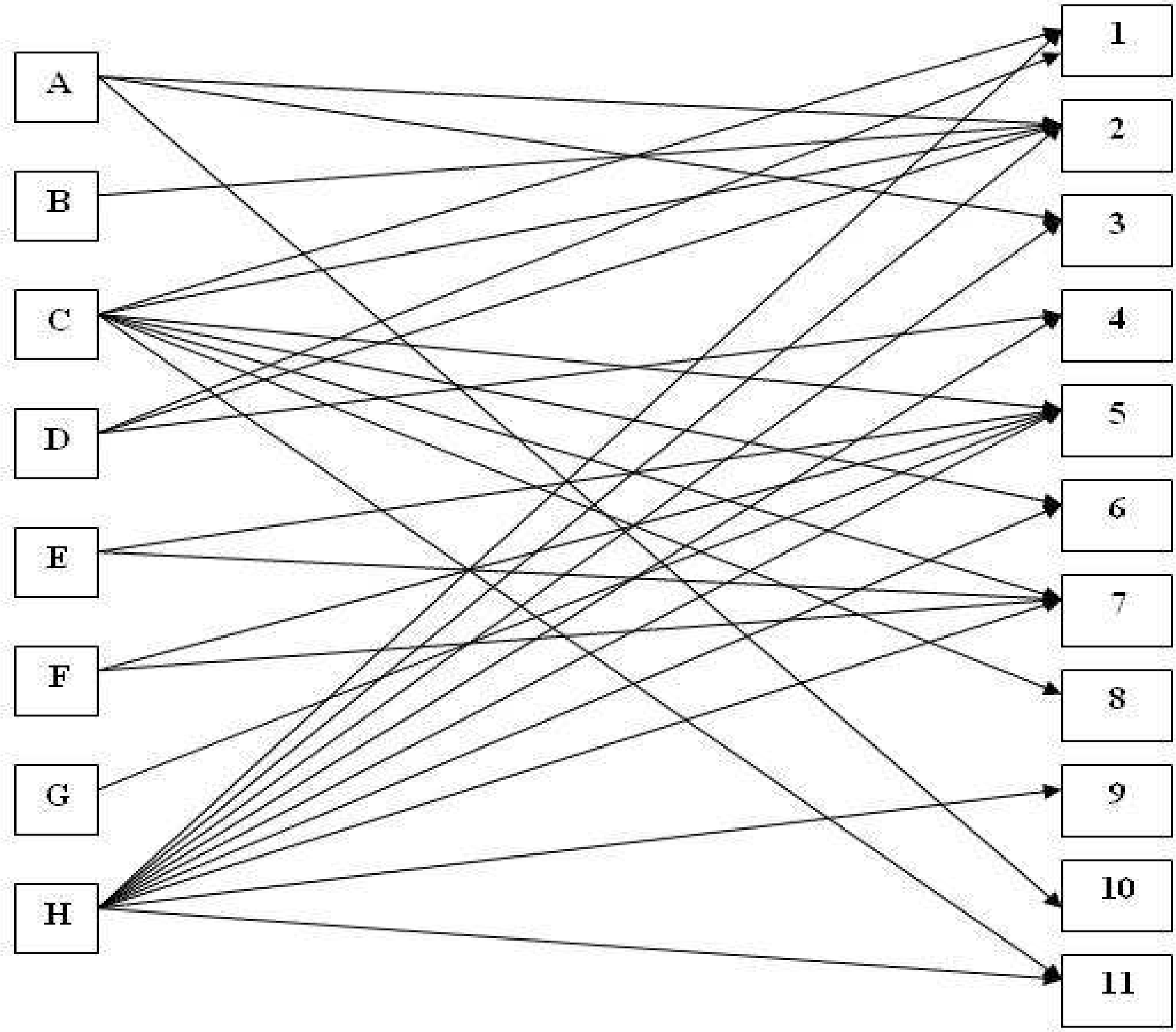
It can be observed from Table 6.7 that the correlation coefficients of the following paired dimensions are greater than 0.4 for the manufacturing enterprises under study, these are: information sharing with supplier related to purchasing and sales with cost effectiveness (0.41) and innovativeness (0.4). Information sharing with supplier related to inventory status with cost effectiveness (0.44). Information sharing with supplier related to product development and future requirement with product quality (0.47), engineering & technology expertise (0.42) and Sales and marketing (0.46). Information sharing with supplier related to sales forecasting with product quality (0.46). Information sharing with supplier related to technology know-how with product quality (0.51), responsiveness to customer needs (0.42).

Table 6.7: Pearson Correlation between Information Sharing with Supplier and Competitive Strength of the Organization

Competitive Strength	Information sharing with supplier to							
	Purchasing and Sales	Inventory Status	Product Development	Sales and Forecasting	Market Development	Future Plans	Production Cost	Technology know-how
Product Quality	0.19*	0.13	0.47**	0.46**	0.23**	0.27**	0.06	0.51**
Cost Effectiveness	0.41**	0.44**	0.30**	0.36**	0.13	0.11	0.10	0.30**
Responsiveness to customer needs	0.37**	0.18*	0.15	0.10	0.13	0.11	0.01	0.42**
Service level	0.13	0.05	0.15	0.33**	0.10	0.07	0.03	0.33**
Engineering Expertise	.013*	0.17*	0.42**	0.05	0.43**	0.37**	0.39**	0.32**
Product Customization	0.17*	0.03	0.36**	0.03	0.10	0.08	0.04	0.37**
Market share	0.14	0.13	0.33*	0.21**	0.32**	0.39**	0.17*	0.34**
Sales and Marketing	0.20**	0.07	0.46**	0.06	0.11	0.19**	0.07	0.10
Manufacturing Strength	0.08	0.04	0.11	0.13*	0.14*	0.10	0-.01	0.33**
Innovativeness	0.40**	0.05	0.27**	0.08	0.10	0.15*	0.12	0.24**
Labor Productivity	0.26**	0.06	0.31**	0.12	0.015*	0.22**	0.17*	0.37**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The pairs have been presented in Figure 6.1 with correlation significant at the 0.01 level and more than 0.3. Information sharing with supplier related to technology know how made maximum nine pair followed by product development and future requirements with seven pair and purchasing and sales with 3 pairs. Thus information sharing related to technology know how has wide impact on competitive strengths of the enterprises. Similarly several types of information sharing is required to achieve cost effectiveness and engineering expertise



Symbol	Type of Information sharing
A	Purchase and sales
B	Inventory status
C	Product development
D	Sales and forecasting
E	Market development
F	Future plan
G	Production cost
H	Technology know how

Symbol	Competitive Strength
1	Product quality
2	Cost effectiveness
3	Responsiveness to customer needs
4	Service level
5	Engineering expertise
6	Product customization
7	Market share
8	Sales and Marketing
9	Manufacturing strength
10	Innovativeness
11	Labor productivity

Figure 6.1: Significant Relations between Information Sharing with Supplier and Competitive Strength

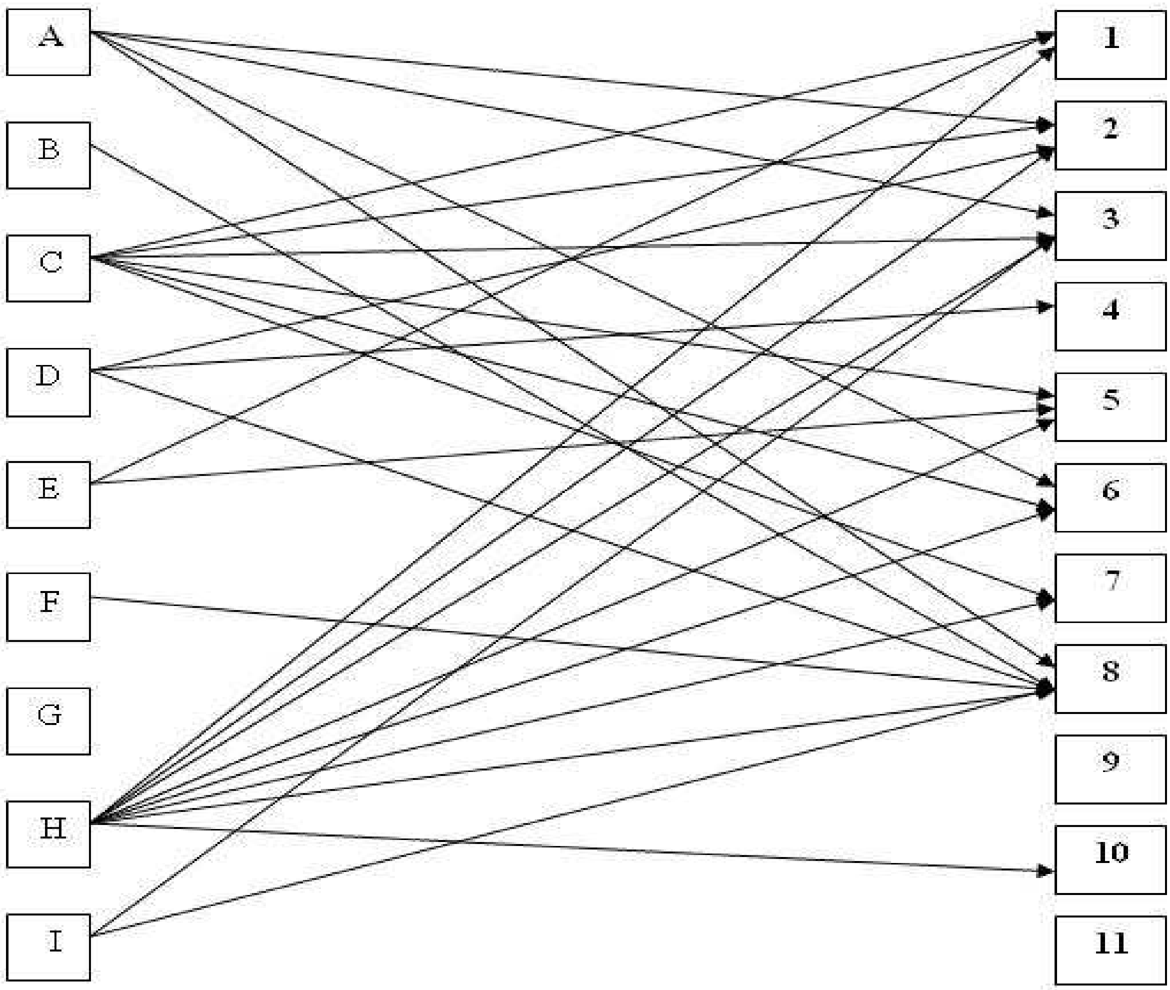
Table 6.8: Pearson Correlation between Information Sharing with Customer and Competitive Strength of the Organization

Competitive Strength	Information sharing with customer related to								
	Purchase and sales	Inventory status	Product development	Sales forecasting	Market developments	Company's future plans	Company's production costs	Technology know-how	Order tracking
Product Quality	0.18*	0.09	0.42**	0.11*	0.32**	0.10	0.07	0.37**	0.09
Cost effectiveness	0.34**	0.22**	0.32**	0.35**	0.19*	0.09	0.25**	0.31**	0.26**
Responsiveness to customer needs	0.37**	0.06	0.40**	0.16*	0.16*	0.12*	0.13*	0.42**	0.33**
Service level	0.17*	0.17	0.19*	0.39*	0.09	0.17*	0.12	0.17*	0.24**
Engineering Technological Expertise	0.13	0.11	0.36**	0.13	.039**	0.21**	0.26**	0.38**	0.15*
Product Customization	0.30**	0.03	0.32**	0.08	0.01	0.13	0.13	0.37**	0.03
Market Share	0.12	0.14*	0.34**	0.13*	0.29**	0.29**	0.14*	0.32**	0.25**
Sales and Marketing	0.35**	0.34**	0.15*	0.31**	0.22**	0.32**	0.29**	0.32**	0.32**
Manufacturing Strength	0.12	0.16*	0.21**	0.02	0.05	0.13*	0.24**	0.26**	0.16*
Innovativeness	0.14*	0.13*	0.27**	0.06	0..26**	0.19**	0.15	0.33**	0.13
Labor Productivity	0.02	0.07	0.26**	0.12	0.11	0.24**	0.15	0.25**	0.13*

Information sharing related to technology know how is found to be the most important attribute as an impact on competitive strength is concerned. Strengths like product quality, cost effectiveness, responsiveness to customer needs, engineering & technological expertise, product customization and market share are affected by information sharing related to technology know how with both supplier and customer. Such information sharing with supplier found to be related with strength like service level, manufacturing strength and labor productivity. Such results supports Mohr and Spekman (1994) who points out, trust commitment, information sharing, joint planning and joint problem resolution, all serve to better align supplier's expectations, goals and competitive strength.

The impact of information sharing with supplier is much wider than information with customer. There are nine pairs of correlation coefficient more than 0.4 in Table 6.7 related to information sharing with supplier as compared to three in Table 6.8 related to information sharing with customers. It slightly contradicts the result obtained by (Yu et al., 2001). According to them if the retailer shares information with the manufacturer in addition to placing orders, the retailer will not obtain any benefits, while the manufacturer is able to reduce inventory levels. However, if the retailer outsourcers inventory replenishment to the manufacturer, both the retailer and the manufacturer benefit through lower inventory costs. On both information-sharing levels, the manufacturer obtains more benefits than the retailer.

Information sharing related to product development and future requirement is also found to be precious with supplier and customer both. Strengths like engineering & technology expertise, product customization, cost effectiveness, market share, product quality are found to be related with this information sharing with customer and supplier both. Further if share with supplier it also affects sales and marketing and labor productivity and share with customer then it affects the responsiveness to customer needs.



Symbol	Type of Information sharing
A	Purchase and sales
B	Inventory status
C	Product development
D	Sales and forecasting
E	Market development
F	Future plan
G	Production cost
H	Technology know how
I	Order Tracking

Symbol	Competitive Strength
1	Product quality
2	Cost effectiveness
3	Responsiveness to customer needs
4	Service level
5	Engineering expertise
6	Product customization
7	Market share
8	Sales and Marketing
9	Manufacturing strength
10	Innovativeness
11	Labor productivity

Figure 6.2: Significant Correlation between Information Sharing with Customer and Competitive Strength

6.6.4 Information sharing with customer and competitiveness:

Table 6.8 represents the correlation coefficients and the following paired dimensions have the value greater than 0.4 for the manufacturing enterprises under study, these are: information sharing with customer related to product development with product quality (0.42) and responsiveness to customer needs (0.40) Information sharing with customer related to technology know how with responsiveness to customer needs (0.42). The pairs have been shown with correlation coefficient more than 0.3. Information sharing with customer related to technology know-how has maximum eight pair followed by product development and future requirements with six pair and purchasing and sales with four pairs. Information sharing with customer related to order tracking, and market development has two pair each. Thus information sharing related to technology know how wide impact has on competitive strengths of the enterprises. Related impacts of information sharing with customer on particular competitive strength can be identified using Figure 6.2.

Figure 6.2 shows that information sharing about product development and technology know how are very important as they influence the large number of attributes of competitive strength. Similarly to improve cost effectiveness and sales & marketing several types of information sharing is essential.Sale forecasting information sharing is found to be useful at both end and related to cost effectiveness. This supports the (Mishra et al., 2001) according to them forecast Information-sharing is very valuable to the retailer if variance in demand data is high, the retailer's forecast is more accurate than the manufacturer's, and the correlation between forecasts is low. On the other hand, demand information-sharing is not that beneficial if demand variance is high while the available information relative to the uncertainty in the demand supply network is small and thus the cost reduction is not that effective (Gavirneni et al., 1999; Li et al., 2001). Forecast information-sharing is especially beneficial in industries where demand is more dynamic and customer taste changes frequently. The manufacturer obtains a larger reduction in inventory levels and costs when demand variability is high and highly correlated over time (Lee et al., 2000). If the supplier is able to use the customer's demand information, as opposed to the customer's order information, one stage of information distortion is eliminated and the demand is less variable than in the "no information-sharing" case (Li et al., 2001). Compared to other information-sharing levels, demand information-sharing can make it possible to reduce costs by up to 35 percent (Gavirneni et al., 1999) and decrease inventory levels by 53 percent (Li et al., 2001), or, as Lee et al. (2000) have calculated by up to 40 percent.

The information sharing related to order tracking with customer is correlated to responsiveness to customer need and sales and marketing. (Cachon and Fisher, 2000) also stated that order information-sharing leads to almost equally good results as inventory-level information-sharing if orders are placed frequently enough and demand is stationary

Information sharing related to purchasing & sales both with supplier and customer is found to have good correlation with cost-effectiveness, responsiveness to customer needs Information sharing related to production cost with customer hasn't found any strong correlation with any of competitive strength but if this information is shared with supplier then it has correlation with engineering & technology expertise.

Information sharing related to Market development and company's future plan with supplier have the correlation with engineering & technological expertise and market share.

Such information if share with customer then apart from engineering and technology expertise they also affects the product quality and sales & marketing.

6.7 CONCLUSION

This study provides an empirical support to the research objective revealing a positive significant correlation between various types of information sharing and competitive strengths. This study strengthens the result of Zhao et al. (2002) that information-sharing influences supply chain performance in terms of total cost and service level. Similarly, Li et al. (2002) demonstrate higher level of information sharing is associated with lower total cost and shorter order cycle time. However, it should be noted that while sharing information is crucial, its impact on the performance of a supply chain depends on what type of information is shared, how it is shared, and with whom. Thus managers and executives need to give serious thought to adopt a policy of information sharing their way to SCM implementation and to enhance the particular competitive strengths of the enterprise.

CHAPTER 7
PERFORMANCE MEASUREMENT SYSTEM IN SCM

7.1 INTRODUCTION

For any business enterprise it is important to have an effective performance measurement system, which has strategic implications for any company. Identifying the required performance measures on most of the criteria is essential and it should be an integral part of any business strategy. Owing to the changes brought about by the new realities and demands of the marketplace, manufacturing performance measurement is becoming an illusive multifaceted construct. In this context, manufacturing executives not only have to understand the different facets of manufacturing performance, but they also must be able to design a manufacturing performance measurement system (PMS) capable of measuring these different facets. In practice, this is rather a difficult task for which the manufacturing executives are left with many questions and very few practical answers (Gomes et al. 2006).

Although there is an ever-increasing amount of literature addressing theories and practices of supply chain management, the existing performance measurement methods fail to provide significant assistance in supply chain development and an effective method is lacking (Chan & Qi, 2002). Many methods and techniques have been suggested over the years for SCM evaluation. Traditional methods focus on well-known financial measures, such as the return on investment (ROI), net present value (NPV), the internal rate of return (IRR), and the payback period. These methods are best suited to measure the value of simple SCM applications. Unfortunately, evaluation methods that rely on financial measures are not well suited for newer generation of SCM applications. These complex supply chains typically seek to provide a wide range of benefits, including many that are intangible in nature (Gunasekaran et al., 2001).

The selection of appropriate performance measures in a supply chain is a crucial issue. Many researchers have expressed their opinion about the design and the measures to be used in such a system. Neely et al. (1995) have categorized the large number of performance measures into four categories. These categories include quality, time, flexibility and cost. The adoption of performance indicators should deal with the following questions (Beamon and ware, 1998; Beamon, 1999): which aspects should be measured? How to measure these aspects? How to use the measure to analyze, improve and control the productive chain quality? How and when to reevaluate these measures?

7.1.1 Research Agenda

Understanding the significance of effective performance measurement system and to answer the questions of last paragraph, it is important to know the status and readiness of the effective performance measurement system in Indian manufacturing enterprises. The objective of the study is to focus on the current practices of performance measurement indicators in Indian manufacturing enterprises. Specifically, this study focuses on the nature and scope of measures executives tend to use and view to be relevant in their evaluation of supply chain performance. To achieve this objective, a sample of Indian manufacturing enterprises is used to study the value of different performance measure on the basis of frequency of utilization (FoU), predictive usage value (PUV) and Ease of Measurement (EoM) for selected 43 performance measurement indicators.

7.1.2 Characteristics of Performance Measures

The performance measurement literature highlights some relevant characteristics of performance measures as summarized below (Gomes et al 2006):

- It should be based on organizational objectives, critical success factors, and customer needs and monitoring both financial and non-financial aspects (Manoochehri, 1999);
- Financial and non-financial measures should be aligned, and used within a strategic framework (McNair and Mosconi, 1987; Drucker, 1990);
- It should reflect relevant non-financial information , based on key success factors of each organization (Clarke, 1995);
- It should stimulate the continuous improvement processes (Kaplan and Norton, 1992 ; Flapper et al., 1996; Neely et al., 1997; Medori and Steeple, 2000);
- It should be implemented as means of articulating strategy and monitoring organization results (Grady, 1991);
- It should be clearly defined, and have a very explicit purpose (Flapper et al., 1996; Neely et al., 1997);
- It can be change dynamically with the strategy (Bhimani, 1993);
- It should be easy to understand and to use (Kaplan and Norton, 1996);
- It should meet the needs of specific situations in relevant manufacturing operations, and should be long-term oriented, as well as simple to understand and implement (Santori and Anderson, 1987);
- It should make a link to the reward systems (Tsang et al., 1999); and
- It should allow a fast and rigorous response to changes in the organizational environment (Bititici et al., 1997; Medori and Steeple, 2000).

7.2 PERFORMANE METRICS AND THEIR MEASUREMENT IN SCM

According to Chan (2003), performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives. It reflects the need for improvement in areas with unsatisfactory performance. Thus efficiency and quality can be improved. In this section, an attempt is made to summarize some of the most appropriate performance metrics and measures of SCM

7.2.1 Metrics for Performance Evaluation of Planned Order Procedures

For any firm, the first activity to begin with is to procure orders. It is clear that the way the orders are generated and scheduled determines the performance of the downstream activities and inventory levels. Hence, the first step in assessing performance is to analyze the way the order-related activities are carried out. To do this, the most important issues – such as the order entry method, order lead-time and the path of order traverse – need to be considered.

7.2.1.1 *The Order Entry Method*

The order entry method determines the way and the extent to which the customer specifications/requirements are converted into useful information, and are passed down along the supply chain. According to Mason-Jones and Towill (1997), such information connects all levels of supply chain and affects the scheduling of all activities. Proper control of the order is possible, provided that the order entry method is capable of providing timely, accurate and usable data at various entry levels, and hence, can be used as a metric of performance measure.

7.2.1.2 *Order Lead-Time*

The total order cycle time, which is called “order lead time”, refers to the time, which elapses between the receipt of the customer’s order and the delivery of the goods. This includes the following time elements:

Total order cycle time = Order entry time (through forecast/direct order from the customer) + Order planning time (Design + Communication + Scheduling time) + Order sourcing, assembly and follow up time + Finished goods delivery time.

A reduction in the order cycle time leads to a reduction in the supply chain response time (Gunasekaran et al., 2001). This is an important measure as well as major source of competitive advantage (Bower and Hout, 1988; Christopher, 1992). According to Towill (1997), it directly influences the customer satisfaction level. Equally important is the reliability and consistency of the lead-time. Because of bottlenecks, inefficient processes and fluctuations in the volume of orders handled, there will be variations in activity completion times. The overall effect of this may lead to a substantial reduction in delivery reliability and customer service level. To deal with these, for example, the concept of “manufacturing cell” can be applied, in which well integrated actions are performed in parallel by cross functional teams to effectively decrease the order lead-time and reduce the redundancies (Schonberger, 1990).

7.2.1.3 The Customer Order Path

The path that order traverse is another important measure whereby the time spent in different routes and non-value adding activities can be identified, and suitable steps can be taken to eliminate those (Gunasekaran et al., 2001). For example, by tracing through the order path, the delays in the paperwork, time consumed while the product sits in the warehouse, time spent in checking and rechecking can be identified and eliminated using methods such as JIT, reengineering, and information technology (e.g. e-commerce, electronic data interchange (EDI) and Internet.

7.2.2 Supply Chain Partnership and related Metrics

Buyer–supplier partnership has gained a tremendous amount of attention from industries and researchers, resulting in a steady stream of literature promoting it (e.g. Ellram, 1991; Fisher, 1997; Graham et al., 1994; Gunasekaran et al., 2001; Landeros et al., 1995; Maloni and Benton, 1997; McBeth and Ferguson, 1994; Thomas and Griffin, 1996; Toni et al., 1994; and Towill, 1997). Most of these studies stress the partnership for better supply chain operations. Accordingly, an efficient and effective performance evaluation of buyer and/or suppliers is not just enough; the extent of partnership that exists between them needs to be evaluated and improved, as well. The parameters that measure the level of partnership are summarized in Table 7.1

Table 7.1 Partnership Evaluation Parameters in a Supply Chain (Gunasekaran et al, 2001)

Partnership evaluation criteria	**References**
Level and degree of information sharing	Toni et al. (1994), Mason-Jones and Towill (1997)
Buyer–vendor cost saving initiatives	Thomas and Griffin (1996)
Extent of mutual co-operation leading to improved quality	Graham et al. (1994)
The entity and stage at which supplier is involved	Toni et al. (1994)
Extent of mutual assistance in problem solving efforts	Maloni and Benton (1997)

7.2.3 Measuring Customer Service and Satisfaction

This measurement is aimed to integrate the customer specification in design, set the dimensions of quality and the feedback for the control process. They contain product/service flexibility, customer query time, and post-transaction service.

7.2.3.1 Flexibility

Being flexible refers to making available the products/services to meet the individual demand of customers. Toyota is using FMS and logistic principles to provide a high level of responsiveness to customer needs. (Bower and Hout, 1988; Stewart, 1995) presents a list of practices that world-class companies employ to improve flexibility. His analysis reveals a strong correlation of supply chain response time and flexibility.

7.2.3.2 The Customer Query Time

The customer query time refers to the time it takes for a firm to respond to a customer inquiry with the required information. On several occasions, a customer enquires or needs to be informed about the status of an order, and the potential problems on stock availability or delivery. Providing such information genuinely helps the customers to schedule their activities, and helps the firm to retain them as customers. Thus, providing online information is an important element of customer service, and it can be evaluated for improving the same. To measure customer service, questions "what are the response times", and "what procedures exist to inform customers" should be considered.

7.2.3.3 Post Transaction Measures of Customer Service

The function of a supply chain simply does not end by providing the goods to the customer. The post transaction activities play an important role both as part of customer service, and for valuable feedback for further improvements in the supply chain. For example, timely availability of spares helps companies to provide better customer service, and to trace the problems arising from warranty claims; then making improvements on them.

7.2.4 Production Level Measures and Metrics

As an important part of SCM, the performance of the production process also needs to be measured, managed, improved, and suitable metrics for it should be established. This category consists of range of product and services, capacity utilization, and effectiveness of scheduling techniques.

7.2.4.1 Range of Products and Services

According to Mapes, New, and Szwejczewski (1997), a company that manufactures a wide range of products is likely to introduce new products at a slower rate than companies with a narrow product range. Based on a statistical analysis of "UK Best Factory Awards Database", these authors show that plants that manufacture a wide range of products are likely to perform poorly on added-value per employee, speed and delivery reliability. Furthermore, a company with an extensive product portfolio less frequently breeds new products of innovation. This indicates the impact of "product range" on supply chain performance, and so, it needs to be measured. The same analysis can be applicable for services, as well.

According to Fisher (1997), the selection of right supply chain strategy depends upon the nature of product variety and innovation. This also implies that the range of products and services acts as an important strategic metric, and hence, it should be considered in performance evaluation.

7.2.4.2 Capacity Utilization

According to Wild (1995): "All the operations planning takes place within the framework set by capacity decisions."

From the above statement, the role of “capacity” in determining the level of all supply chain activities is clear. This highlights the importance of measuring and controlling the capacity utilization. According to Slack, Chambers, Harland, Harrison, and Johnston (1995), capacity utilization directly affects the speed of response to customers’ demand. Hence, by measuring capacity, gains in flexibility, lead-time and deliverability will be achieved.

7.2.4.3 Effectiveness of Scheduling Techniques

Scheduling refers to the time or date at which activities are to be undertaken. Such fixing determines the manner in which the resources flow through an operating system. The effectiveness of this has a significant impact on the performance of supply chain (Gunasekaran et al., 2001). For example, scheduling based on JIT has tremendous influence on inventory levels. Similarly, computer generated schedules based on systems like MRP, and more recently ERP, provide a detailed and accurate bill of materials. These impact the effectiveness of purchasing, throughput time and batch size. However, the applications of such systems should not be limited to scheduling of shop floor activities and comparing their performance with others. In the case of supply chains, since scheduling depends heavily on customer demand and supplier performance, the scheduling tools/methods should also be viewed from that context. Based on these, it can be concluded that measuring and improving effectiveness of scheduling techniques will improve the performance of a supply chain.

7.2.5 Performance Evaluation of Delivery Link

These measures are designed to evaluate the performance of delivery and distribution cost in supply chain. The typical measures for delivery performance evaluation are lead-time reduction in the delivery process, on-time delivery (delivery-to-request date, delivery-to-commit date and order fill lead-time), distribution mode, the delivery channel, vehicle scheduling, and warehouse location, the percentage of goods in transit, quality of information exchanged during delivery, number of faultless notes invoiced, flexibility of delivery systems to meet particular customer needs (Gelders et al., 1994; Novich, 1990; Stewart, 1995).

7.2.5.1 Measures for Delivery Performance Evaluation

In any typical delivery distribution mode, the delivery channel, vehicle scheduling, and warehouse location play an important role in delivery performance (Gunasekaran et al., 2001). An increase in delivery performance is possible by selecting suitable channel, scheduling and location policies. A survey conducted by Gelders et al. (1994) in Belgium shows that tremendous opportunities exist to improve the supply chain performance based on lead-time reduction in the delivery process. What is needed, according to Gelders et al. (1994), is an understanding of the link between delivery channels and organizational operating schedules.

Another aspect of delivery performance evaluation is the percentage of goods in transit. A higher percentage signifies low inventory turns, leading to unnecessary increase in tied up capital. Various factors that can be attributed to this are vehicle speed, driver reliability, frequency of delivery, and the location of depots. An increased effectiveness in these areas may well lead to a decrease in inventory levels under consideration.

Like other activities, delivery heavily relies on the quality of information exchanged. For example, once the activities are scheduled, continuous monitoring is possible based both on information derived and information supplied across the channels of distribution. Thus, the quality and the way the information is presented determine the delivery performance to a large extent, which, therefore, can be used to measure and improve performance (Gunasekaran et al., 2004).

Moreover, the following aspects of delivery also reflect customer satisfaction:

– Number of faultless notes invoiced: An invoice shows the delivery date, time and the condition under which goods are received. By comparing these with the previous agreement, it can be determined whether a perfect delivery has taken place or not. Also, the areas of discrepancy can be identified so that improvements in delivery performance can be made.

– Flexibility of delivery systems to meet particular customer needs: Nowadays, the delivery systems are becoming more flexible towards customer needs. By being flexible, a delivery system can positively influence the decision of customers to place orders, and hence, this can be regarded as a metric for winning and retaining customers. According to Novich (1990), customers can be grouped into different segments based on their needs. Thus, they can be grouped critically based on their economic profitability and flexibility.

7.2.6 Supply Chain Finance and Logistics Cost

Determining the total logistics cost can assess the financial performance of a supply chain. It is necessary to decide on a broad level of strategies and techniques that would contribute to the smooth flow of information and materials in the supply chain environment. They are used to assess the financial performance of supply chain, such as assets cost, return on investment, and total inventory cost.

7.2.6.1 Cost associated with Assets and Return on Investment

Supply chain assets include accounts receivable, plant, property and equipment and inventories (Stewart, 1995). With increasing inflation and decreased liquidity, pressure is on firms to make the assets sweat, i.e. improve the productivity of their capital. In this regard, it is essential to determine how the costs associated with each asset, combined with its turnover, affects the "total cash flow time". According to Stewart (1995), this can be measured as the average number of days required transforming the cash invested in assets into the cash collected from a customer.

Once the total cash flow time is determined, it can readily be combined with profit with the objective of providing an insight into the rate of return on investment (ROI). This determines the performance that the top management can achieve on the total capital invested in business. As a corollary to this, the logistics management policies have a significant impact on ROI.

For example, superior customer service leads to improved sales and an increased profit, and subsequently, a higher ROI. Likewise, other areas of organization can be explored. By measuring ROI and the impact of the logistics policies on it, significant insights can be gained about the financial health of the supply chain.

7.2.6.2 Total Inventory Cost

In a supply chain, inventories range from raw materials, subassemblies and assemblies to finished products, as well as inventories held up in transit. What was traditionally perceived as a buffer in production to cope with uncertainties actually emerged to be one of the reasons for the increase in lead-time (Slack et al., 1995). As customer service requirements constantly increase, effective management of inventory in a supply chain becomes increasingly critical and important. Hence, it is essential that costs associated with inventory should be evaluated, and proper trade-offs, with suitable performance measures, should be implemented.

In a supply chain, the total costs associated with the inventory (Christopher, 1992; Dobler and Burt, 1996; Lee and Billington, 1992; Levy, 1997; Slack et al., 1995; Stewart, 1995) consist of the following:

• Opportunity cost consisting of warehousing, capital and storage,

• Cost associated with inventory as incoming stock level, work in progress,

• Service costs, consisting of costs associated with stock management and insurance,

• Cost held up as finished goods in transit,

• Risk costs, consisting of costs associated with pilferage, deterioration, damage.

• Cost associated with scrap and rework.

• Cost associated with shortage of inventory accounting for lost sales/lost production.

In dealing with these costs, consideration should also be given to part/material size. A low cost part may have large size, and consequently, a large space requirement. Also, in deciding which cost should be tackled first, Pareto analysis can be used to prioritize the options. In addition, proper trade-offs should be considered in dealing with inventory at various levels in a supply chain. An excellent discussion on this, based on pitfalls and opportunities, is provided by Lee and Billington (1992). In particular, they point out that the cost of reworking stored components due to engineering changes and the risk of obsolescence could inflate the inventory holding costs by 40%. Clearly, not considering such factors may lead to inappropriate choices.

In dealing with inventory in transit, a trade-off is needed because changing the mode of transportation can significantly affect inventory investment and service performance. A faster and more expensive shipping mode may save enough in inventory investment to justify increase in shipping cost, but if inventory costs rates are appropriately chosen. According to Levy (1997), care must also be taken for longer lead-time due to longer distance as it increases the “volatility” of inventories, resulting in either too high or too low inventory levels. This, in turn, can lead to higher administrative costs being incurred, and can be the cause of costs due to lost sales.

Another factor that needs to be measured and dealt with regarding inventory is the accuracy of forecasting techniques. According to Fisher (1997), supply chain in many industries suffers from inventory, owing to their inability to predict demand. A new demand forecasting system that takes sales data from distributor's computer and combines with on-hand inventory could serve as a technique to deal with this problem. Harrington (1996) shows that using such techniques, Microsoft has been able to keep production schedules open until one week, and make what the market will accept.

Therefore, measuring inventory at supply, production, distribution and scrap levels as well as accuracy of forecasting techniques, can provide an insight into the cost performance and reduce the lead-time in a supply chain.

7.3 PERFORMANCE EVALUATION FRAMEWORK FOR SCM

Complex supply chains typically seek to provide a wide range of benefits, including many that are intangible in nature. There is, however, a greater need to study the measures and metrics in the context of following reasons (Gunasekaran et al., 2001):

(I) Lack of a balanced approach. Financial measures, which are required for examination by external stakeholders, are generally well developed. However, operational measures are typically ad hoc and lack formal structure (Hudson et al., 2001). Many firms have realized the importance of financial and non-financial performance measures. However, they failed to understand them in a balanced framework. According to Kaplan and Norton (1992), while some managers and researchers have concentrated on financial measures of performance, others have concentrated on operational measures. Such equality does not lead to metrics that can present a clear picture of the organizational performance. As suggested by Maskell (1991), for a balanced approach, companies should bear in mind that, while financial performance measurements are important for strategic decisions and external reporting, day-to-day control of manufacturing and distribution operation is better handled with non-financial measures.

Table 7.2: A List of Key SCM Performance Metrics (Gunasekaran et al., 2001)

Level	Performance metrics	References
Strategic	Total cash flow time	Stewart (1995)
	Rate of return on investment	(Christopher, 1992; Dobler and Burt, 1996)
	Flexibility to meet particular customer needs	(Bower and Hout, 1988; Christopher, 1992)
	Delivery lead time	(Rushton and Oxley, 1991) and (Christopher, 1992)
	Total cycle time	(Christopher, 1992) and (Stewart, 1995)
	Buyer–supplier partnership level	Toni et al. (1994)
	Customer query time	Mason-Jones and Towill (1997)
Tactical	Extent of co-operation to improve quality	Graham et al. (1994)
	Total transportation cost	Rushton and Oxley (1991)
	Truthfulness of demand predictability/ forecasting methods	(Fisher, 1997) and (Harrington, 1996)
	Product development cycle time	Bower and Hout (1988)
Operational	Manufacturing cost	Wild (1995)
	Capacity utilization	Stewart (1995)
	Information carrying cost	(Levy, 1997) and (Lee and Billington, 1992)
	Inventory carrying cost	(Stewart, 1995) and (Dobler and Burt, 1996); Slack et al. (1998); Pyke and Cohen (1994)

(II) Lack of understanding on deciding on the number of metrics to be used. Quite often, companies have a large number of performance measures to which they keep on adding based on suggestions of employees and consultants, and fail to realize that performance measurements can be better addressed using a good few metrics.

(III) Lack of clear distinction between metrics at strategic, tactical, and operational levels. Metrics that are used in performance measurement influence the decisions to be made at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate.

Therefore, it is clear that for effective management of supply chain, measurement goals must consider the overall scenario and the metrics to be used. These should represent a balanced approach and should be classified at strategic, tactical, and operational levels.

This being the background, Gunasekaran et al. (2001) illustrated the above discussed performance measures and metrics of the SCM with help of a framework that gives cohesive picture to address what needs to be measure. The framework developed is shown in Table 7.3.

Table 7.3: The Four Perspectives in a Balanced Scorecard (Kaplan & Norton, 1992)

Customer perspective (value-adding view) Mission: to achieve our vision by delivering value to our customer	**Financial perspective (shareholders' view)** Mission: to succeed financially, by delivering value to our shareholders
Internal perspective (process-based view) Mission: to promote efficiency and effectiveness in our business processes	**Learning and growth perspective (future view)** Mission: to achieve our vision, by sustaining innovation and change capabilities, through continuous improvement and preparation for future challenges

7.4 BALANCE SCORECARD FOR SCM EVALUATION

SCM captures the notion of organization and coordination of activities from procurement of raw materials to the final customer.

The BSC for SCM framework presented here is structurally similar to the BSC framework at the corporate management level as proposed by Kaplan and Norton (1992). Gunasekaran et al. (2001) identified supply chain metrics and proposed a framework for SCM performance evaluation. Here, in this section, the BSC is applied to these metrics with the intent to evaluate SCM performance comprehensively. Four perspectives of the BSC are applied to these discussed metrics are shown in Table 7.3 or in another words the different metrics are fitted into four different perspectives of BSC as shown in Table 7.4. Each of the four perspectives should be translated into corresponding metrics and measures that reflect strategic goals and objectives. The perspectives should be reviewed periodically and updated as necessary. The measures included in the given BSC should be tracked and traced over time, and integrated explicitly into the strategic SCM process.

7.4.1 Measuring and Evaluating Customer Perspective

How do customers see the business: the BSC demands that the management must translate their general mission statement on customer service into specific measures that reflect the factors that really matter to the customers? Customers generally, concern to lead-time, quality of products and services, company's performance service and the cost effectiveness. But on long term basis and more importantly in the era of globalization any firm's competitiveness lies on different customer related factors are shown in Table 7.4.

Table 7.4: Performance Metrics Related to Different Perspective of BSC

Four perspectives of performance measures	Symbol	Performance measure variable related to different perspective
A Customer Service related	A1	On time delivery
	A2	After-sales service
	A3	Increase in customer base
	A4	Retention of old customers
	A5	Product customization
	A6	Better product quality
	A7	Ease in tracking customer order
	A8	Increase in market share
	A9	Online receipt of order
	A10	Order fill rate
B Financial related	B11	Cost per unit of product
	B12	Net profit per unit of sales
	B13	Turnover
	B14	Return of investment (ROI)
	B15	Economic value added
	B16	Working capital required
	B17	Logistics costs
	B18	Revenue earned per employee
C Internal Business related	C19	Inventory turnover ratio
	C20	Assets utilization
	C21	Throughput time
	C22	Purchase lead-time
	C23	Manufacturing lead-time
	C24	Outsourcing
	C25	Operating costs
	C26	Reduced waste
	C27	Plant productivity
	C28	Just in time environment
	C29	Reduction in number of breakdown
	C30	Stabilized master schedule
	C31	Accuracy of documentation
	C32	Cash in cash time
D Innovation and others	D33	Low new product development time
	D34	Employee turnover
	D35	Employees' skill and training
	D36	Manpower requirement
	D37	Improved relations within organization
	D38	Improved relations outside the organization
	D39	Responsiveness
	D40	Forecasting accuracy
	D41	Few schedule change in supply chain
	D42	Total supply chain inventory control
	D43	Suppliers sharing the forecasting process

7.4.2 Measuring and Evaluating Financial Metrics

Financial performance measures indicate whether the company's strategy, implementation and execution are effectively contributing to the bottom line improvement of a firm. Financial goals include achieving profitability, maintaining liquidity and solvency both short term as well as long term, growth in sales turnover and maximizing wealth of shareholders. Financial performance indicators are shown in Table 7.4. In simplicity, financial goals are to survive, succeed and prosper. Survival is measured by cash flow, success by growth in sales and operating income and prosperity by increased market share and return on equity and capital employed.

7.4.3 Measuring and Evaluating Internal Business Perspective

What must business excel at: the internal measures for the BSC stems from the business process that have the greatest impact on customer's satisfaction factors that affect cycle time, quality, skill of the employees, and of course, productivity. Firms should decide what processes and competencies they must excel at and specify measures for each of them. Performance metrics for the internal business perspective are shown in Table 7.4.

7.4.4 Measuring and Evaluating Innovation and Learning Perspective

Can we continue to improve and create value: a company's ability to innovate, improve and learn lies directly to company's value? Innovation and continuous learning process can bring about efficiency in operating domain of the business. Moreover, it ensures cost reduction and product differentiation to meet the varied requirements of the customers. As a result, it strengthens the financial ability through earning higher profitability and greater degree of appropriation of profit and retaining larger share of earnings to finance the forthcoming expansion of future projects of the company under consideration. Performance metrics for the innovation and learning perspective in a BSC includes measures as shown in Table 7.4.

7.5 INSTRUMENT OF THE RESEARCH

Forty three performance measures as presented in Table 7.4 are selected for the survey under four broad categories, this include customer service related measures symbolized as A, financial performance measures symbolized as B, internal business measures symbolized as C, innovation and other performance measures symbolized as D. Out of forty three measures ten measures comes under A and symbolized as A1, A2…….A10, eight measures comes under B and symbolized as B11, B12……..B18, fourteen measures comes under C and symbolized as C19, C20…….C32, eleven measures comes under the category D and symbolized as D33, D34……….D43. (Table 7.4) Respondents are asked to rate the different performance measures in terms of frequency of use (FoU), perceived use value (PUV) and ease of measurement (EoM) on the Likert scale. On the Likert scale, 1 stands for very low and 5 for very high.

The questionnaire was tested for two main types of validity: Content validity; and Construct validity. Content validity primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978). The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and detailed evaluations by academicians and practicing managers during pre-testing. The construct validity was verified by factor analysis. All the items in the question related to barriers loaded with a minimum factor loading of 0.49. This is in agreement with Kim and Mueller (1978) who suggested the use of only those items, which have a factor loading more than 0.40 Table 7.5.

Table 7.5: Factor Analysis of Performance Measures

Symbol	Performance measure variable (FoU, PUV and EoM)	Factor loading	Percentage of variance	Internal consistency
A1	On time delivery	0.752	51.324	α = 0.8551
A2	After-sales service	0.626		
A3	Increase in customer base	0.886		
A4	Retention of old customers	0.805		
A5	Product customization	0.580		
A6	Better product quality	0.784		
A7	Ease in tracking customer order	0.760		
A8	Increase in market share	0.678		
A9	Online receipt of order	0.678		
A10	Order fill rate	0.518		
B11	Cost per unit of product	0.575	49.485	α = 0.7453
B12	Net profit per unit of sales	0.619		
B13	Turnover	0.678		
B14	Return of investment (ROI)	0.757		
B15	Economic value added	0.796		
B16	Working capital required	0.700		
B17	Logistics costs	0,717		
B18	Revenue earned per employee	0.815		
C19	Inventory turnover ratio	0.735	59.834	α = 0.7929
C20	Return on assets (ROA)	0.645		
C21	Throughput time	0.708		
C22	Purchase lead-time	0.608		
C23	Manufacturing lead-time	0.528		
C24	Outsourcing	0.560		
C25	Operating costs	0.568		
C26	Reduced waste	0.719		
C27	Plant productivity	0.810		
C28	Just in time environment	0.645		
C29	Reduction in number of breakdown	0.596		
C30	Stabilized master schedule	0.497		
C31	Accuracy of documentation	0.562		
C32	Cash in cash time	0.538		
C33	Low new product development time	0.620	54.290	α = 0.7058
D34	Employee turnover	0.782		
D35	Employees' skill and training	0.538		
D36	Manpower requirement	0.682		
D37	Improved relations within organization	0.598		
D38	Improved relations outside the organization	0.729		
D39	Responsiveness	0.836		
D40	Forecasting accuracy	0.649		
D41	Few schedule change in supply chain	0.628		
D42	Total supply chain inventory control	0.583		
D43	Suppliers sharing the forecasting process	0.645		

7.6. DATA ANALYSIS

In the first phase, five clusters were made on the basis of the mean scores to evaluate the responses. The frequency that executives associated with the use of each of the 43 performance measures, executives' perceived usage value PUVs, and regarding the ease of measurement for these measures were examined.

The second phase of the data analysis utilized multiple regressions. The linear relationship tested is based on the variables included in the research instrument, where the frequency of use of the performance measures (FoU) is assumed to be a function of its PUV and of the ease of measurement (EoM).

Thus, the model tested is Equation 1 The linear function to be estimated is: Equation 2 where FoUi, the mean frequency of use score on the ith measure; PUVi , the mean PUV score on the ith measure; EoMi , the mean ease of measurement score on the i^{th} measure and e_i , the variable that represents the residual; a_0 , a_1, e, a_2, the linear parameters.

The observation unit used for this model is the average of the responses of all executives for each measure. The use of regression analyses in this manner is consistent with Gomes et al. (2006). After analyzing the data to verify the assumptions relevant to this model, it was used to evaluate the profile of the manufacturing enterprise in relation to the relative use of financial and non-financial measures.

The third phase of the data analysis utilized gap analysis to gain a better understanding of the relative importance of the non-financial measures. The differences between the PUV and the ease of measurement (EoM) 43 measures were determined. Then, these differences were multiplied by their PUVs, as given in (Equation 3) the differences between the PUV and ease of measurement were multiplied by their PUVs to provide scores that reflect the relative importance of the PUV for the measure utilization (Foster and Gupta, 1994). Thus, the larger the gap indicator is, the greater the disparity between the usefulness of the measure and its ease in measurement.

Finally on the basis of gap indicator four clusters has been made to obtain the distinction between different measures. The equations used in the data analysis are given as follows

$$\mathbf{FoU = f\,(PUV, EoM)} \quad \text{……..} \ \mathbf{1}$$

$$\mathbf{FoU_i = a_0 + a_1\,PUV_i + a_2\,EoM_i + e_i} \quad \text{……..} \ \mathbf{2}$$

$$\mathbf{GAP_i = (PUV_i - EoM_i)} \quad \text{……..} \ \mathbf{3}$$

$$\mathbf{FoU_i = a_0 + a_1\,PUV_i + a_2\,EoM_i + a_3\,OEM_i + e_i} \quad \text{……..} \ \mathbf{4}$$

$$\mathbf{FoU_i = a_0 + a_1\,PUV_i + a_2\,EoM_i + a_3\,ToP_i + e_i} \quad \text{……..} \ \mathbf{5}$$

$$\mathbf{FoU = a_0 + a_1\,PUV + a_2\,EoM + e} \quad \text{……..} \ \mathbf{6}$$

$$\mathbf{FoU = -\,0.375 + 0.731\,PUV + 0.390\,EoM} \quad \text{……..} \ \mathbf{7}$$

$$\mathbf{GAP = (PUV - EoM)} \quad \text{……..} \ \mathbf{8}$$

7.7. RESULTS

7.7.1 Mean Score Results

The results of the mean score for each measure on the basis of frequency of use, perceived use value and ease of measurement are shown in Tables 7.6 – 7.8. The first column in these tables represents the cluster number, the second column designates the measure, the third column represents the symbol, the fourth and fifth columns report the mean and standard deviation and the last column reports the coefficient of variation. The results in Table 7.6 present the frequency of use of the different measures is interesting. The first cluster, representing the most used measures, it contains three financial measures and two customer service related measure and. The remaining financial measures appear in the second cluster (five measures). Two observations stand out in terms of the utilization of the measures of the financial category.

The first observation relates to that all financial measures got place in top two clusters. It shows the superiority of the relative traditional, financial measures in terms of application in Indian manufacturing enterprises. The second observation relates to the measure B13 (Turnover), which is positioned in the top of the first cluster. Such position is perhaps understood, given the manufacturing organizations concerns for the amount of business done by their enterprise.

Analyzing the other measures included in the most used two clusters reveals that A category (customer service related measures) leads with six measures, followed by the C category (Internal business measures) with two measures, the D category (innovation and other measure) with one measures.

Table 7.6: Cluster based on the Mean Value for Frequency of Utilization (FoU)

Cluster	Performance measure variable	Symbol	Mean	SD	Coefficient of variation
I	Turnover	B13	4.79	0.58	0.15
	Net profit per unit sales	B12	4.52	0.89	0.22
	Return on investment (ROI)	B14	4.45	1.10	0.29
	Better product quality	A6	4.43	0.75	0.19
	On time Delivery	A1	4.22	1.05	0.25
II	Return on assets (ROA)	C20	4.10	0.98	0.22
	Retention of old Customer	A4	4.08	1.00	0.28
	Increase in market share	A8	4.04	1.04	0.31
	Cost per unit of product	B11	3.89	1.23	0.35
	Increase in customer base	A3	3.85	1.20	0.25
	Logistic costs	B17	3.79	1.15	0.32
	Low employee turnover	D34	3.78	1.29	0.31
	Working capital required	B16	3.73	1.46	0.42
	Operating costs	C25	3.68	1.09	0.30
	Economic value added (EVA)	B15	3.65	1.17	0.28
	Product customization	A5	3.60	1.16	0.24
	Revenue earn per employee	B18	3.60	1.17	0.29
III	Responsiveness	D39	3.58	1.36	0.36
	Manufacturing lead time	C23	3.56	1.45	0.42
	Ease in tracking customer order	A7	3.55	1.41	0.40
	Order fill rate Plant productivity	A10	3.52	1.25	0.29
	Plant productivity	C27	3.50	1.10	0.26
	Cash-in-cash time	C32	3.48	1.34	0.33
	Reduced waste	C26	3.46	1.26	0.36
	Online receipt of order	A9	3.39	1.19	0.31
	Reduction in Throughput time	C21	3.36	1.30	0.30
	Just in time environment	C28	3.25	1.47	0.49
	Employee skill and training	D35	3.25	1.26	0.35
	After sales service	A2	3.22	1.19	0.30
	Inventory turnover ratio	C19	3.11	1.28	0.35
	Improved relation outside of the organization	D38	3.09	1.32	0.42
IV	Total supply chain inventory control	D42	3.02	1.17	052
	Reduction in no. of breakdown	C29	2.9	1.25	0.59
	Stabilizing in master schedule	C30	2.88	1.22	0.44
	Low New product development time	D33	2.85	1.52	0.60
	Manpower requirement	D36	2.39	1.13	0.29
V	Forecasting accuracy	D40	2.37	1.42	0.68
	Purchase lead time	C22	2.35	1.23	0.57
	Outsourcing	C24	2.3	1.40	0.72
	Improved relation within the organization	D37	2.27	1.28	0.48
	Accuracy of documentation	C31	2.09	1.20	0.23
	Supplier sharing the forecasting process	D43	2.05	1.15	0.60
	Few schedule changes in supply chain	D41	1.86	1.01	0.50

Note; Cluster were predefined to 5 to provide an analogy with the scale used on the questionnaire

Table 7.7: Cluster based on the Mean Value for Perceived Usage Value (PUV)

Cluster	Performance measure variable	Category	Mean	SD	Coefficient of variation
I	Turnover	B13	4.58	0.64	0.17
	Return on investment (ROI)	B14	4.48	0.92	0.23
	Better product quality	A6	4.40	1.05	0.24
	Net profit per unit sales	B12	4.22	0.99	0.22
	On time Delivery	A1	4.21	0.90	0.19
	Return on assets (ROA)	C20	4.12	1.18	0.25
II	Increase in market share	A8	4.06	1.20	0.28
	Retention of old Customer	A4	3.90	1.14	0.31
	Responsiveness	D39	3.80	1.46	0.36
	Increase in customer base	A3	3.78	1.28	0.29
	Economic value added (EVA)	B15	3.70	1.27	0.32
	Low employee turnover	D34	3.68	1.39	0.34
	Cost per unit of product	B11	3.64	1.35	0.39
	Cash-in-cash time	C32	3.62	1.24	0.38
	Reduction in operating cost	C25	3.58	1.40	0.40
III	Revenue earn per employee	B18	3.55	1.27	0.35
	Product customization	A5	3.52	1.24	0.34
	Logistic costs	B17	3.50	1.25	0.32
	Ease in tracking customer order	A7	3.49	1.47	0.43
	Just in time environment	C28	3.45	1.47	0.49
	Plant productivity	C27	3.44	1.16	0.35
	Order fill rate Plant productivity	A10	3.42	1.23	0.35
	Manufacturing lead time	C23	3.40	1.42	0.42
	Reduced waste	C26	3.40	1.36	0.36
	Online receipt of order	A9	3.36	1.13	0.30
	Working capital required	B16	3.35	1.26	0.42
	Employee skill and training	D35	3.30	1.14	0.35
	Reduction in throughput time	C21	3.26	1.22	0.35
	After sales service	A2	3.25	1.29	0.30
	Total supply chain inventory control	D42	3.20	1.37	052
	Inventory turnover ratio	C19	3.20	1.28	0.35
	Improved relation outside of the organization	D38	3.14	1.34	0.42
IV	Stabilizing in master schedule	C30	2.98	1.33	0.44
	Reduction in no. of breakdown	C29	2.90	1.28	0.59
	Low New product development time	D33	2.75	1.52	0.60
	Purchase lead time	C22	2.60	1.36	0.48
V	Forecasting accuracy	D40	2.47	1.49	0.68
	Outsourcing	C24	2.41	1.25	0.62
	Manpower requirement	D36	2.35	1.06	0.49
	Supplier sharing the forecasting process	D43	2.25	1.15	0.65
	Accuracy of documentation	C31	2.19	1.19	0.33
	Improved relation within the organization	D37	2.15	1.33	0.38
	Few schedule changes in supply chain	D41	2.08	0.89	0.48

Note; Cluster were predefined to 5 to provide an analogy with the scale used on the questionnaire

Table 7.8: Cluster based on the mean value for Ease of Measurement (EoM)

Cluster	Performance measure variable	Category	Mean	SD	Coefficient of variation
I	Turnover	B13	4.78	0.58	0.11
	Return on investment (ROI)	B14	4.59	0.89	0.20
	Logistic costs	B17	4.25	1.05	0.25
	Cost per unit of product	B11	4.20	0.98	0.22
II	Net profit per unit sales	B12	4.05	1.10	0.29
	Increase in market share	A8	3.95	1.04	0.31
	Increase in customer base	A3	3.91	1.20	0.25
	Retention of old Customer	A4	3.84	1.00	0.28
	Low employee turnover	D34	3.78	1.29	0.31
	Better product quality	A6	3.73	0.75	0.19
	Return on assets (ROA)	C20	3.70	1.23	0.35
	Reduction in operating cost	C25	3.70	1.30	0.30
	Revenue earn per employee	B18	3.69	1.17	0.29
	Economic value added (EVA)	B15	3.65	1.17	0.28
	Product customization	A5	3.65	1.16	0.24
	On time Delivery	A1	3.63	1.15	0.32
	Working capital required	B16	3.60	1.41	0.40
III	Plant productivity	C27	3.56	1.10	0.26
	Order fill rate Plant productivity	A10	3.56	1.25	0.29
	Manufacturing lead time	C23	3.51	1.45	0.42
	Ease in tracking customer order	A7	3.46	1.26	0.36
	Online receipt of order	A9	3.45	1.19	0.31
	Cash-in-cash time	C32	3.38	1.34	0.33
	Reduced waste	C26	3.34	1.46	0.42
	Reduction in no. of breakdown	C29	3.25	1.26	0.35
	Reduction in throughput time	C21	3.24	1.24	0.35
	After sales service	A2	3.20	1.19	0.30
	Employee skill and training	D35	3.20	1.28	0.35
	Responsiveness	D39	3.15	1.36	0.36
	Just in time environment	C28	3.10	1.47	0.49
	Improved relation outside of the organization	D38	3.04	1.32	0.42
	Total supply chain inventory control	D42	2.98	1.22	0.44
IV	Inventory turnover ratio	C19	2.90	1.25	0.59
	Low New product development time	D33	2.71	1.52	0.60
	Total supply chain inventory control	C30	2.61	1.17	0.52
	Improved relation within the organization	D37	2.49	1.29	0.51
	Forecasting accuracy	D40	2.46	1.39	0.68
	Manpower requirement	D36	2.45	1.37	0.52
V	Outsourcing	C24	2.35	1.13	0.29
	Accuracy of documentation	C31	2.23	1.20	0.23
	Purchase lead time	C22	2.20	1.23	0.57
	Supplier sharing the forecasting process	D43	2.17	1.15	0.60
	Few schedule changes in supply chain	D41	1.77	0.91	0.50

Note; Cluster were predefined to 5 to provide an analogy with the scale used on the questionnaire

Indian manufacturing enterprises are facing stiff competition with Chinese product, as a result most of Indian enterprises start using customer related performance measures more frequently to retain their market. D34 (low employee turnover) emerges as an important performance measure and that is only innovation measure in these clusters. Top management is often using this data to evaluate their human resource policies.

Based on the results in Table 7.6, cluster 5 which includes the least used measures consists of five measures from category D (innovation and other measure), three measures from C category (Internal business measure), It is very surprising that innovative measures related to supply chain issues are among the least used performance indicators among Indian enterprises, this confirms the (Sahay et. al 2003). They highlighted various reasons why Indian enterprises are yet to conceive supply chain management strategies. In category C the measures like purchase lead time; outsourcing and accuracy in documentation are finding their place in bottom cluster.

The results of the performance measurement status based on the executive's perceived use value (PUV) of each of the 43 measures are shown in Table 7.7. In this table, the first cluster has the same measures as in the case of the frequency of use with the augmentation of one measure from category C (C20 Assets utilization). It is interesting to see three financial measures are absent from top two clusters. It indicates that financials measures fail to show the complete domination in terms of perceive uses value (PUV). Customer related measures are given due importance in terms of perceptual value by Indian manufacturing executives.

The results related to ease of measurement (EoM) are shown in Table 7.8 As expected, the first cluster includes all the measures from the financial category, and none from the non-financial category. The second cluster includes nine measures from non-financial categories; many of them are customer related performance measures. It has been noticed that in second cluster innovative measure is finding the place, which is D34 low employee turnover, shows that concern of top management towards this performance measure in Indian manufacturing enterprise. Most of performance measure below the median are internal business measures or innovative measures; shows that still there is lack of effective performance measurement system to evaluate innovative and supply chain related measures. Most of the measures from C and D category were found to have the low PUV and the low frequency of utilization.

Table 7.9 shows the average of responses for each category, as well as the ranking of these values for the three variables (FoU, PUV and EoM). Based on the results in Table 7.9 the measures of the financial category are in first place for all three values. Though customer service related measures scores very close to financial related measures in terms of PUV but behind in EoM and PUV in total.. Thus, the frequent use of financial measures in the evaluation of manufacturing performance may not be attributed only to the fact that information on these measures are the most readily available, but also due to the high PUVs of these measures. The relative similar ranking of both FoU and PUV appears to indicate that executives are using the measures which they perceive to have high PUVs. Table 7.10 shows the average value of each cluster in three different ways of measurement i.e FoU, PUV and EoM.

Table 7.9 Ranking of Performance Measure Categories

Measures	Mean of FoU	Rank	Mean of PUV	Rank	Mean of EoM	Rank
B Financial	4.063	1	3.877	1	4.101	1
A Customer service	3.805	2	3.729	2	3.634	2
C Internal business	3.145	3	3.182	3	3.076	3
D Innovation and other	2.765	4	2.833	4	2.745	4

Table 7.10 Mean of the Clusters

Clusters	Mean of FoU	Mean of PUV	Mean of EoM
I	4.482	4.335	4.455
II	3.832	3.74	3.742
III	3.38	3.366	3.275
IV	2.912	2.990	2.603
V	2.205	2.271	2.144

7.7.2 Regression Analysis Results

As shown in Chapter 3, 39.3 % of the organizations surveyed in this study are OEM and rests are supplier to OEM. Thus, the question of whether the views of the executives of OEM tend to be different than the view of supplier to OEM worthy of investigation. The model below is used to address this question: Equation 4 In this model, which was defined earlier in the methodology section, OMi is the binary variable which assumes the value of 1, if an executive represents a OEM organization and the value of 0 otherwise. The regression results related to testing this model are shown in Table 7.11.

Based on the results in Table 5.11, the R^2 -value indicates that the model explained 93.8 percent of the variations in the dependent variable (frequency of use). However, the coefficient of the variable OEM is not statistically significant (α=0.05). Therefore, it is concluded that no significant differences exist between OEM organizations and their counterparts representing supplier to OEM organizations with respect to the performance measures studied.

Table 7.11 OEM Regression Results

variable	R 0.972 Unstandard coefficients B	R^2 0.938 Std. error	Adjusted R^2 0.936 Standardized Coefficient β	Std. error of the estimate 0.1570 t	Sig.
Constant	- 1.048	0.099		-7,348	0.000
PUV	0.635	0.044	0.452	11.759	0.000
EoM	0.436	0.021	0.394	9.067	0.000
OM	-0.036	0.028	-0.004	-0.058	0.834

Table 7.12 Performance Trend Regression Results

variable	R 0.968 Unstandard coefficients B	R^2 0.930 Std. error	Adjusted R^2 0.928 Standardized Coefficient β	Std. error of the estimate 0.1120 t	Sig.
Constant	- 1.105	0.118		-10,186	0.000
PUV	0.778	0.056	0.566	14.742	0.001
EoM	0.605	0.037	0.284	12.006	0.000
ToP	0.017	0.028	0.007	0.284	0.455

The executives were also requested to provide information regarding their organizations last three years profit trends. Using the provided information, we calculated the indicator for each organization: Equation 5.In this model, ToPi is the binary variable which assumes the value of 1, if an executive represents a manufacturing enterprise with 10 % or more increase in profit during the last three years, and the value of 0 otherwise. The regression results related to testing this model are shown in Table 7.12.

Table 7.13 Regression Results

variable	R 0.995 Unstandard coefficients B	R^2 0.990 Std. error	Adjusted R^2 0.989 Standardized Coefficient β	Std. error of the estimate 0.07382 t	Sig.
Constant	-0.375	.061		-6.163	.000
PUV	0.731	.040	.655	18.467	.000
EoM	0.390	.038	.365	10.279	.000

Based on the results in Table 7.12, the R^2 -value indicates that the model explained 92.8 percent of the variations in the dependent variable (frequency of use). However, the coefficient of the variable ToP is not statistically significant (α=0.05). Therefore, it is concluded that no significant differences exist between executives of manufacturing organizations with high growth in profit and low growth in profit with respect to the performance measures studied.

Table 7.14 Residuals Errors with More Deviation from the Estimated Profile

Measure	Symbol	Standardized residual
Significant positive residual (more use)		
Working capital required	B16	3.541582
Better product quality	A6	1.880697
Improved relation within the organization	D37	1.436156
Increase in market share	A8	1.358203
Significant positive residual (less use)		
Cost per unit of product	B11	-1.87985
Reduction in no. of breakdown	C29	-1.57872
Cash-in-cash time	C32	-1.53686
Just in time environment	C28	-1.48812
Economic value added (EVA)	B15	-1.4495

Based on the results of above two analyses, it has been decided to abandon the above two models in favor of the general model initially proposed in the methodology section. Thus, the linear function to be estimated is: Equation 6 The observation unit used in this model is the average of the responses of the executives surveyed for each measure. After verifying the assumptions relevant for linear regression, we used a stepwise procedure to select variables to include in the model. This procedure resulted in the inclusion of the two independent variables.

The regression results shown in Table 7.13 indicate a high R^2 -value of 99.0 percent. Thus, revealing that 99 percent of the total variability in the frequency of use measure has been explained by the PUV and EoM. The estimated regression coefficients were found to be significant (α=0.01). This helps in establishing the relationship presented in Equation 7. Table 7.14 shows the measures with maximum residual errors. Such measures have more deviation in their observed value of FoU from the estimated profile as given in Equation 7.

7.7.3 Cluster Analysis Results

To better understand how manufacturing executives utilize non-financial measures, the relationship between the PUV and the EoM scores for each of the 43 measures is examined using the Equation 8. As was mentioned earlier in the data analysis, the larger the gap indicator is, the greater will be the disparity between the usefulness of the measure and its measurement from the perspective of the executives.

Thus, the measures can be divided in four clusters. The first and second clusters include the measures with relatively larger and smaller positive value of GAP indicators respectively. Third and fourth clusters include the measures with relatively smaller and larger negative value of GAP indicator respectively. Different clusters are shown in Figure 2. It can be observed from Figure 2 that there are nine, fifteen, eleven and eight measures (with their GAP indicator value in bracket) occupying the place in cluster I to IV respectively. The measure with high FoU are finding the place in the top of the cluster while the measures with low FoU are placed in the bottom of each cluster.

The first cluster has majority of customer related measures and internal business measures those are difficult to measures but high perceived use value. The executives need to develop an effective information system with available technologies so that their measurement can become conducive. It will possibly help them to be more comfortable with significant non financial measures, in their use, demonstration and presentation in front of top management, workers and customer. The success of the application of the measures like better product quality (A6) depends upon the right anticipation and interpretation of the executive.

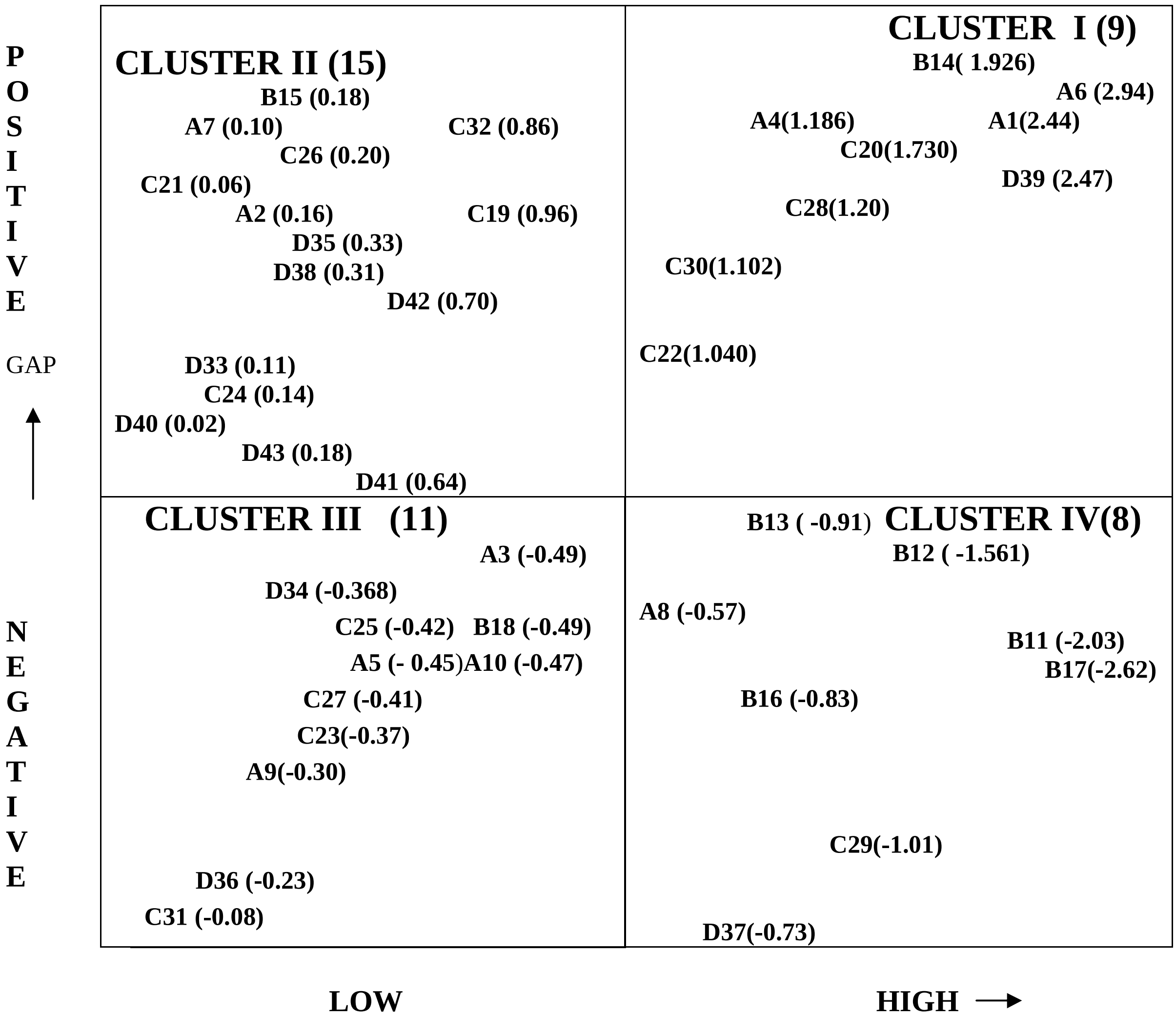


Figure 7.1: Cluster Analysis based on GAP Indicator Value

In the top of the second cluster it may be observed the measures economic value added (B15), Cash in cash time (C32), reduced waste (C26) and ease in tracking of customer order (A7) these are comparatively easy to measure and high FoU and PUV. In the bottom there exist several innovative measures, on which Indian executive need to be focus. These measures have strategic importance and should be used more frequently in long term interest of Indian manufacturing enterprises.

The third cluster includes the measures like employee turnover (D34), revenue earn per employee (B18), order fill rate (A10), product customization (A5) etc. that shows the relative ease in measurement. It can be noticed that in this cluster only two innovative measures making their presence. This number has been further reduced in fourth cluster. This clearly indicates that in Indian manufacturing enterprises there is dearth of an effective measurement system for innovative measures like, total supply chain inventory control (D42), improved relationships within and outside of the organization (D37, D38) that need to be develop in order to be conceive the SCM practices.

As expected the fourth cluster is dedicated to financial measures because of their high EoM and FoU. Such traditional measures are extremely important to acknowledge the sound health of the enterprise. These are the fundamental measures and have been given maximum importance by Indian manufacturing executives. The internal business measure like reuction in number of breakdown (C29) got the place in this cluster. Increase in market share (A8) also registers its presence in this cluster. Indian tradition and culture supports to be very cautious towards the financial measures.

7.8 CONCLUSION AND IMPLICATIONS

The objective of this study is to gain an understanding of practices related to manufacturing performance measures and measurement process. The results derived from this study based on a sample of 206 Indian manufacturing executives, and 43 measures lead to the following conclusions and implications.

First, there appear to be a consistent pattern of utilization, relevance and ease of measurement in relation to practices associated with the studied measures. In this context, Indian executives, in ways similar to most of their counterparts in other business cultures, appear to be consistently utilizing traditional financial and efficiency-based measures. Their rational for using such measures appears to be based on their perceptions that these measures have high PUVs. However, it turned out to be that information regarding most of these measures appears to be readily available.

Second,, while a closed system efficiency-based orientation may have served Indian manufacturing organizations well during the inflationary periods of the past, this orientation may not be effective in a multi-faceted performance and open system global manufacturing environment. Since the global manufacturing environment is judging effectiveness based on efficiency, quality, innovation, customer satisfaction, and concern for the environment, continuing to under-utilize such facets of manufacturing performance will translate into competitive disadvantage for Indian manufacturing organizations in the global marketplace. Therefore, Indian manufacturing executives are called upon to realign their approaches and practices in relation to performance measurement to be consistent with the demands of the dynamic global marketplace. In this context, these executives need to reengineer their organizational cultures and their information systems in order to not only make information on non-financial measures available, but also to promote the systematic utilization of these measures in the performance evaluation process.

Finally, the findings reported here with regard to the under-utilization of non-financial measures are by no means unique to the Indian manufacturing environment. They are rather indicative of a general pattern found across different manufacturing cultural settings.

The practice of manufacturing performance measurement is an evolving process. Recently, this process has been challenged by dramatic changes relevant to how technology is used, and how markets are served. These challenges have made the efficiency-based closed manufacturing system mode of operations obsolete. Based on the results of this study, it appears that these challenges have not yet been met. Manufacturing executives appear to be still struggling with escaping the mentality of the efficiency focus of the closed system orientation of the past. Therefore, applied research is called for to facilitate the practical transition to an open system orientation where manufacturing performance should be viewed as dynamic and multi-faceted in nature.

CHAPTER 8

MODELING INTEGRATION AND AGILITY OF SUPPLY CHAIN USING INTERPRETIVE STRUCTURAL MODELLING

8.1 MODELING INTEGRATION OF SUPPLY CHAIN

The concept of supply chain management is about managing coordinated information, material flows, plant operations, and logistics. It provides flexibility and agility in responding to consumer demand shifts. The fundamental logic of this philosophy is integration among multiple independent business entities and improved coordination within and among various supply-chain members. Increased coordination can lead to reduction in lead times and costs, alignment of interdependent decision-making processes, and improvement in the overall performance of each member as well as the supply chain. Interpretive Structural Modeling (ISM) has been used in this chapter as a methodology for identifying and summarizing relationships among specific integration enablers of a supply chain, which define an issue or problem. It provides a mean by which order can be imposed on the complexity of such enablers and their relationships. In this chapter key enablers (also referred to as variables) for the integration of supply chain has been identified and analyzed to obtain an ISM, which shows the inter-relationship of the variables and their levels. These variables have also been categorized depending upon their driving power and dependence.

A supply chain is a network of members formed by autonomous entities (and their systems) by bonding together to provide the products and services to the satisfaction of the customers at minimum cost. With their collective and collaborative efforts, they sustain the progress of each member as well as the group. Collaboration between members require effective communication. In a collaborative environment, a member may modify its norms of behavior to accommodate other member's perspectives (Simchi-Levi et al., 2008).

Increasing competition due to market globalization, product diversity and technological breakthroughs stimulates independent firms to collaborate in a supply chain that allows them to gain mutual benefits. This requires the collective know-how of the coordination mode, including the ability to synchronize interdependent processes, to integrate information systems and to cope with distributed learning.

Coordination among independent firms, such as raw-material suppliers, manufacturers, distributors, third-party logistics providers and retailers, is the key to attaining the flexibility necessary to enable them to progressively improve logistics processes in response to rapidly changing market conditions. Poor coordination among the chain members can cause dysfunctional operational performance. Some of the negative consequences of poor coordination include higher inventory costs; longer delivery times, higher transportation costs, higher levels of loss and damage, and lowered customer service (Lee *et al*., 1997). Since changes that occur in any one of the chain members are likely to affect the performance of the others, coordination is useful for managing interdependent logistics activities in order to mitigate demand variability and unnecessary inventory. A process of planning, executing and controlling the interdependencies of activities carried out by different supply chain members or business units in order to create value for the end customer is known as supply chain management (Lambert *et al*., 1998).

Integration across the supply chain is achieved through synchronization of activities at the member entity and aggregating its impact through process, function, business, and on to enterprise levels, either at the member entity or the group entity. With integration, there will often be many direct connections between people at various decision levels across the interlinked firm in the supply chain. Technicians from the buyer will communicate directly with technicians of the supplier. Production planners at the supplier will be in close contact with purchasing personnel at the buyer (Bagchi and Larsen, 2003). Thus, by synchronization of supply-chain components, existing bottlenecks in the system at various levels are eliminated, while future ones are prevented from occurring.

8.2 INTERPRETIVE STRUCTURAL MODELING

ISM is an interactive learning process .A set of different and directly related elements are structured into a comprehensive systematic model. The model so formed portrays the structure of a complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words. ISM methodology helps to impose order and the direction on the complexity of relationships among elements of a system, Saxena et al. (1990) identifies the key variables using direct as well as indirect inter relationships amongst the variables and presents the results of the application of ISM methodology to the case of 'Energy conservation of in Indian Cement Industry'. To identify the key actors, objectives and activities for energy conservation in the Indian Cement Industry, ISM (Saxena et al. 1992) has been used to develop direct relationship matrices. Sharma et al. (1995) carry out ISM to develop a hierarchy of action required to achieve the future objective of waste management in India. Some important vendor selection criteria have been analyzed (Mandel and Deshmukh, 1994) using an ISM that shows the inter-relationship of criteria and their levels. These criteria have been categorized depending upon their driving power and dependence.

The method is interpretive as the judgment of the group decides whether and how the variables are related. It is structural as on the basis of relationships an overall structure is extracted fro the set of complex variables, It is a modeling technique on the specific relationships and overall structure are portrayed in diagraph model. ISM is primarily intended as a group learning process, but individual can also use it.

ISM starts with an identification of elements, which are relevant to the problem or issue and then extends with group problem- solving technique. Then a contextually relevant subordinate relation is chosen. Having decided on the element set and the contextual relation, a structural self-interaction matrix (SSIM) is developed based on pair-wise comparison of elements. In the next step, the SSIM is converted into a reachability matrix and its transitivity is checked. Once a transitivity embedding is complete a matrix model is obtained. Then, the partitioning of the elements and an extraction of the structural model, called ISM is derived.

8.2.1 Steps in ISM

Various steps involved in the ISM technique are given below. The flow diagram for preparing the ISM is given in Figure 8.1.

1. Variables are listed down, which can be Objectives, Actions, Individuals etc., and a contextual relationship is established among variables with respect to which pairs of the variable would be examined.
2. A Structural Self-Interaction Matrix (SSIM) is developed for variables of the system.
3. A reachability matrix is developed from the SSIM and is checked the matrix for transitivity.
4. The reachability matrix is partitioned into different levels.

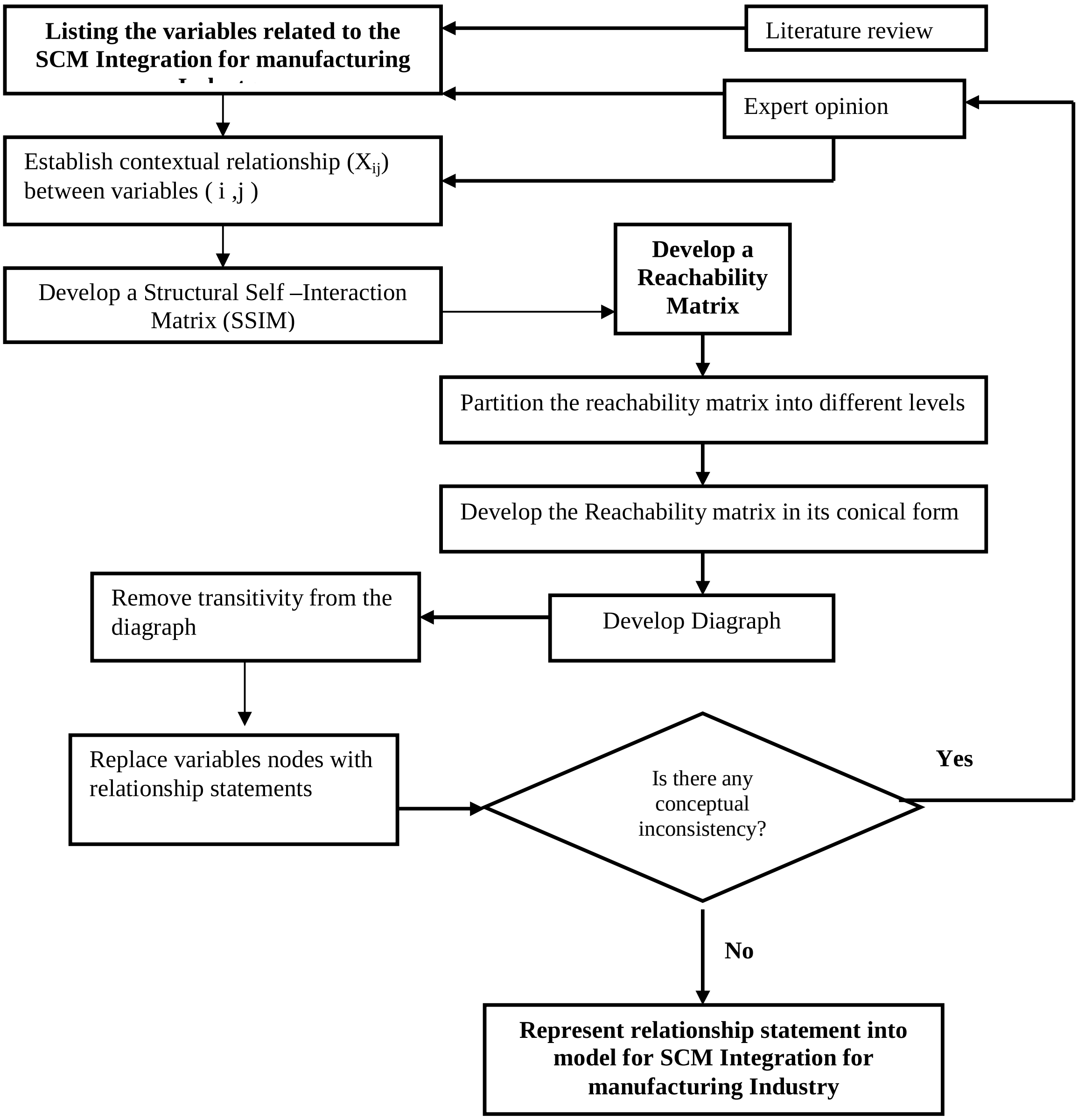


Figure 8.1: Flow Diagram for Preparing ISM

5. The reachability matrix is developed in the conical form i.e. with most zero (0) variables in upper diagonal half of the matrix and most unitary (1) variables in the lower half.

6. Based on the above a Directed Graph (Digraph) is drawn and transitive links are removed and the resultant Digraph is converted into an ISM by replacing variables nodes with statements.
7. The ISM model is reviewed to check for conceptual inconsistency and incorporate makes the necessary modifications.

8.3 IDENTIFICATION OF ENABLER VARIABLES FOR INTEGRATION

Based on literature review and expert opinion, following SCM Integration parameters have been categorized into three groups

1. Strategic level integration enablers
2. Operational level integration enablers
3. Performance level integration enablers

1. Strategic level integration enablers: These are the variables that help in integration of supply chain management at strategic level; such variables basically influenced the strategic level objectives for the supply chain. Some of the enablers are

I. Top management commitment
II. Financial resources
III. Collective learning

2. Operational level integration enablers: These are the variables that help in integration of supply chain management at operational level, i.e. such parameters basically influenced the operational decisions of supply chain management that may be taken from time to time or periodically (daily, weekly or monthly etc.).Some of these parameters are

IV. Collaborative Planning Forecasting and Replenishment (CPFR)
V. Enterprise resource planning (ERP)

VI. JIT Tools e.g. Kanban

VII. Point of Sale (POS) Information

VIII. Information sharing

IX. Logistics synchronization

X. Profit sharing

XI. Customer Relationship Management (CRM)

3. Performance level integration enablers: These variables indicate the performance of the supply chain management and its integration, some of these parameters are

XII. Customer satisfaction

XIII. Buyer supplier relationship

XIV. Lead time reduction

Fourteen supply chain integration enabler variables have been identified and briefly discussed as follows;

8.3.1 Top Management Commitment

Commitment of top management is crucial to the success of any effort aimed at changing the strategic and operational philosophy of the organization. Without the support of management the behavior of the members of the organization is unlikely to change. It has been argued that change will be more successful if upper management is committed to the change (Senge, 1990). The critical role of top managers in shaping the success of strategic changes in organizations is also noted often (Bourgeois and Eisenhardt, 1988). Top management plays a decisive role in paradigm shifts in critical areas such as quality management, product development and other innovation (Hoffman and Hagerty, 1994; Johne and Snelson, 1989). Top management commitment at every stage of supply chain is one of the essential parameter towards its integration Success of supply chain integration will depend, on the level of top management commitment. When top management reveals its commitment to integration of supply chain management, this may provides subordinates with salient clues for impressing upper management. Thus, when a firm attempts to implement a planned change, employees at all levels are more likely to invest time and effort in the change program if that program has the full and credible support of top management (Cole *et al.*, 1993; Krantz, 1989).

8.3.2 Financial Resources

It denotes funds and other resources to support the infrastructure and manpower requirements for the integration of supply chain management. The smooth and efficient flow of material and information need good financial back up to develop effective logistics and information infrastructure. All the entities of the supply chain need some funds, information systems, relevant software etc. for effective focus on supply chain management. Information Technology (IT) is the one of the most important enabler of the supply chain management. IT infrastructure requirement is essential because without IT infrastructure, the information accessing, information creating and information sharing is not possible. Financial resources are required for the development of IT infrastructure, logistics, transport and warehousing etc.

8.3.3 Collective Learning

The coordination of collective learning deals with how to tackle the coherency problem of initiation and diffusion of knowledge across organizational borders (Sawhney and Prandelli, 2000). Special emphasis is placed on practical learning from one another for understanding and creating unspoken capability in implementing particular logistics improvement initiatives. Mastering unspoken capability involves intensive dialogue, experimentation and discussion of data, information and knowledge to attain collective sense making (Senge, 1990). The objective of the coordination of collective learning is to extend each partner's capability that is useful for accomplishing ongoing improvements throughout the supply chain.

8.3.4 Collaborative Planning Forecasting and Replenishment (CPFR)

CPFR is a Web-based attempt to coordinate the various activities including production and purchase planning, demand forecasting and inventory replenishment between supply chain trading partners. Its objective is to exchange selected internal information on a shared Web server in order to provide for reliable, longer term future views of demand in the supply chain (Fliedner, 2003). CPFR is designed to improve the flow of goods from the suppliers, to the end user. It is also designed to quickly identify any discrepancies in the forecasts, inventory, and ordering data so that the problems can be corrected before they negatively impact sales or profits. Entities can share their sales history, sales projections and other important information with their supply chain partners, and they in turn share their raw material availability, lead times and other important information. Then the information is integrated, synchronized, and used to eliminate excess inventory and improve in-stock positions making everyone in the supply chain more profitable.

8.3.5 Enterprise Resource Planning (ERP)

ERP is a business management system that integrates all facets of the business, including planning, finance, manufacturing, sales, and marketing. ERP systems have become fixtures to provide a basis for business process management integration across business functions (Mabert *et al*., 2000) As the ERP methodology has become more popular, software applications have emerged to help business managers implement ERP in business activities such as inventory control, order tracking, customer service, finance and human resources. Early enterprise resource planning (ERP) systems were not primarily focused on the supply chain. Their initial focus was to execute and integrate such internally oriented applications that support finance, accounting, manufacturing, order entry, and human resources. Even in the early days, however, a link to supply chain management (SCM) was present in the form of inventory management.

8.3.6 JIT Tools

JIT, Just in time is capable to improve profits and return on investment by reducing inventory levels (increasing the inventory turnover rate), reducing variability, improving product quality, reducing production and delivery lead times, and reducing other costs (such as those associated with machine setup and equipment breakdown). The kanban system is an element of just-in-time system that can be used in integration of the entities in supply chain management. kanban is a Japanese word that means "visible sign" or card. An advantage of the kanban system is its ability to control production. Other advantages include its simplicity in production scheduling, reduced burden on operators, ease of identification of parts by the kanbans attached to the containers and substantial reduction in paper work. The kanban system is viewed as an information system. The kanban contains information such as the type, component name and code, the station location and the destination station. Monden (1993) and Suzaki (1987) discuss the different types of kanbans and their functions. These include withdrawal kanbans, production kanbans, supplier kanbans, signal kanbans, common kanbans, tunnel kanbans, express kanbans and emergency kanbans. Kanban has been proved to be effective tool for pull system supply chain management. In a pull system supply chain management entities can be integrated with the advantages of kanban.

8.3.7 POS Information

A Point of Sale information system may include credit card processors, cash drawers, receipt printers, magnetic stripe readers, pole displays, bar code scanners and signature capture pads, all integrated with a computer-based system. Point of Sale Software is used to manage and control all of these components, and to organize product, customer and sale information Point of Sale (POS) information is very important data to enable JIT tools in supply chain management. This leads to a decrease in lead times achieved through the ability to better anticipate incoming orders from the retailers. Other benefits include a decrease in inventory at the retailer, a decrease in the variability in the system (Simchi-Levi et al., 2000), POS information requires a very effective and quick communications system, and this information can be equally utilized by all the stages of the supply chain.

8.3.8 Information Sharing

The coordination of information sharing attempts to make relevant, accurate and timely information available to the decision-makers (Lee, 2000). Chain members often have different private information, which is often not shared with others - thus asymmetric information is inherent in supply chains (Simatupang and Sridharan, 2002). For example, the retailer has better projected customer demand compared with the manufacturer. The manufacturer has better information about products, delivery lead-times and production capacity than the retailer (Lee *et al.*, 1997). Traditional communication between the manufacturer and the retailer is made through periodic ordering in large batches. This ordering behavior distorts original demand information, because demand variance becomes larger, as order data percolate to the upstream members. The idea is, then, to share demand information with the upstream members. The visibility of demand data and inventory at the point of sales allows the upstream members to update forecasts and ensure continuous replenishment of the products.

Information technology (IT) such as the EDI, Internet, intranet, software application packages and decision support systems can be applied to facilitate information sharing with customers and partners, and optimization of supply chain performance. IT applications for customer orientation include informational facility (i.e. online information about custom and standard products, a comprehensive, frequently asked questions section, contact person, return policy, etc.) and transactional facility (e.g. online order submission, order modification, order notification, order tracking, security of online payment and technical assistance). IT applications for partner orientation enable participating members to gain visibility about customer demand (e.g. customer profiles, products, prices, locations, quantity and demand patterns), resource planning (e.g. forecasting, shipping schedules, inventory, capacity, location, lead-times and products), and contract status such as price, automatic ordering, order-status tracking, invoicing, auction, incentive score-board and electronic payment. This level of information sharing acts as the glue that integrates all chain members. IT, for instance, enables chain members to monitor the order fulfillment process from manufacturing, shipping and order receiving. IT applications for optimization provide analysis of supply chain status and various intelligent recommendations for operational and tactical decisions (Simchi-Levi *et al*., 2008).

8.3.9 Logistics Synchronization

Logistics synchronization means recognizing and concerting improvement initiatives that significantly contribute to value creation in the acquisition, consumption and disposition of products and services in today's rapidly changing markets. This typical coordination refers to the market mediation function of a supply chain that aims to match the variety of products reaching the marketplace with customer needs and wants (Fisher, 1997). Understanding customer demand and concerting inventory management, facility and transportation between partners help to realize improvements in the forms of rapid response to customer requirements, lowered inventory costs, improved product availability, minimum obsolescence and minimum variance of any unexpected events such as forecasting errors and delays that disrupt chain performance (Lambert *et al*., 1998).

Logistics synchronization also assists participating members to resolve role conflict, so each member can perform specific tasks and assume certain responsibility to ensure the attainment of chain profitability. The real challenges include focusing on core activities that provide real value to the customer, and subordinating other supporting activities to ensure the value creation process. Analyzing the value creation process across the supply chain can provide a road map for strategic initiatives that clarify specific roles for each participating member. Govindarajan and Gupta (2001), suggest three interrelated areas to ensure logistics synchronization:

(1) customer definition;

(2) customer value identification; and

(3) value creation process design.

If the chain members can redefine the customer base, reinvent the concept of customer value, and redesign the end-to-end value chain architecture, then they are likely to create competitive advantage from the customer's viewpoint.

Several strategies of logistics synchronization have been developed based on the principles of logistics management - such as collaborative logistics processes, operational flexibility, logistics postponement and collaborative transportation. The collaborative logistics processes refer to joint decision-making such as assortment planning, joint forecasting, joint inventory management and replenishment (Simchi-Levi *et al*., 2000). Operational flexibility aims to provide various demand response strategies by considering supply capacity such as make-to-forecast, locate-to-order, amend-to-order and build-to-order (BTO) (Holweg and Pil, 2001). Logistics postponement refers to delaying product differentiation to the latest possible time until customer orders are received (van Hoek, 2001). Collaborative transportation attempts to employ the third-party logistics providers to accomplish in-bound and out-bound logistics. Direct shipping, warehousing, and cross docking are three distinct out-bound strategies to deliver goods to end customers (Simchi-Levi *et al*., 1999).

8.3.10 Profit Sharing

Profit sharing defines how decision-makers are to be rewarded or penalized for the decisions they make. Conflict of interest is likely to occur when the existing profit sharing lead to actions that maximize personal gain but often reduce the total profitability (Clemons and Row, 1993). Traditional profit sharing schemes are often based on local costs and short-term concessions that attempt to fill the gap in inventory between chain members. The perverse incentives, such as local inventory cost, transportation cost and lot-size-based quantity discounts, often do not support the value creation process of improving customer services, because those incentives are tied to the action of reducing the internal costs of one stage of the supply chain. This local optimization often sacrifices the total profit (Simchi-Levi *et al*., 2000). For example, the manufacturer rewards the retailer based on the number of units or lot-size purchased over a set period. The retailer takes advantage of this quantity discount by loading up inventory. Then it sells the product later at the regular price (forward-buying) or sells it to other retailers for profit (diversion) (Clemons and Row, 1993).

One way to resolve such a conflict of interests is to offer incentive schemes linked to the global performance that reflects both value creations for the customers and profitability (Simatupang and Sridharan, 2002). This coordination mode is called incentive alignment that induces the partner behavior, which is consistent with customer focus and total profit (Lee, 2000). Firms that share complementarities of business process will attempt to resolve incentive misalignment in mutually satisfying ways based on a relational contract especially to manage risks associated with demand uncertainty. A relational contract specifies parameters such as price, quantity, time and quality that guide how a buyer places orders and a seller fulfils orders. Examples come in many forms including relationship pricing (i.e. volume-based quantity discounts, functional allowances and promotional allowances); a subsidy for products returned, consignment and price protection; capacity reservation such as back-up agreements and quantity flexibility contracts; tying bonuses to desirable performance, such as minimizing forecasting errors, sales-through, customer service, speed of delivery and product availability; stabilizing the transfer price, such as an every-day-low-price (EDLP) and every-day-low-cost (EDLC), and gain-sharing schemes (Stern *et al*., 1996; Simchi-Levi *et al*., 2000) .

8.3.11 CRM

Customer Relationship Management (CRM) is about finding, getting, and retaining customers. It includes the methodologies, software, and Internet capabilities that help a company manage customer relationships in an efficient and organized manner, CRM is at the core of any customer-focused business strategy and includes the people, processes, and technology questions associated with marketing, sales, and service, (Peppers and Rogers, 1999). In today's competitive world, organizations looking to implement successful CRM strategies need to focus on a common view of the customer using integrated information systems and contact center implementations that allow the customer to communicate via any desired communication channel. Customer relationship management is a comprehensive approach that promises to maximize relationships with all customers, including Internet or "e-customers", distribution channel members, and suppliers. Getting to "know" each customer through data mining techniques and a customer-centric business strategy helps the organization to proactively and consistently offer (and sell) more products and services for improved customer retention and loyalty over longer periods of time. Peppers and Rogers (1999) refer to this as maximizing "lifetime customer share", resulting in customer retention and profitability.

8.3.12 Customer Satisfaction

Customer satisfaction is the result of delivering a product or service that meets customer requirements. The degree to which customers are satisfied with the product and/or service received, and can be applied to internal customers or external customers. Customer satisfaction comprises of three elements; namely, pre-transaction satisfaction, transaction satisfaction, and post-transaction satisfaction (Chan et al., 2002). Variables that contribute to satisfaction, such as logistics and marketing customer service, are important because ongoing relationships between channel members are contingent on the level of satisfaction of each firm (Jarrell, 1992). If the customer's expectations are not met, customer dissatisfaction will result. And the lower the satisfaction level, the more likely the customer is to stop purchasing the product or service. High levels of customer satisfaction and high rates of customer retention are strongly related to one another and to corporate profitability, Oliver (1993). The degree to which customers are satisfied with the product and/or service received, and can be applied to internal customers or external customers. Customer satisfaction comprises of three elements; namely, pre-transaction satisfaction, transaction satisfaction, and post-transaction satisfaction.

8.3.13 Buyer Supplier Relationship

The final level of customer value is an increased connection between the firm and its customers through development of a relationship. This makes it more difficult for customers to switch to another provider since a relationship requires an investment of time from both the customer and the provider, (Simchi-Levi *et al*., 2008). In the mid-twentieth century, mass production techniques and mass marketing changed the competitive landscape by increasing product availability for consumers. However, the purchasing process that allowed the shopkeeper and customer to spend quality time getting to know each other was also fundamentally changed. Customers lost their uniqueness, and shopkeepers lost track of their customer's individual needs as the market became full of product and service options. Many companies today are racing to re-establish their connections to new as well as existing customers to boost long-term customer loyalty. Organizations today must focus on delivering the highest value to customers through better communication, faster delivery, and personalized products and services (Bultema, 2000).

8.3.14 Lead Time Reduction

Lead-time reduction within the supply chain is the mechanism for time-based competition (Tersine and Hummingbird, 1995). Eliminating delays at various stages invariably improves throughput and customer services. Measures for reductions in design times, cycle times, setup times, throughput times and delivery times are to be taken for over all lead-time reduction. Eliminating delays and improving product flows involves creativity, specialized skills, capital investments and behavioral changes that challenge the status quo. Frequently, significant improvements can be attained with relatively little, additional capital investment.

8.4 STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

After the identification of variables, which helps in the integration of supply chain, their contextual relationships are developed. Two variables can be independent to each other, they may help each other or one variable helps in the attainment of other while the reverse is not true. The existence of a relation between any two sub-variables (i and j) and the associated direction of the relation is questioned. Four symbols are used for the type of the relation that exists between the two sub-variables under consideration:

V for the relation from i to j but not in both direction: In this type of relationship variable i helps in achieving the variable j,

A for the relation from j to i but not in both directions

X for both direction relations from i to j and j to i, and: In this type of relationship i variable help in achieving j and j helps in achieving i.

Table 8.1: Structural Self-Interaction Matrix (SSIM)

Variables	14	13	12	11	10	9	8	7	6	5	4	3	2
1	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**X**	**V**	**V**	**V**	**X**	**V**
2	**O**	**O**	**O**	**V**	**O**	**V**	**V**	**V**	**O**	**V**	**V**	**O**	
3	**V**	**X**	**V**	**V**	**V**	**V**	**A**	**A**	**O**	**X**	**X**		
4	**V**	**X**	**V**	**X**	**O**	**V**	**A**	**A**	**X**	**X**			
5	**V**	**A**	**O**	**O**	**O**	**V**	**X**	**A**	**A**				
6	**V**	**O**	**O**	**O**	**O**	**V**	**A**	**A**					
7	**O**	**A**	**O**	**X**	**V**	**V**	**V**						
8	**V**	**X**	**V**	**X**	**V**	**V**							
9	**V**	**X**	**V**	**X**	**O**								
10	**O**	**X**	**V**	**A**									
11	**O**	**X**	**V**										
12	**A**	**X**											
13	**X**												

No.	Variable name	No.	Variable name	No.	Variable name
1	Top management commitment	6	JIT tools e.g. kanban	11	Customer relationship management (CRM)
2	Financial resources	7	POS information	12	Customer satisfaction
3	Collective learning	8	Information sharing	13	Buyer-supplier relationship
4	CPFR	9	Logistics synchronization	14	Lead Time Reduction
5	ERP	10	Profit sharing		

O if the relation between the variables does not appear valid

For analyzing the variables, a contextual relationship is chosen, such that one variable leads to another. Based on this contextual relationship a SSIM has been developed. To obtain consensus, the SSIM was discussed in a group of experts. Based on their responses, the SSIM has been presented as shown in Table 8.1.

Top management commitment (1) is essential to implement and achieve financial resources (2), collective learning (3) CPFR (4), ERP (5), JIT Tools e.g.kanban (6), creation of POS information (7); information sharing (8) logistics synchronization (9) profit sharing (10), CRM (11), customer satisfaction (12), buyer supplier relationship (13) and lead time reduction (14) whereas collective learning (3) and POS information (7) leads to top management commitment.

Financial resource needed to meet the expenses in implementation of CPFR (4), ERP (5), POS Information (7), Information sharing (8) and CRM (9). No variable is directly leading to financial resources as for as supply chain integration is concern

Collective learning leads to CPFR (4), ERP (5), logistics synchronization (9), profit sharing (10), CRM (11), customer satisfaction (12), buyer-supplier relationship (13), and

Lead-time reduction (14), whereas CPFR (4), ERP (5), POS information (7), information sharing (8) and buyer-supplier relationship (13) leads to collective learning.

CPFR leads to ERP (4) JIT Tools (6), logistics synchronization (9), CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14), whereas ERP (5), JIT Tools (6), POS information (7), Information sharing (8), CRM and buyer-supplier relationship (13) leads to CPFR. ERP leads to Information sharing (8), logistics synchronization (9) and lead-time reduction (14), whereas JIT Tools (6), POS information (7), information sharing (8) and buyer-supplier relationship leads to ERP.

JIT Tools (6) leads to logistics synchronization (9) and lead-time reduction (14) whereas information sharing (8) and POS information (7) leads to JIT Tools

Financial resources needed to meet the expenses in implementation of CPFR (4), ERP (5), POS Information (7), Information sharing (8) and CRM (9). No variable is directly leading to financial resources as for as supply chain integration is concern

Collective learning leads to CPFR (4), ERP (5), logistics synchronization (9), profit sharing (10), CRM (11), customer satisfaction (12), buyer-supplier relationship (13), and lead-time reduction (14), whereas CPFR (4), ERP (5), POS information (7), information sharing (8) and buyer-supplier relationship (13) leads to collective learning. CPFR leads to ERP (4) JIT Tools (6), logistics synchronization (9), CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14), whereas ERP (5), JIT Tools e.g.kanban (6), POS information (7), Information sharing (8), CRM and buyer-supplier relationship (13) leads to CPFR. ERP leads to Information sharing (8), logistics synchronization (9) and lead-time reduction (14), whereas JIT Tools (6), POS information (7), information sharing (8) and buyer-supplier relationship leads to ERP.

JIT Tools (6) leads to logistics synchronization (9) and lead-time reduction (14) whereas information sharing (8) and POS information (7) leads to JIT Tools. POS information leads to logistics synchronization (9), profit sharing (10), information sharing (8) and CRM (11), whereas CRM (11) and buyer-supplier relationship (13) leads to POS information.

Information sharing leads to logistics synchronization (9), profit sharing (10), CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14) whereas CRM (11) and buyer-supplier relationship (13) leads to information sharing (8). Logistics synchronization leads to CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14) whereas CRM (11) and buyer-supplier relationship (13) leads to logistics synchronization. Profit sharing leads to customer satisfaction (12) and buyer-supplier relationship (13) whereas CRM (11) and buyer-supplier relationship (13) leads to profit sharing (10). Customer satisfaction (12) leads to buyer-supplier relationship (13) whereas buyer-supplier relationship (13) and lead-time reduction (14) leads to customer satisfaction. Lead-time reduction leads to buyer-supplier relationship and vice versa.

8.5 REACHABILITY MATRIX

The SSIM format is transformed into a reachability matrix format by transforming the information in each entry of the SSIM into 1's and 0's in the reachability matrix. The methodology of performing is as follows:

1. If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and (j, i) entry becomes 0.

2. If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and (j, i) entry becomes 1.

3. If the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and (j, i) entry becomes 1.

4. If the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and (j, i) entry becomes 0.

Following these rules, reachability matrix for the variation is prepared as shown in Table 8.2

Table 8.2: Reachability Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	1	0	1	1	0	1	1	1	0	1	0	0	0
3	1	0	1	1	1	0	0	0	1	1	1	1	1	1
4	0	0	1	1	1	1	0	0	1	0	1	1	1	1
5	0	0	1	1	1	0	0	1	1	0	0	0	0	1
6	0	0	0	1	1	1	0	0	1	0	0	0	0	1
7	1	0	1	1	1	1	1	1	1	1	1	0	0	0
8	0	0	1	0	1	1	0	1	1	1	1	1	1	1
9	0	0	0	0	0	0	0	0	1	0	1	1	1	1
10	0	0	0	0	0	0	0	0	0	1	0	1	1	0
11	0	0	0	1	0	0	1	1	1	1	1	1	1	0
12	0	0	0	0	0	0	0	0	0	0	0	1	1	0
13	0	0	1	1	1	0	1	1	1	1	1	1	1	1
14	0	0	0	0	0	0	0	0	0	0	0	1	1	1

8.6 PARTITIONING THE REACHABILITY MATRIX

The matrix is partitioned by assessing the reachability and antecedent sets for each variable. The variable for which the reachability and the intersection sets are the same is given the top level variable in the ISM hierarchy, which would not help achieve any other variable above their own level. After the identification of the top-level element, it is discarded from the other remaining variables. Customer satisfaction (12) is found at level 1 in first iteration (Table 8.3).

Table 8.3: First Level of SCM Integration Variables

Iteration 1

Variable	**Reachability Set: R (P)**	**Antecedent Set: A (P)**	**Intersection R (P)**	**Level**
1	**1,2,3,4,5,6,7,8,9,10,11,12,13,14**	**1,3,7**	**1,3,7**	
2	**2,4,5,7,8,9,11**	**1,2,10,13**	**2**	
3	**1,3,4,5,9,10,11,12,13,14**	**1,3,4,5,7,8,13**	**1,3,4,5,13**	
4	**3,4,5,6,9,11,12,13,14**	**1,2,3,4,5,6,7,11,13**	**3,4,5,6,11,13**	
5	**3,4,5,8,9,14**	**1,2,3,4,5,6,7,8,13**	**3,4,5,8**	
6	**4,5,6,9,14**	**1,4,6,7,8**	**4,6**	
7	**1,3,4,5,6,7,8,9,10,11**	**1,2,7,11,13**	**1,7,11**	
8	**3,5,6,8,9,10,11,12,13,14**	**1,2,4,6,7,8,11,13**	**6,8,11.13**	
9	**9,11,12,13,14**	**1,2,3,4,5,6,7,8,9,11,13**	**9,11,13**	
10	**10,12,13**	**1,3,7,8,10,11,13**	**10,13**	
11	**4,7,8,9,10,11,12,13**	**1,2,3,4,7,8,9,11,13**	**7,7,8,9,11,13**	
12	**12,13**	**1,3,4,8,9,10,11,12,13,14**	**12,13**	**I**
13	**3,4,5,7,8,9,10,11,12,13,14**	**1,3,4,8,9,10,11,12,13.14**	**3,4,8,9,10,11,12,13,14**	
14	**12,13,14**	**1,3,4,5,6,8,9,13,14**	**13,14**	

Thus it would be positioned at the top of the ISM model. This iteration is continued till the levels of each variable are found out. The identified levels aids in building the final model of ISM. The process is completed in seven iterations as presented in Table 8.4 – Table 8.9.

Table 8.4: Second Level of SCM Integration Variables Iteration 2

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,3,4,5,6,7,8,9,10,11,13,14	1,3,7	1,3,7	
2	2,4,5,7,8,9,11	1,2,10,13	2	
3	1,3,4,5,9,10,11,12,13,14	1,3,4,5,7,8,13	1,3,4,5,13	
4	3,4,5,6,9,11,13,14	1,2,3,4,5,6,7,11,13	3,4,5,6,11,13	
5	3,4,5,8,9,14	1,2,3,4,5,6,7,8,13	3,4,5,8	
6	4,5,6,9,14	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8,9,10,11	1,2,7,11,13	1,7,11	
8	3,5,6,8,9,10,11,13,14	1,2,4,6,7,8,11,13	6,8,11.13	
9	9,11,13,14	1,2,3,4,5,6,7,8,9,11,13	9,11,13	
10	10,13	1,3,7,8,10,11,13	10,13	II
11	4,7,8,9,10,11,13	1,2,3,4,7,8,9,11,13	7,7,8,9,11,13	
13	3,4,5,7,8,9,10,11,13,14	1,3,4,8,9,10,11,13.14	3,4,8,9,9,10,11,13,14	
14	13,14	1,3,4,5,6,8,9,13,14	13,14	II

Table 8.5: Third Level of SCM Integration Variables Iteration 3

Variable	Reachability Set:	Antecedent Set:	Intersection set	Level
1	1,2,3,4,5,6,7,8,9,11,13	1,3,7	1,3,7	
2	2,4,5,7,8,9,11	1,2,13	2	
3	1,3,4,5,9,11,13	1,3,4,5,7,8,13	1,3,4,5,13	
4	3,4,5,6,9,11,13	1,2,3,4,5,6,7,11,13	3,4,5,6,11,13	
5	3,4,5,8,9	1,2,3,4,5,6,7,8,13	3,4,5,8	
6	4,5,6,9	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8,9,11	1,2,7,11,13	1,7,11	
8	3,5,6,8,9,11,13	1,2,4,6,7,8,11,13	6,8,11.13	
9	9,11,13	1,2,3,4,5,6,7,8,9,11,13	9,11,13	III
11	4,7,8,9,11,13	1,2,3,4,7,8,9,11,13	7,8,9,11,13	III
13	3,4,5,7,8,9,11,13	1,3,4,8,9,11,13	3,4,8,9,11,13	

Table 8.6: Fourth Level of SCM Integration Variables Iteration 4

Variable	Reachability Set	Antecedent Set:	Intersection set	Level
1	1,2,3,4,5,6,7,8,13	1,3,7	1,3,7	
2	2,4,5,7,8	1,2,13	2	
3	1,3,4,5,13	1,3,4,5,7,8,13	1,3,4,5,13	IV
4	3,4,5,6,13	1,2,3,4,5,6,7,13	3,4,5,6,13	IV
5	3,4,5,8	1,2,3,4,5,6,7,8,13	3,4,5,8	IV
6	4,5,6	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8	1,2,7,13	1,7	
8	3,5,6,8,13	1,2,4,6,7,8,13	6,8,13	
13	3,4,5,7,8,13	1,3,4,8,13	3,4,8,13	

Table 8.7: Fifth Level of SCM Integration Variables Iteration 5

Variable	Reachability Set:	Antecedent Set:	Intersection set	Level
1	1,2,6,7,8,13	1,7	1,7	
2	2,7,8	1,2,13	2	
6	6	1,6,7,8	6	V
7	1,6,7,8	1,2,7,13	1,7	
8	6,8,13	1,2,6,7,8,13	6,8,13	V
13	7,8,13	1,8,13	8,13	

Table 8.8: Sixth Level of SCM Integration Variables Iteration 6

Variable	Reachability Set:	Antecedent Set:	Intersection set	Level
1	1,2,7,13	1,7	1,7	
2	2,7	1,2,13	2	
7	1,7	1,2,7,13	1,7	VI
13	7,13	1,13	13	

Table 8.9: Seventh & Eighth Levels of SCM Integration variables Iteration 7

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,13	1	1	VIII
2	2	1,2,13	2	VII
13	13	1,13	13	VII

The levels of ISM model are found as Customer satisfaction (12) is put in level 1. Profit sharing (10) and Lead-time reduction (14) are placed at level II. Logistics synchronization (9) and CRM (11) are placed at level III. Collective learning (3), CPFR (4) and ERP (5) are placed at level IV. JIT Tools (6) and Information sharing (8) are placed at level V. POS information (7) is placed at level VI. Financial resources (2) and buyer-supplier relationship are placed at level VII. Top management commitment (1) is placed at level VIII

8.7 DEVELOPING CONICAL MATRIX

A conical matrix is developed by clubbing together variables in the same level, across rows and columns of the final reachability matrix, as shown in Table 8.10.

Table 8.10: Conical Form of Reachability Matrix

Variables	**12**	**10**	**14**	**9**	**11**	**3**	**4**	**5**	**6**	**8**	**7**	**13**	**2**	**1**
12	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
10	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
14	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
9	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
11	**1**	**1**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**0**
3	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**
4	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**
5	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**
6	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
8	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**
7	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**1**
13	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**0**
2	**0**	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**1**	**0**
1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

8.8 DEVELOPMENT OF THE DIAGRAPH

Based on the conical form of reachability matrix, the initial diagraph including transitive links is obtained as shown in Figure 8.2. After removing indirect links, the final digraph is obtained as shown in Figure 8.3.

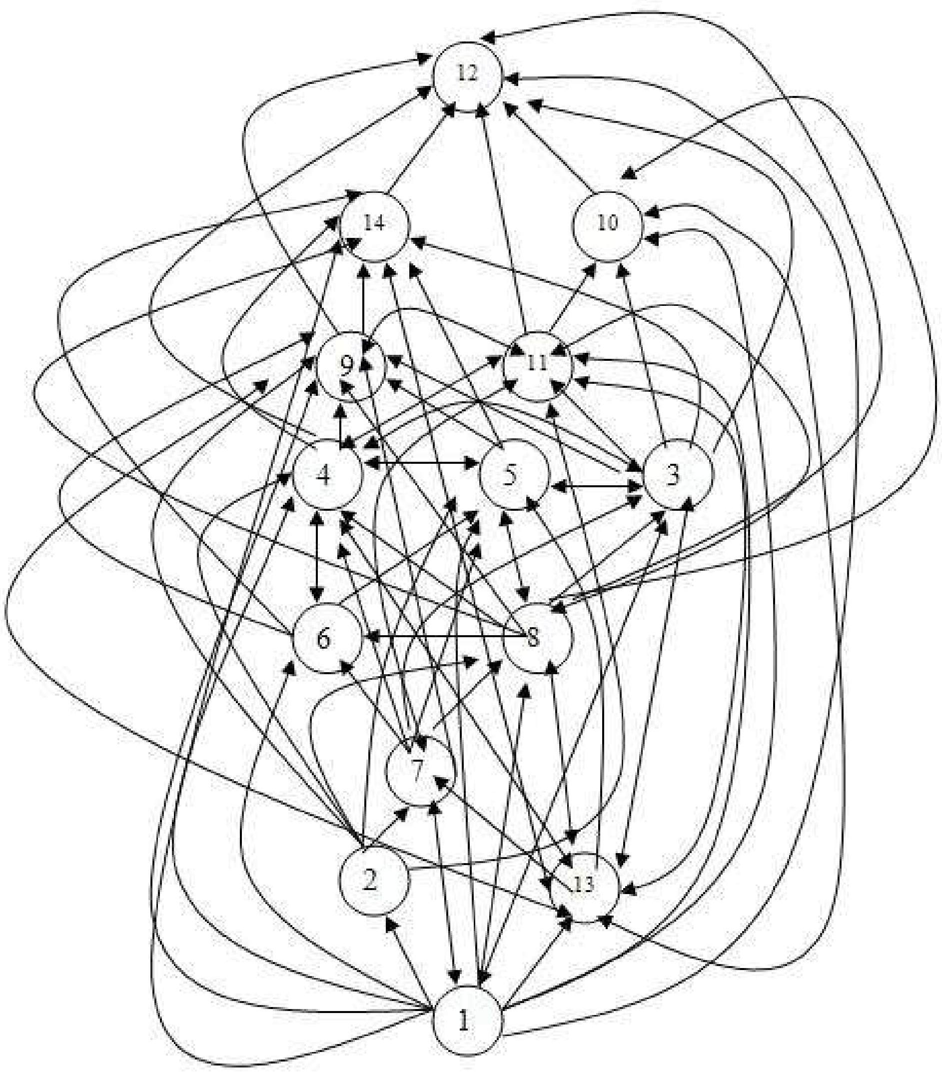


Figure 8.2: Digraph Depicting the Relationships among the SCM Enabler Variables

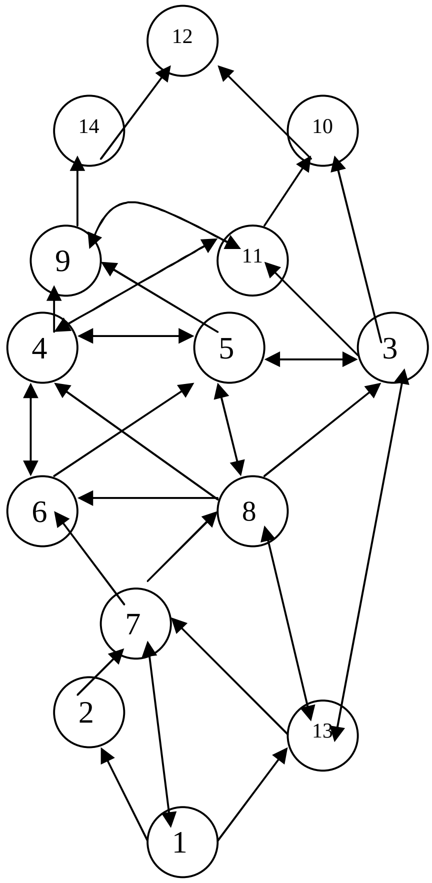


Figure 8.3: Digraph Showing the Levels of SCM Integration Enablers

From Figure 8.4, it is observed that Top management commitment (1) plays significant role in SCM integration and it comes at the base of ISM hierarchy. Customer satisfaction (12) is SCM integration variable on which effectiveness of SCM integration depends. Customer satisfaction appeared at the top of the hierarchy.

For integration of supply chain, it is top management commitment that arranges required financial resources and maintains buyer supplier relationship (13), these are the basic drivers of the SCM integration and appeared in the bottom level of the hierarchy after the top management commitment, Financial resources leads to information sharing by providing an effective communication and information infrastructure, at the same time buyer-supplier relationships leads to Information sharing and POS information.

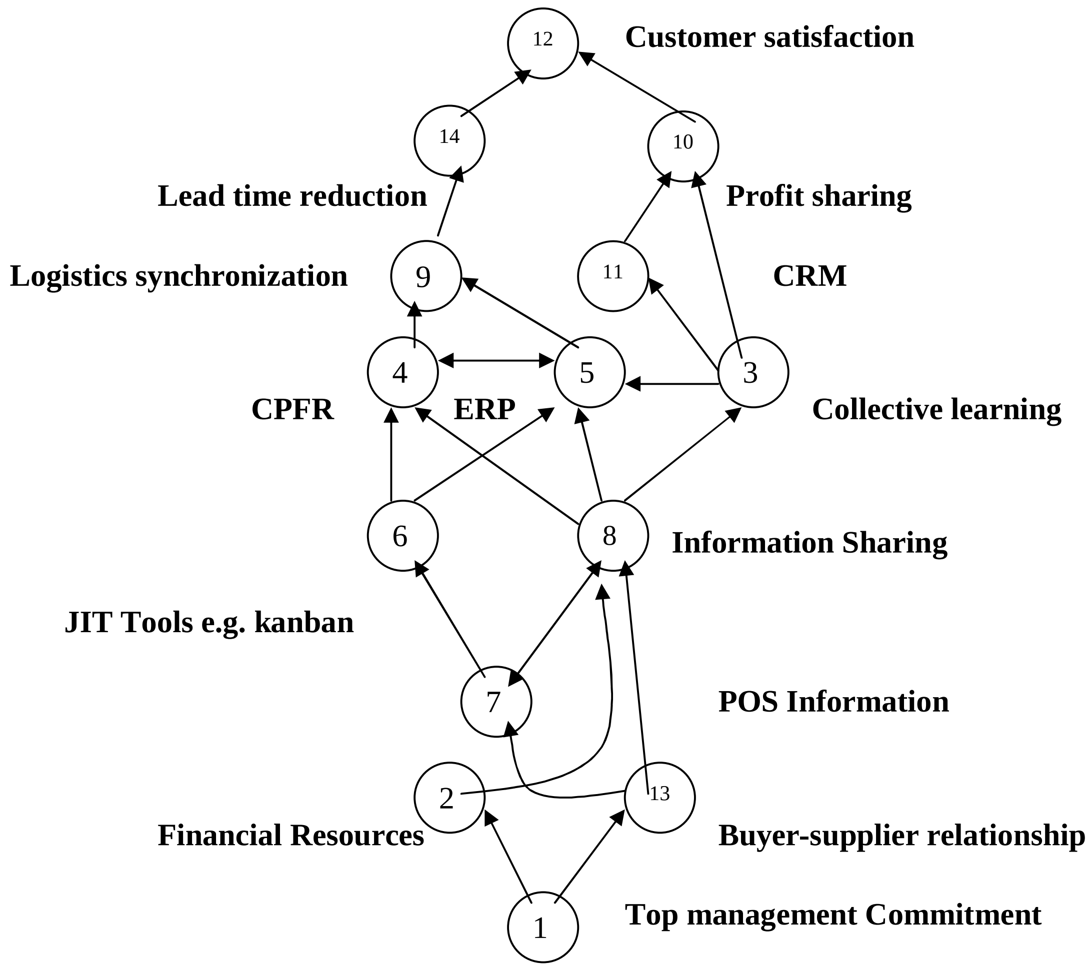


Figure 8.4: Interpretive Structural Model showing the Levels of SCM Integration Variables

Without buyer-supplier relationships information sharing and true POS information is not possible. POS information is very important input for JIT Tools e.g.kanban and information sharing; this is the reason of placing it in the bottom level after financial resources and buyer-supplier relationship. Information sharing leads to collective learning, CPFR and ERP. Collaborative planning and ERP needs the outcome data of information sharing. JIT Tools e.g.kanban leads to CPFR and ERP both. CPFR and ERP lead to logistics synchronization. Information sharing, particularly POS information leads to CRM. Collective learning is the enabler that basically leads towards profit sharing and CRM. Customer satisfaction in the environment of supply chain integration is depends on the delivery in time and cost effectiveness. Delivery in time and the cost effective ness both depends on the two enabler's namely lead time reduction and profit sharing. So lead time reduction and profit sharing both leads to customer satisfaction hence they are enablers directly connected with the customer satisfaction

8.9 MICMAC ANALYSIS

The objective of MICMAC analysis is to analyze the driving power and dependence of SCM integration enabler variables (Mandal and Deshmukh, 1994). The SCM integration variables are classified into four clusters. First cluster includes "autonomous variables" that have weak driving power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of dependent variables that have weak driver power and strong dependence, these variables are unstable. Any action on these variables will have an effect on others and also a feed back effect on themselves. Fourth cluster includes independent variables having strong driving power but weak dependence. It is observed that a variable with the very strong driving power, called as the key variables falls into the category of independent variables. In the Table 8.11, an entry of "1" along the columns and rows indicates the dependence and driving power respectively.

Table 8.11: Driving Power and Dependence in Reachability Matrix

Variables	12	10	14	9	11	3	4	5	6	8	7	13	2	1	Driving	Rank
12	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2	X
10	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	X
14	1	0	1	0	0	0	0	0	0	0	0	1	0	0	3	IX
9	1	1	1	1	1	0	0	0	0	0	0	1	0	0	6	VII
11	1	1	0	1	1	0	1	0	0	1	1	1	0	0	8	V
3	1	1	1	1	1	1	1	1	0	0	0	1	0	1	9	IV
4	1	0	1	1	1	1	1	1	1	0	0	1	0	0	9	IV
5	0	0	1	1	0	1	1	1	0	1	0	0	0	0	6	VII
6	0	0	1	1	0	0	1	1	1	0	0	0	0	0	5	VIII
8	1	1	1	1	1	1	0	1	1	1	0	1	0	0	10	III
7	0	1	0	1	1	1	1	1	1	1	1	0	0	1	10	III
13	1	1	1	1	1	1	1	1	0	1	1	1	1	0	12	II
2	0	0	0	1	1	0	1	1	0	1	1	0	1	0	7	VI
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	I
Dependence	10	9	10	11	9	7	4	4	5	7	5	8	3	3		
Ranks	II	III	II	I	III	V	VII	VII	VI	V	VI	IV	VIII	VIII		

The variables are categorized into ranks. For example variable 4 seventh rank in dependence and fourth in driving power while variable 2 sixth in driving power and eighth in dependence. Four categories are presented in Figure 8.6. Top management commitment (1), financial resources (2), collective learning (3), POS information (7), information sharing (8) and CPFR (4) comes under the category IV and therefore categorized as independent drivers. It can be observed in Figure 8.6 that Top management commitment (1) is the strongest driver, as for as driving power is concern information sharing (8), POS information (7), CPFR (4), collective learning. (3) and financial resources (2) come in descending order respectively. As for as dependence is concern, top management commitment (1) and financial resources (2) are the least dependent enablers.

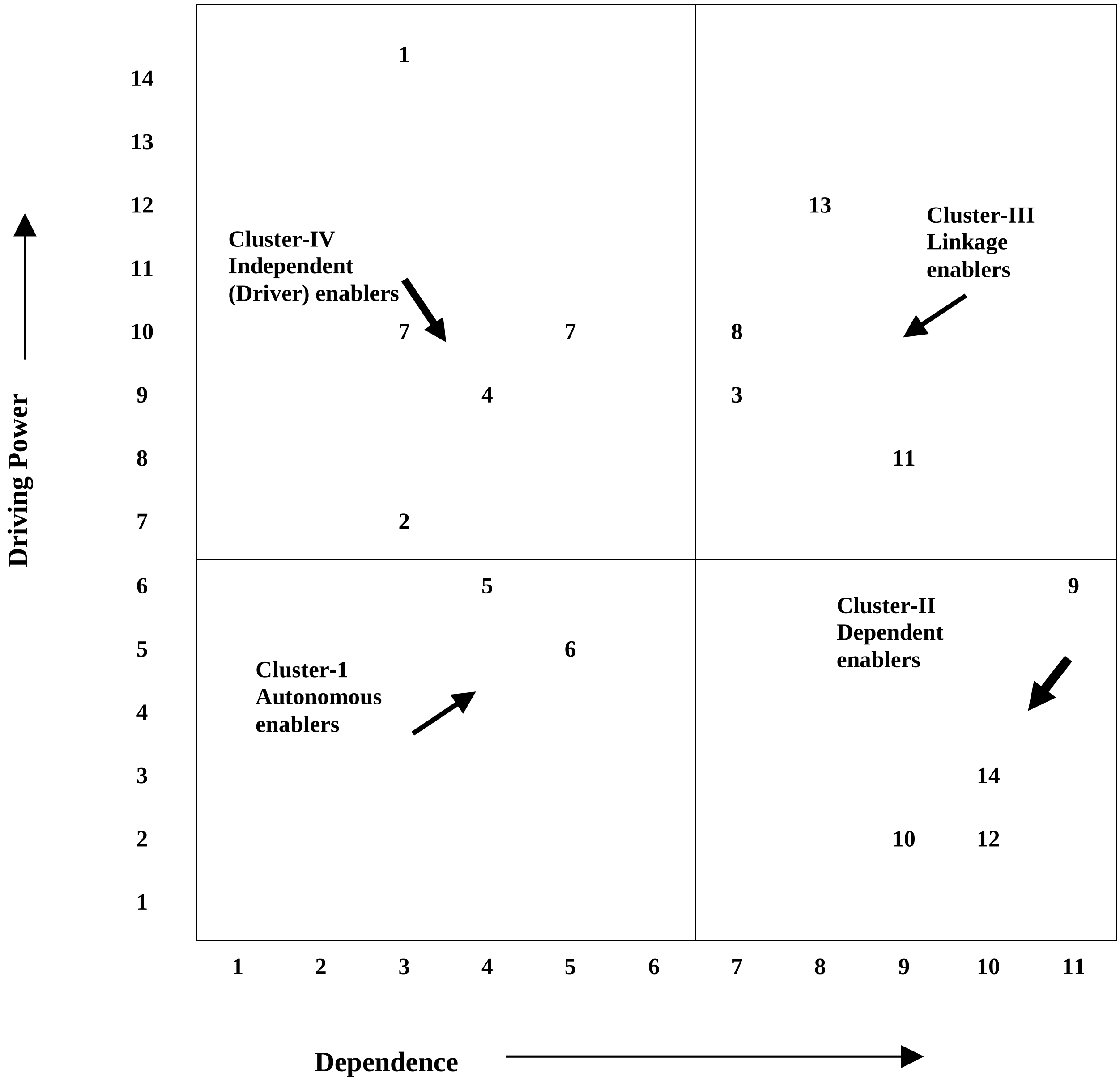


Figure 8.5: Clusters of the Entities in the Integration of Supply Chain Management

JIT Tools e.g.kanban (6) and ERP (5) are autonomous variables and are kept under category 1. Profit sharing (10), logistics synchronization (9), lead-time reduction (14), Customer satisfaction (12), are found as dependent variable. Buyer-supplier relationship has high driving power in supply chain integration and so many times it plays a key role in integration process, at the same time it has high dependence also. Buyer-supplier relationship (13) and CRM (11) are linkage variables with high dependence but high driving power.

8.10 MODELING AGILITY OF SUPPLY CHAIN

A key feature of the present day business is the idea that it is supply chains that competes not companies (Christopher, 1992). Philosophy of integration and collaboration is again dominating the business, society and world. What would be the nature of supply chain to be more competitive? A simple answer may be the supply chain that is more integrated and agile. Some of the definitions and ideas related to agility are:

The concept of an agile enterprise came about as the result of a collaborative, cross-industry workshop in 1991. Agility was initially defined as "the ability of an organization to thrive in a continuously changing, unpredictable business environment" (Dove et al., 1991). Dove (1999) has since redefined the agility as "the ability to manage and apply knowledge effectively," recognizing the importance of information in firm decision making.

Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindsets. A key characteristic of an agile organization is flexibility. In that respect, the origins of agility as a business concept lie partially in flexible manufacturing systems. Initially it was thought that the route to manufacturing flexibility was through automation to enable rapid changeovers (i.e. reduced set-up times) and thus enable a greater responsiveness to changes in product mix or volume. Later this idea of manufacturing flexibility was extended into the wider business context (Nagel and Dove, 1991) and the concept of agility as an organizational orientation was born.

Naylor *et al.* (1999) interpret a*gility* means using market knowledge and a virtual corporation to exploit profitable opportunities in volatile marketplace. The word agility is now replacing the word flexibility in present production and business literature. The need of the hour is not only flexibility but also flexibility with fair amount of the speed and competitiveness.

Under the heading “strategies for enriching the customer” Goldman et al. (1995) define four basic dimensions of agility. These are:

(1) enriching the customer;

(2) cooperating to enhance competitiveness;

(3) organizing to master change and uncertainty;

(4) leveraging the impact of people and information.

Agility is further defined as the business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindsets (Christopher and Towill, 2001). Supply chain agility is a key to inventory reduction, adapting to market variations more efficiently, enabling enterprises to respond to consumer demand more quickly, and integrating with suppliers more effectively. Moving a step forward from agility, researchers (van-Hoek, 2000; Mason-Jones et al., 2000; Naylor et al., 1999) have discussed combining agility with leanness resulting in leagile supply chains. Leagility enables cost effectiveness of the upstream chain and high service levels in a volatile marketplace in the downstream chain.

One of the key drivers for agility is the integration of processes with business partners in the supply chain (Preiss et al., 1996). The supplier-buyer relationship can be short term, where the relationship does not go beyond traditional customer-buyer interaction, to a long-term collaboration where the relationship is extended at a strategic level between interdependent partners (Mohr and Nevin, 1990; Bititci et al., 2005). The main objectives of this paper are:

- to identify and rank the enablers of agility in supply chain;
- to find out the interaction among identified enablers using ISM; and
- to discuss the managerial implications of this research

After going through extensive literature related to agile manufacturing and agile supply chain management, their implication in strategic, tactical and operational level has been identified.

Thirty six variables were selected that help in making supply chain more agile as given in Table 8.12. The list of these variables is shortened by clubbing similar type of enabler variables together. Finally twelve enabler variables are chosen for interpretive structural modeling.

In this work it has been assumed that organizations are having good organizational structures and participative mindset of the workforce to implement and adopt agility in supply chains.

Table 8.12 Selection of Enabler Variables for Agility in SCM

S.No.	Randomly selected enablers	Clubbing of enablers	Enabler for ISM
1	e-business	Multiple operation strategies	
2	Use of IT tools	Intelligent automation	1.Automation
3	Use of Communication Technologies	Flexible manufacturing system	
4	Multiple operation strategies	Trust development	
5	Intelligent automation	Buyer-supplier relationship Customer relationship	2.Buyer-Supplier relationship & Trust
6	Flexible manufacturing system	Leadership	
7	Concurrent engineering	Collaborative Planning, Forecasting & Replenishment	3.CPFR
8	Quality improvement		
9	Minimizing uncertainty	Concurrent engineering	
10	Trust development	Process integration	
11	Buyer-supplier relationship	Employee empowerment	4.Process
12	Third Party logistics	Minimizing resistance to change	
13	Process integration		
14	Just in time (JIT)	e-business	
15	POS Information	Use of IT tools	
16	Logistics synchronization	Use of Communication Technologies	5.Use of ICT tools
17	Employee empowerment	POS Information	
18	Financial resources	Logistics synchronization	6.Logistics planning
19	Leadership	Vendor Managed Inventory	and management
20	Transparent product customization	Third Party logistics	
21	Product differentiation	Just in Time (JIT)	7.JIT appraches
22	Market sensitiveness	Waste reduction	
23	Delivery speed	Market potential	
24	Data accuracy	Market sensitiveness	8.Understanding
25	New product introduction	Intensity of competition	market volatility
26	Collaborative Planning, forecasting &	Minimizing uncertainty	
27	Lead time reduction	Delivery speed Lead time reduction	9.Delivery performance
28	Service level improvement	Data accuracy	
29	Cost minimization	Financial resources	10. Cost
30	Minimizing resistance to change	Quality improvement	11.Quality improvement
31	Vendor Managed Inventory,	Service level improvement	
32	Information Sharing,	New product introduction	
33	Customer relationship management	Transparent product	12.Customer
34	Market potential	Product differentiation	
35	Intensity of competition		
36	Waste reduction		

8.11 ENABLER VARIABLES OF AGILITY IN SCM

SCM is a complex issue involving many dimensions. To make the supply chain agile, large numbers of variables play their role. Some of these variables are the subset of the other or they are contemporary in nature. In this study, from literature twelve critical variables have been identified which enables agility in supply chains. Out of twelve enablers four enablers namely Buyer supplier relationship, CPFR, JIT tools and customer satisfaction has been discussed in last section. Remaining eight enablers are discussed as under:

8.11.1 Automation

The meaning of automation may be the replacement of manual operations by computerized methods or executes decisions with least human intervention. The major shift in automation is to increase flexibility, repeatability, convertibility and quality to the manufacturing process as it was previously used to increase only productivity and cost efficiency. In supply chain management context the automation in factory and office are equally important in enhancing the agility. Some of the tools used in factory automation are CAD/CAM software, computerized controlled machine tools & material handling systems, rapid prototyping and other computerized machines used in various manufacturing processes. FMS, concurrent engineering, collaborative engineering and intelligent manufacturing are the upcoming concepts in factory automation; the orientation of each one is to make manufacturing more agile. Office automation refers to integrating clerical tasks such as typing, filing and appointment scheduling Some of the equipments capable to increase agility of the office related activities may be Personal Computers, Laser printers, computerized copier machines, fax, scanners, digital cameras, LCD projectors etc.

8.11.2 Process Integration

Supply chain consists of multiple sub systems, and each of these sub systems are part of an overall business function. For example, a business function such as processing an incoming order may require the participation of the customer management system, the inventory system, the shipping system, and one or more financial systems. The business could operate more efficiently if the systems could be integrated so that the business function could be completed automatically. The major advantage of process integration is increased flexibility. The process manager can support a variety of configurations that would be difficult to implement in many traditional programming models. Supporting a variety of configurations gives the process manager the flexibility to adapt to many different business requirements. In a supply chain, process integration is achieved through collaborative working between buyers and suppliers. This may involve joint product development, common system design and shared information. Such collaborations across each partner’s core business processes may involve a range of partnerships covering buyer-supplier relations, vendor managed inventory, information sharing, etc. In the context of SCM, investments in shared or compatible high technology, investments in shared or compatible manufacturing systems (such as MRP II systems) and common approaches to cycle time reduction are the kinds of routes that may be taken to improved performance (Mason-Jones and Towill, 1999).

8.11.3 Use of ICT Tools

Various SCM software solutions are being developed to fulfill the requirement of all stages of the supply chain. These tools helps in processing, recording, editing and updating all the data related to transactions more accurately, methodically and quickly. The quick and faster flow of information makes supply chain more agile. Use of internet, extranet, electronic data interchanger and related communication technologies are capable to connect all the partners of the supply chain together to enhance ability to respond quickly. The Information and Communications Technology (ICT) is an increasingly used powerful tool for participating in global markets; promoting accountability; improving the delivery of services; and enhancing growth in opportunities.

8.11.4 Logistics Planning and Management

Several strategies of logistics have been developed based on the principles of logistics management - such as collaborative logistics processes, operational flexibility, logistics postponement and collaborative transportation. The collaborative logistics processes refer to joint decision-making such as assortment planning, joint forecasting, joint inventory management and replenishment (Simchi-Levi *et al*., 2008). Operational flexibility aims to provide various demand response strategies by considering supply capacity such as make-to-forecast, locate-to-order, amend-to-order and build-to-order (BTO) (Holweg and Pil, 2001). Logistics postponement refers to delaying product differentiation to the latest possible time until customer orders are received (van Hoek, 2001). Collaborative transportation attempts to employ the third-party logistics providers to accomplish in-bound and out-bound logistics. Direct shipping, warehousing, and cross docking are three distinct out-bound strategies to deliver goods to end customers (Simchi-Levi *et al*., 2008).

8.11.5 Understanding Market Volatility

The variables that have been included in this enabler are market potential, market sensitiveness and intensity of competition (Greg W. Marshall et al 2004). Market potential refers to conditions where the providers of a service can consistently charge prices above those that would be established by a competitive market. Market sensitiveness reflects the degree of variability or fluctuations in demand or prices. Increased agility in supply chain is able to overcome the negative implications of demand variability. Adequate knowledge and practice of these variables can give a good foundation to understand the market volatility. This variable becomes more relevant in present global market scenario. A good understanding of market volatility among the chain partner can make supply chain more agile.

8.11.6 Delivery Performance:

Delivery performance is measured by four variables (Milgate, 2001), with the first two measuring speed and the last two measuring reliability. First, delivery lead-time may be defined as average actual time that elapses from the placement of an order until its shipment to the customer (i.e. transportation time is not included). Second, throughput time was defined as the time to complete an order from the start of its production to its completion. Third, the percentage of customer orders delivered by due date can be used as one measure of reliability. The percentage of on time deliveries is widely applied in industry, and sometimes referred to as the service level. For those orders that are delivered late, the average lateness is the fourth variable of performance.

8.11.7 Cost Minimization

Cost reduction in manufacturing is the need of the hour, especially for the people of developing countries who can’t afford high prices to enhance their standard of living. Tata Motors of India didn’t reveal much about the cost reduction strategies used in its Rs 100,000 (approx $ 2000) ‘nano’ car project. Some of the possible strategies applied by the company may be the cost minimization through design (concurrent engineering, design for manufacturability), lean production cost minimization (reduction of waste, JIT, kanban, pull based manufacturing), overhead cost minimization (build-to-order and mass customization), standardization cost minimization (implementation of standardization), product line rationalization cost minimization (focus on most profitable products), Supply Chain Management cost minimization (Supply chain simplification, inclusion of pull parts into production without forecast or inventory),quality cost minimization (The cost of quality can be 15% to 40% of revenue which should be justified) (Kumar and Brittain 1995).

8.11.8 Quality Improvement

According to ISO 9000:2000 the definition of Quality improvement is "part of quality management focused on increasing the ability to fulfill quality requirements" Other definition may be "An approach to the study and improvement of the processes of providing services to meet needs of clients." The indicator of the quality improvement are non-conformity rate of products manufactured, the importance of employee's participation in the improvement of process efficiency and product quality, number of work-related accidents, absenteeism rate, average response time to customer's complaints, extent of customer satisfaction after complaints, percentage of orders not delivered on time, or in the quantities ordered, number of registered complaints from customers, customers' perceptions of the effectiveness of the warranty policy offered by the firm. (Yasin et.al. 2004)

8.12 STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

ISM methodology suggests the use of the expert opinions based on various management techniques such as brain storming, nominal technique, etc. in developing the contextual relationship among the variables. Thus, in this research for identifying the contextual relationship among the enablers of agility in a supply chain two experts from academia with research interests in the area of small business and two supply chain managers working for leading automobile manufacturer were consulted for the same.

Although the subject of agility in context of a supply chain is relatively new but these experts from the industry and academia were well conversant with agility of individual organizations which are now extended to the whole supply chains. For analyzing the enablers of the agility, a contextual relationship of “leads to” type is chosen. This means that one variable helps to ameliorate another variable. Based on this, contextual relationship between the variables is developed.

Keeping in mind the contextual relationship for each variable, the existence of a relation between any two enablers (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the enablers (i and j):

V: enabler i will ameliorate enabler j;

A: enabler j will be ameliorated by enabler i;

X: enabler i and j will ameliorate each other; and

O: enablers i and j are unrelated.

The following would explain the use of the symbols V, A, X, and O in SSIM (Table 8.13):

Enabler 5 (use of ICT tools) would ameliorate enabler 6 (logistics planning and management). In deciding appropriate logistics planning ICT tools are playing significant role. At the same time logistics strategies are not helping much to the variable use of ICT tools. This unidirectional forward relationship has been entered as V Table 8.13.

Table 8.13: Structural Self-Interaction Matrix (SSIM)

Variables	12	11	10	9	8	7	6	5	4	3	2
1	V	V	V	V	A	X	O	X	V	V	V
2	X	X	X	X	A	O	X	A	V	V	
3	V	V	V	V	A	O	X	A	X		
4	V	V	V	V	O	O	X	A			
5	V	V	V	V	V	V	V				
6	V	O	V	V	A	A					
7	V	V	V	V	O						
8	O	O	V	O							
9	V	V	O								
10	V	O									
11	V										

No.	Variable Name	No	Variable Name	No	Variable Name	No	Variable Name
1	Automation	4	Process Integration	7	Just in Time (JIT)	10	Cost minimization
2	Buyer-Supplier relationship & Trust	5	Use of ICT Tools	8	Understanding market	11	Quality Improvement
3	CPFR	6	Logistics planning and management	9	Delivery Performance	12	Customer satisfaction

Enabler 4 (process integration) is ameliorated by enabler 5 (use of ICT tools), i.e. process integration is helped by variable 5 (use of ICT tools. process integration is not helping the variable use of ICT tools. This unidirectional reverse relationship has been entered as A (Table 8.13).

Enabler 2 (buyer-supplier relationship and trust) leads to enabler 10 (cost minimization) and cost minimization leads to buyer supplier relationship and trust. This mutual relationship has been entered as X (Table 8.13). No relationship seems to exists between enabler 6 (logistics planning and management) and enabler 11 (product quality) so the relationship is O (Table 8.13).

8.13 REACHABILITY MATRIX

The SSIM is transformed into a binary matrix, called the reachability matrix by substituting V, A, X, O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are given earlier in article 8.4.

In Table 8.14, the driving power and the dependence of each enabler are also shown. The driving power for each enabler is the total number of enablers (including itself), which it may impact. Dependence is the total number of enablers (including itself), which may be impacting it. These driving power and dependencies will be used in the MICMAC analysis, where the enablers will be classified into four groups of autonomous, dependent, linkage, and independent (driver) enablers.

Table 8.14 Final Reachability Matrix

No.	Enablers	1	2	3	4	5	6	7	8	9	10	11	12	Driving Power
1	Automation	1	1	1	1	1	0	1	0	1	1	1	1	**10**
2	Buyer-Supplier relationship and trust	0	1	1	1	0	1	0	0	1	1	1	1	**8**
3	CPFR	0	0	1	1	0	1	0	0	1	1	1	1	**7**
4	Process integration	0	0	1	1	0	1	0	0	1	1	1	1	**7**
5	Use of IT tools	1	1	1	1	1	1	1	1	1	1	1	1	**12**
6	Logistics planning and management	0	1	1	1	0	1	0	0	1	1	0	1	**7**
7	Just in time approaches	1	0	0	0	0	1	1	0	1	1	1	1	**7**
8	Understanding market volatility	1	1	1	0	0	1	1	1	0	1	0	0	**7**
9	Delivery performance	0	1	0	0	0	0	0	0	1	0	1	1	**4**
10	Cost minimization	0	1	0	0	0	0	0	0	0	1	0	1	**3**
11	Quality improvement	0	1	0	0	0	0	0	0	0	0	1	1	**3**
12	Customer satisfaction	0	1	0	0	0	0	0	0	0	0	0	1	**2**
	Dependence	**4**	**9**	**7**	**6**	**2**	**7**	**4**	**2**	**8**	**9**	**8**	**11**	

8.14 LEVEL PARTITIONS

From the final reachability matrix, the reachability and antecedent set (Warfield, 1974) for each enabler are found. The reachability set consists of the element itself and the other elements which it may impact, whereas the antecedent set consists of the element itself and the other elements which may impact it. Thereafter, the intersection of these sets is derived for all the enablers. The enablers for whom the reachability and the intersection sets are the same occupy the top level in the ISM hierarchy. The top-level element in the hierarchy would not help achieve any other element above its own level. Once the top-level element is identified, it is separated out from the other elements (Table 8.15). Then, the same process is repeated to find out the elements in the next level.

Table 8.15 Partition of Reachability Matrix First Iteration

Variable (P)	Reachability Set: R (P)	Antecedent Set: A (P)	Intersection R (P) and A (P)	Level
1	1,2,3,4,5,7,9,10,11,12	1,5,7,8	1,5,7	
2	2,3,4,6,9,10,11,12	1,2,5,6,8,9,10,11,12	2,6,9,10,11,,12	
3	3,4,6,9,10,11	1,2,3,4,5,6,8	3,4,6	
4	3,4,6,9,10,11,12	1,2,3,4,5,6	3,4,6	
5	1,2,3,4,5,6,7,8,9,10,11,12	1,5,6	1,5,6	
6	3,4,5,,6,9,10,12	2,3,4,5,6,7,8	3,4,6	
7	1,6,7,9,10,11,12	1,5,7	1,7	
8	1,2,3,6,7,8,10	5,8	8	
9	2,9,11,12	1,2,3,4,5,6,7,9	2,9	
10	2,10,12	1,2,3,4,5,6,7,8,10	2,10	
11	2,11,12	1,2,3,4,5,7,9,11	2,11	
12	2,8,12	1,2,4,5,6,7,8,9,10,11,12	2,8,12	I

This process is continued until the level of each element is found. Results for iteration ii-v are summarized in Table 8.16.

Table 8.16: Partition of Reachability Matrix Second to Fifth Iteration

iteration	Variable (P)	Reachability Set: R (P)	Antecedent Set: A (P)	Intersection R(P) and A (P)	Level
ii	9	2,9	1,2,3,4,5,6,9	2,9	II
ii	10	2,10	1,2,3,4,5,6,7,10	2,10	II
ii	11	2,11	1,2,3,4,5,,9,11	2,11	II
iii	3	3,4	1X2,3,4,5,6,8	3,4	III
iii	4	3,4,6	1,2,3,4,5,6	3,4,6	III
iii	6	3,4,5,,6	2,3,4,5,6,7,8	3,4,5,6	III
iv	2	2	2,5	2	IV
Iv	7	7	1,5,7,8	7	IV
v	1	1,5,	1,5,	1,5	V
v	5	5	1,5,	5	V
v	8	8	5,8	8	V

8.15 BUILDING THE ISM MODEL

From the final reachability matrix (Table 8.14), the structural model is generated by means of vertices or nodes and lines of edges. If there is a relationship between the enablers j and i this is shown by an arrow which points from i to j.

This graph is called a directed graph or digraph. After removing the transitivities as described in ISM methodology, the digraph is finally converted into ISM as shown in Figure 8.6.

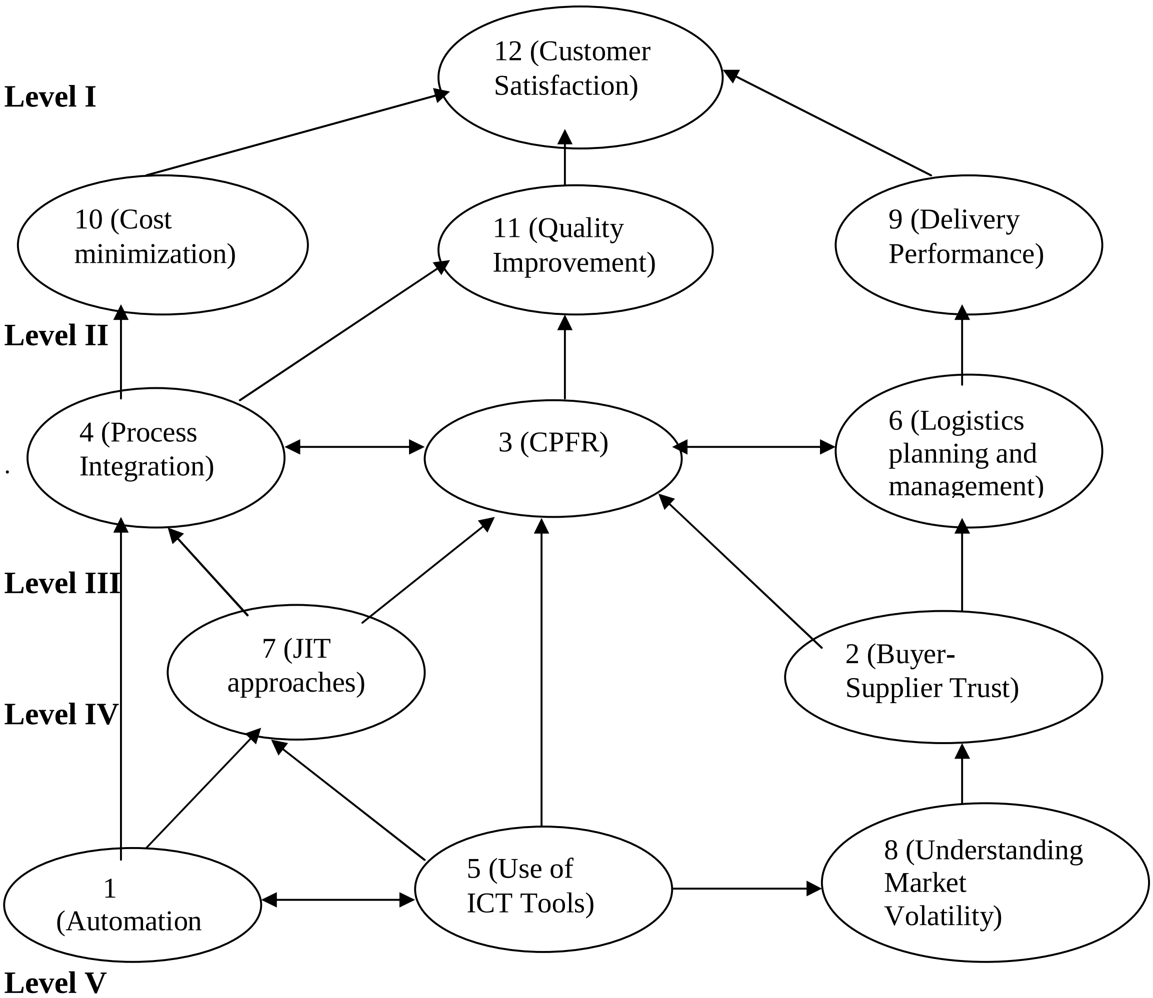


Figure 8.6: ISM showing the levels of SCM agility variables

For the variables identified in this research the ISM model developed depicts that to make supply chain agile it is imperative to facilitate use of automation (enabler 1), ICT tools (enabler 5) among supply chain members that would help to develop trust among supply chain partners (enabler 2) and assist in migrating from short term to collaborative relationships (enabler 3). Once partners in a supply chain starts sharing information and their relationships mature on a continuum of collaboration and partnerships, it would be much easier for them to achieve delivery performance (enabler 9), cost minimization (enabler 10) and quality improvement (enabler 11) that could impact the whole supply chain else every member of the supply chain try to optimize and plan for agility that have an impact on its performance without considering the overall supply chain. This holistic perspective will help to develop JIT approaches (enabler 7) to enhance integration and agility. But this would also require alignment of logistics planning and management (enabler 6) and CPFR (enabler 3).

8.16 MICMAC Analysis

The objective of the MICMAC analysis is to analyze the driver power and the dependence power of the variables (Mandal and Deshmukh, 1994). The variables are classified into four clusters (Figure 8.7). The first cluster consists of the "autonomous enablers" that have weak driver power and weak dependence. These enablers are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the dependent enablers that have weak driver power but strong dependence. Third cluster has the linkage enablers that have strong driving power and also strong dependence. These enablers are unstable in the fact that any action on these enablers will have an effect on others and also a feedback on themselves. Fourth cluster includes the independent enablers having strong driving power but weak dependence. It is observed that a variable with a very strong driving power called the key variables, falls into the category of independent or linkage enablers. The driving power and the dependence of each of these enablers are shown in Table 8.3. In this table, an entry of "1" along the columns and rows indicates the dependence and driving power, respectively. Subsequently, the driver power-dependence diagram is constructed which is shown in (Figure 8.7).

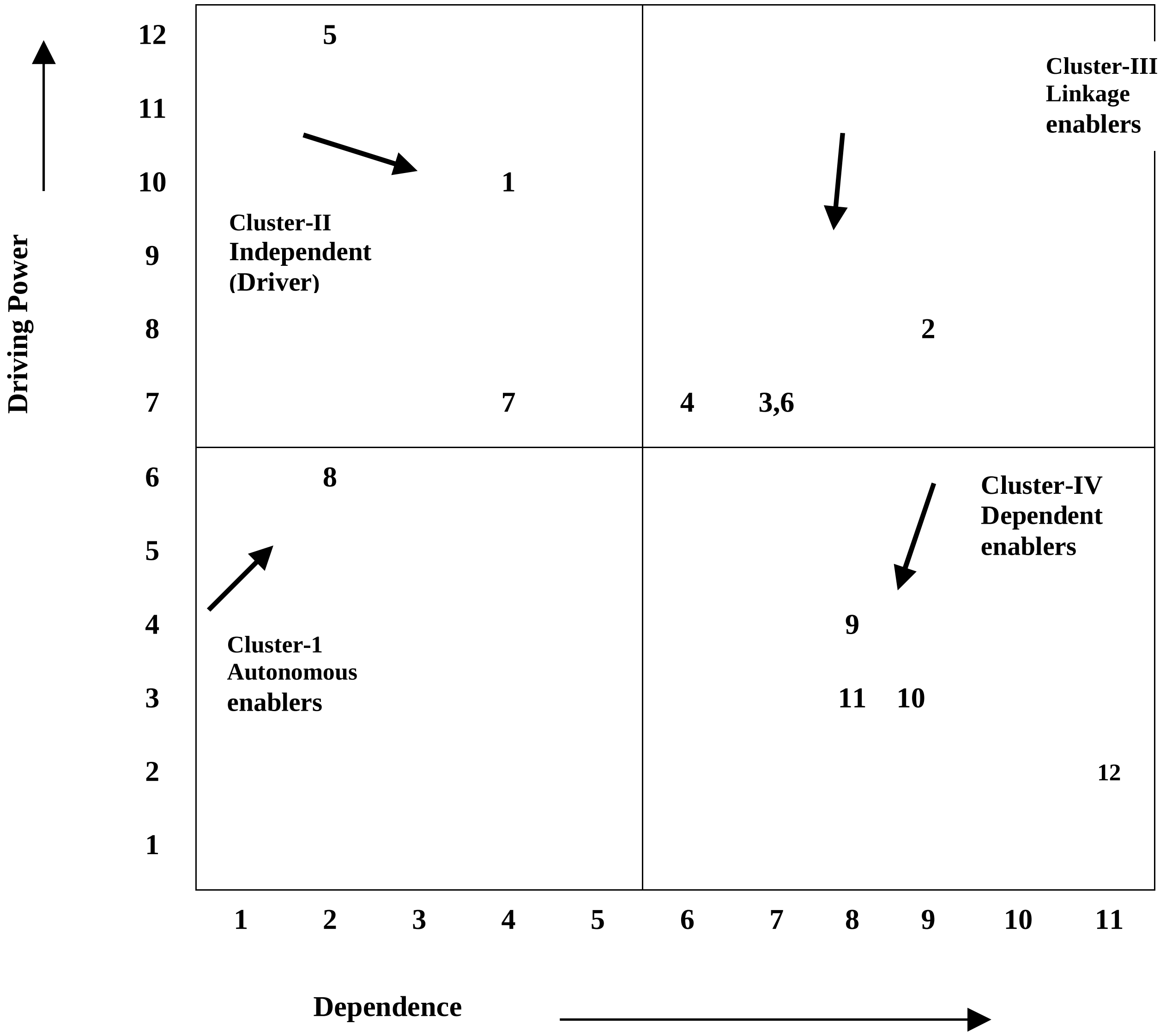


Figure 8.7 Clusters of the Entities in the Agility of Supply Chain Management

As an illustration, it is observed from Table 8.14 that enabler 10 (cost minimization) has a driver power of 3 and a dependence of 9. Therefore, in this figure, it is positioned at a place corresponding to a driver power of 3 and a dependency of 9.

8.17 DISCUSSION AND COMPARISON OF ISM OF INTEGRATION AND AGILITY VARIABLES

8.17.1 Discussion on ISM of Integration Variables

Ranks of the elements based on their driving power indicate that top management commitment (1) is the key variable in SCM integration. It has strong driving power and less dependence on other variables under study. Information sharing has also strong driving power next to management commitment (1) but comparatively more dependence. Collective learning (3) and POS information (7) have similar driving power but POS information is less dependent. Financial resources (2) have less driving power than other independent variables but it has least dependence.

ERP (5) and JIT (6) are less dependent on other variables, JIT tools has less driving power than ERP. These variables plays less significant role in integration of supply chain.

Dependent variables are logistics synchronization (9), profit sharing (10) lead- time reduction (14) and customer satisfaction (12) Out of these customer satisfaction (12), profit sharing (10) and lead-time reduction have strongest dependence with least driving power. Logistics synchronization (9) but it shows high dependence

CRM (11) and buyer-supplier relationship (13) are fall under the category of linkage variables. These variables are unstable. Any action on these variables has great impact on supply chain integration. These also have feedback effect on themselves. This shows that success or failure of CRM (11) and particularly buyer-supplier relationship (13) is the success or failure of SCM integration.

8.17.2 Discussion on ISM of Agility Variables

Automation, use of ICT tools and understanding the market volatility occupies the bottom level i.e. fifth level in the model (Figure 8.6). These variables have high driving power and less dependence on other variables. Buyer-Supplier relationship & trust and JIT approach are placed in the fourth level. Process integration, CPFR and logistic planning and management are in middle level, normally such variables have great significance in operation and closely connected with the performance level variables like cost minimization, quality improvement and delivery performance. Customer satisfaction occupies the top level that may be the indicator of the performance and direct or indirect objective of all other variables. Customer satisfaction is the variable on which not only the profit but existence of supply chain lies. To make supply chain agile bottom level variables play a very significant role. In this context the variables automation and use of IT tools can be termed as foundation enabler variables.

The driver dependence diagram as presented in Figure 8.7 helps to classify various enablers of agility The enabler 8 (understanding market volatility) is in the category of autonomous cluster which means management hasn't much to do on this enabler using other variables. Though use of ICT tools helps to understand market volatility up to certain extent but still due to lack of simplified information, a big challenge among the practitioners is to reinforce this enabler. The management has to pay an attention to all other identified enablers of agility. The next cluster consists of independent variables like automation, use of ICT tools and JIT approaches that have high driving power but little dependence. These enablers play a key role to enhance the agility of a supply chain. Generally, agility in manufacturing organization has a narrow perspective but knowledge about agility expands when the whole supply chain is considered.

The next cluster consists of those variables that are termed as linkage variables and include buyer supplier relationship and trust, CPFR, process integration and logistics planning and management which is influenced by lower level variables with high driving power, but these variables has directly connected to the top level performance enable. The success of performance enabler lies with effective management and execution of linkage variable, this enhance the significance of linkage variables. Some of these linkage variables like buyer supplier relationship, CPFR and process integration also needs strategic importance by the management.

The last cluster includes variables like delivery performance, cost minimization, quality improvement and customer satisfaction. In this particular cluster, customer satisfaction has the least driving power and have highest dependence and form the top most level in the ISM hierarchy. They represent those variables that are resultant of the effective agility in a supply chain. Their strong dependence indicates that they require all the other enablers to come together so as to enable them to realize. But they are important as if these enablers that are finally required by the supply chain to realize its success

8.17.3 Comparison in ISM for Integration and Agility and Managerial Perspective

It is important to integrate the supply chain before acquiring agility. It will be easier for any supply chain to become agile after integration of all entities**.** The ISM developed for the integration helps the managers and practitioners to develop strategies for integration. Driving variables of the two ISMs' are top management commitment, buyer supplier relationships, financial resources, automation, use of ICT tools and understanding market volatility. These variables have proven to be main driving variables for integration and agility both. It is interesting to observe that the variable at the top in both ISM is customer satisfaction which is ultimate aim of the efficient supply chain management. The common intermediate enablers are CPRR, JIT, Logistics planning and management. These enablers can play a role of a bridge to acquire integration and agility in the supply chain management.

The prime focus should be the integration, and the variables shown in ISM of integration need to be used in strategic and tactical planning. These are the pre requisite to attain agility. The efforts to impart agility without integration may not work in long term. Practitioners can take advantage by clubbing two ISM to find the hierarchy to fit their requirements. Based on the objectives of the enterprise and the supply chain they can further prioritize the enablers.

8.18 MANAGERIAL INSIGHTS OF ISM FOR AGILITY

The analysis of the ISM provides interesting managerial insights. The model categorizes the variables selected for supply chain agility into five levels. Level 5 has highest driving power and least dependence. The variable under this category are automation, use of ICT tools and understanding the market volatility. These three variables have strategic implication focus and effective use of these enablers help to achieve the next level of variables which are normally the operating level variable such as implementation of JIT system, buyer-supplier relationship and trust, process integration, CPFR and logistics planning and management. These variables are placed in level 3 and 4. The effective management of operating level variable helps to achieve the performance indicator of the supply chain. These indicators have appeared at level 2 and level 1 of the ISM.

Buyer-supplier relationship and trust, process integration, CPFR and logistics planning and management helps to achieve the supply chain objective such as cost minimization, quality improvement and delivery performance. These are the performance indicator if pursued will help to achieve the ultimate objective of the business that is customer satisfaction as appeared in at the level 1 of the ISM.

The management should focus more on strategic variable which help to achieve operational level variable. Effective management of operational variable will facilitate the performance variable of the supply chain. The performance variables have low driving power as compared to strategic variable. This indicates that those managers who focus only on performance variable may not achieve the sustainable advantage without focusing on strategic enabler as selected in this research.

8.19 CONCLUSION

The objective of the ISM model in this research was to develop a hierarchy of variables that would help to impart agility in supply chain of manufacturing units in India. These variables assume importance because today it is not individual organizations that are competing rather it is the supply chains. Consequently it is not particularly one organization that needs to be agile but all the constituents of supply chain must enhance their agility. A supply chain can counter the market variables in an effective manner when all the partners in that chain trust each other and frequently share information which is facilitated by collaborative relationships among the supply chain members. This can serve as an eye opener for the manufacturing organizations in India.

Department of Mechanical and Production Engineering

DELHI COLLEGE OF ENGINEERING, DELHI

Bawana Road, Delhi – 110042 (India)

Research Supervisors: Dr. S.K.Garg, DCE
Dr. Ravi Shankar, IIT Delhi

Subject: **Survey on SCM of Advanced Manufacturing Systems**

Dear Sir

The latest development in computer aided design, manufacturing and related technologies with augmentation with information technology have been directed towards making supply chain integration a reality. Advanced manufacturing technologies facilitate flexibility, speed, lead time reduction, high responsiveness to customer needs, early entry in the market, quality and customer satisfaction etc essential to survive in this global competitive manufacturing industry thereby helps in making efficient supply chain. As a part of Ph.D. research we are conducting a survey to assess the status and readiness of industry in exploiting advanced manufacturing technologies to synchronize the supply chain. To make it possible the industry and academia must share their views. Your feedback in this regard will form a significant input to this study. We request you to spare some time in responding to the enclosed questionnaire
This questionnaire is divided into the following three sections:

Section I: Organizational Profile
Section II: Supply chain and AMT issues
Section III: Performance measurement

We would be grateful if you kindly fill the questionnaire and sent it back as early as possible. A self-addressed envelope is enclosed for the purpose. The objective of the survey is purely research and academic, therefore, all responses will be kept strictly confidential and will be used only for this academic work

We are aware that you have a busy schedule of work but we do hope that you would be able to spare some time to help us in the fulfillment of this noble work

Yours faithfully

(Vivek Chandra Pandey)
Research Scholar

Encl: Questionnaire on SCM of advanced manufacturing systems

Questionnaire on SCM

Section I: Organization Profile

1 Name of products/ services: ……………………………………..

2. Is your organization is: (a) Original equipment manufacturer [ ] (b) Supplier to OEM

3. Please indicate the number of employees at your organization

(A) Less than 100	[ ]	(B) 101 to 500	[ ]	(C) 501 to 1000	[ ]
(D) 1001 to 3000	[ ]	(E) More than 3000	[ ]		

4. Please indicate the approximate percentage of employees using Advanced Manufacturing Tools to perform their jobs

(A) Less than 5%	[ ]	(B) 6-25%	[ ]	(C) 26-60%	[ ]
(D) 61-85%	[ ]	(E) More than 85%	[ ]	(F) can't say	[ ]

5. Please indicate your organization's approximate annual turnover in Rs. of Crores for year 2004-05

(A) Less than 5	[ ]	(B) 5 to 25	[ ]	(C) 25 to 100	[ ]
(D) 100 to 500	[ ]	(E) More than 500	[ ]		

6. Please indicate the approximate trend of profits during the past 3-years

(A) Increased by 10% per year	[ ]	(B) Increased by more than 10% per year	[ ]	(C) Almost constant	[ ]
(D) Decreases [ ]		(E) can't say	[ ]		

7. The average number of suppliers employed for a raw material /out-sourced component in the final product are

(A) Less than 3	[ ]	(B) 3 to 5	[ ]	(C) 6 to 10	[ ]
(D) More than 10	[ ]	(E) can't say	[ ]		

Section II: Supply Chain and Advanced Manufacturing Technology related Issues

8. Please indicate your position on supply-chain collaboration with trading partners
   (A) Strong believer in collaboration and actively extending our supply chain
   (B) Believe in collaboration but use a "go slow" strategy
   (C) Interested in collaboration but have other priorities
   (D) Not interested in any such collaboration

9. Please rank the competitive strengths of your organization

	Very low 1	2	3	4	Very high 5
Product Quality					
Cost Effectiveness					
Responsiveness to customer needs					
Service level					
Engineering/ Technological expertise					
Product Customization					
Market share					
Sales and Marketing					
Manufacturing Strength					
Innovativeness					
Labor Productivity					
Worker Safety					

10. Please rank the areas where majority of delays take place in your organization

	No delay 1	2	3	4	Max. delay 5
Order finalization					
Engineering/ planning					
Material/ service procurement					
Manufacturing/operations					
Delivery					

11. Please indicate the level of information Sharing with your suppliers?

	Hardly 1	2	3	4	Extensively 5
Related to purchasing and sales					
Inventory status					
Product development and future requirements					
Sales forecasting					
Market developments					
Company's future plans					
Company's production costs					
Technology know-how					

12. Please indicate the level of information sharing with your immediate customers in the supply chain?

	Hardly 1	2	3	4	Extensively 5
Related to purchasing					
Order tracking					
Inventory status					
Product development					
Sales forecasting					
Market developments					
Company's future plans					
Company's production costs					
Technology know-how					

13. Please indicate the mode of correspondence used by your organization in the supply chain

	Hardly 1	2	3	4	Extensively 5
Post or Courier					
Phone					
Fax					
E-mail					
Websites					
Electronic Data Interchange(EDI)					

14. Is your organization using following?

	Using now	**Will be using in 6 months**	**Will be using in 1 year**	**Not using**
CNC Machine tools				
Computer aided design and CAPP software				
PLC's or mechatronics devices				
Flexible Manufacturing system				
Automated material handling devices				
Cellular Manufacturing System or Group Technology				
Automatic Data Capture Technologies i.e. optical, magnetic, smart card, machine vision etc.				
Enterprise Resource Planning (ERP)				
SCM Software				
EDI				
Robot				
Rapid prototyping				
Automatic Storage and Retrieval System (AS / RS)				
Reverse Engineering / Reverse Tooling				
LASER oriented facilities				
.Manual/ Automated assembly lines				
Automated Inspection Technologies e.g. CMM, Machine vision, optical				

15.Please indicate the level of Advanced Manufacturing-related information/ documents sharing with the followings

	Very low 1	2	**Moderate** 3	4	**Significant** 5
Customers					
Distributors					
Suppliers					
Warehouses and logistics service providers					

16. Main problems in integrating supply-chain with Internet are

	Strongly disagree 1	2	3	4	**Strongly agree** 5
Lack of trained manpower					
Insufficient bandwidth					
Higher operating costs					
Poor service level					
Security threats					

17. Benefits observed/ perceived due to AMT-enabled Supply chain	**Least** 1	2	**Moderate** 3	4	**Most** 5
Increase in turnover					
Inventory reduction					
Order fulfillment time reduction					
Low working capital requirement					
Product quality					
Reduction in manpower					
Reduced transportation cost					
Improved relations in the supply chain					
Better capacity utilization					
Responsiveness					
Reduction in suppliers base					
Reduced product/material acquisition cost					
Reduction in unit cost of product/service					
Access to world class suppliers/ service providers					
An edge over new entrants in the industry					
Better customer service					
Postponement of point of product differentiation					

18. Please rank the barriers in the AMT- enablement of the supply chain	**Not a barrier** 1	2	**Moderate barrier** 3	4	**Significant barrier** 5
Resistance to change and to adopt innovations					
Low priority by the management					
Poor infra-structural facilities like CNC machine tools, Automated material handling, computers etc					
Lack of funds					
Lack of awareness about AMT					
Lack of trust and faith in supply chain linkages					
Disparity in trading partners' capabilities					
Fear of information system breakdown					
Fear of supply chain breakdown					
Low level of supply chain integration					

19. Reasons for adopting AMT- enabled supply chain	**Not Important** 1	2	3	4	**Most important** 5
Pressure of the trading partners					
To reduce inventory cost					
Quick response to customer needs					
Improvement of overall efficiency					
Quality and warranty of product					
Want early entry in the market					
Short product life cycle					
Consolidation of market share					
Reduce throughput time					

20. Use of AMT in following activities of your organization	**Hardly** 1	2	**Moderate** 3	4	**Extensively** 5
Design and process planning					
Operation and material handling					
Data sharing for design purposes					
Measurement and quality control					
Purchasing					
Collaborative information sharing					
Manufacturing scheduling					
Logistics operations					

21. Please rank the weightages of following factors in formulating AMT-enabled supply chain strategy

	No weightage 1	2	3	4	**Full weightage** 5
Cost-benefit analysis					
Competitors' status					
Product life cycle					
Trading partner's AMT infrastructure and willingness					
Organizational changes required					
Human factors					
Availability of trained manpower					
Financial constraints					
Government regulations					
Upcoming technological developments					
Logistics related factors					

22. Please indicate the degree of investment in the following supply chain automation tools

	No investment 1	2	3	4	**Heavy investment** 5
CNC Machine tools					
Automated material handling devices and controls					
Local area network (LAN)					
Bar coding/Automatic identification					
Computer aided design software					
Office automation					
Employee training					
Automated storage and retrieval system (AS/RS)					
Supply Chain Software					
Enterprise resource planning (ERP)					

23. Please indicate the approximate reduction in Purchase lead- time in your organization in the past three Years

(A) Can't say [ ] (B) 0-20% [ ]
(C) 21-40% [ ] (D) 41-60% [ ]
(E) 61-75% [ ] (F) 76-90% [ ]

24. Please indicate the approximate reduction in order fulfillment (throughput) time in your organization in the past three Years

(A) Can't say [ ] (B) 0-20% [ ]
(C) 21-40% [ ] (D) 41-60% [ ]
(E) 61-75% [ ] (F) 76-90% [ ]

25. The purchase department of your organization has following decision -aid/ support system, please tick all that applies

(A) Individual PCs or terminal for staff [ ] (B) Mainframe based purchase system [ ]
(C) Online real-time supplier information tracking [ ] (D) Purchasing performance evaluation system [ ]
(E) E-mail facility for staff [ ] (F) Internet access [ ]
(G) Automatic release of purchase orders (Based on inventory level) [ ] (H) Vendor rating system [ ]

26. Out of the total supply chain cost the approximate break-up is:

(i) In-bound logistics …%

(ii) Materials …%

(iii) Operations …%

(iv) Out-bound logistics …%

(v) Others

Section III: Performance Measurement Issues

27 a. Please assign ***Weight ages*** to the following indicators with respect to how frequently you are using this in measuring the performance of your supply chain

Customer service related measures	**Least** 1	2	3	4	**Most** 5
On-time delivery					
After-sales service					
Increase in customers base					
Retention of old customers					
Product customization					
Better product quality					
Ease in tracking of customer orders					
Increase in market share					
Online receipt of orders					
Order fill rate (Percentage of orders that were met when the demand were made)					

Financial measures	**Least** 1	2	3	4	**Most** 5
Cost per unit of product					
Net profit per unit of sales					
Turnover					
Return on investment (ROI)					
Economic value added (EVA)					
Working capital required					
Logistics costs					
Revenue earned per employee					

Internal business measures	**Least** 1	2	3	4	**Most** 5
Inventory turnover ratio					
Assets utilization					
Throughput time					
Purchase lead time					
Manufacturing lead time					
Outsourcing					
Operating cost					
Reduced wastes					
Plant productivity					
Just-in-time environment					
Reduction in number of breakdowns					
Stabilized master schedule					
Accuracy of documentation					
Cash-to-cash time					

Innovation and other measures	**Least** 1	2	3	4	**Most** 5
Low new product development time					
Employee turnover					
Employees' skill and training					
Manpower requirement					
Improved relations within organization					
Improved relations outside the organization					
Responsiveness					
Forecasting accuracy					
Few schedule change in supply chain					
Total supply chain inventory control					
Suppliers sharing the forecasting process					

27 b. Please assign ***Weight ages*** to the following indicators with respect to ease in acquiring the information in measuring the performance of your supply chain

Customer service related measures	**Least** 1	2	3	4	**Most** 5
On-time delivery					
After-sales service					
Increase in customers base					
Retention of old customers					
Product customization					
Better product quality					
Ease in tracking of customer orders					
Increase in market share					
Online receipt of orders					
Order fill rate (Percentage of orders that were met when the demand were made)					

Financial measures	**Least** 1	2	3	4	**Most** 5
Cost per unit of product					
Net profit per unit of sales					
Turnover					
Return on investment (ROI)					
Economic value added (EVA)					
Working capital required					
Logistics costs					
Revenue earned per employee					

Internal business measures	**Least** 1	2	3	4	**Most** 5
Inventory turnover ratio					
Assets utilization					
Throughput time					
Purchase lead time					
Manufacturing lead time					
Outsourcing					
Operating cost					
Reduced wastes					
Plant productivity					
Just-in-time environment					
Reduction in number of breakdowns					
Stabilized master schedule					
Accuracy of documentation					
Cash-to-cash time					

Innovation and other measures	**Least** 1	2	3	4	**Most** 5
Low new product development time					
Employee turnover					
Employees' skill and training					
Manpower requirement					
Improved relations within organization					
Improved relations outside the organization					
Responsiveness					
Forecasting accuracy					
Few schedule change in supply chain					
Total supply chain inventory control					
Suppliers sharing the forecasting process					

27 c. Please assign ***Weight ages*** to the following indicators with respect to perceive usage value in measuring the performance of your supply chain

Customer service related measures	**Least** 1	2	3	4	**Most** 5
On-time delivery					
After-sales service					
Increase in customers base					
Retention of old customers					
Product customization					
Better product quality					
Ease in tracking of customer orders					
Increase in market share					
Online receipt of orders					
Order fill rate (Percentage of orders that were met when the demand were made)					

Financial measures	**Least** 1	2	3	4	**Most** 5
Cost per unit of product					
Net profit per unit of sales					
Turnover					
Return on investment (ROI)					
Economic value added (EVA)					
Working capital required					
Logistics costs					
Revenue earned per employee					

Internal business measures	**Least** 1	2	3	4	**Most** 5
Inventory turnover ratio					
Assets utilization					
Throughput time					
Purchase lead time					
Manufacturing lead time					
Outsourcing					
Operating cost					
Reduced wastes					
Plant productivity					
Just-in-time environment					
Reduction in number of breakdowns					
Stabilized master schedule					
Accuracy of documentation					
Cash-to-cash time					

Innovation and other measures	**Least** 1	2	3	4	**Most** 5
Low new product development time					
Employee turnover					
Employees' skill and training					
Manpower requirement					
Improved relations within organization					
Improved relations outside the organization					
Responsiveness					
Forecasting accuracy					
Few schedule change in supply chain					
Total supply chain inventory control					
Suppliers sharing the forecasting process					

Respondent Profile

1. Name (optional): …
2. Designation in the organization …
3. Your area of work in the organization (Please tick)

(A)	Supply chain	[ ]	(B)	Operations	[ ]
(C)	IT/MIS	[ ]	(D)	Marketing	[ ]
(E)	Technical	[ ]	(F)	Any other (specify) …	

4. Your association in years with current organization

(A)	Less than 5 years	[ ]	(B)	5-10 years	[ ]
(C)	More than 10 years	[ ]			

6. Your E-mail address ……
7 Contact No.:

Thank You Very Much for Your Valuable Feedback!

Vivek Chandra Pandey (Cell no.9811335451),
E-Mail: vcpandey_12@rediffmail.com (For any clarification)
Research Scholar. Department of Mechanical and Production Engineering, Delhi College of Engineering, Bawana Road, N Delhi- 42

Survey on SCM of Advanced Manufacturing Systems, Dept. of Mechanical & Production Enginering, Delhi College of Engineering.

List of Publications from Research

International Journals

1. V.C.Pandey. Suresh Garg and Ravi Shankar, 2010, Impact of Information Sharing on Competitive Strength of Indian Manufacturing Enterprises: An Empirical Study, *Business Process Management Journal*, 16, 2.
2. V.C.Pandey and Suresh Garg, 2009, Analysis of interaction among the enablers of agility in supply chain, *Journal of Advances in Management Research*, 6, 1.

National Journals

1. V.C.Pandey. Suresh Garg and Ravi Shankar, 2004, Role of Advanced Manufacturing Technology for integration and agility of Supply chain management, *Productivity Promotion*, 2, 28, 44-57.
2. V.C.Pandey. Suresh Garg and Ravi Shankar, 2005, An Interpretive Structural Modeling of enabler variables for integration in SCM, *Productivity*, 1, 46, 93-108.
3. V.C.Pandey and Suresh Garg, 2007, Design of CMS for Pinion Manufacturing: A Case, GPM *Journal of Technology and Management*, 1, 1, 40-48.

International Conference

1. V.C.Pandey. Suresh Garg and Ravi Shankar, 2005 "An Interpretive Structural Modeling of enabler variables for agility in SCM." Proceedings of 14th ISME International conference on '*Mechanical Engineering in Knowledge age'* 12-14 Dec 2005.

BIOGRAPHICAL PROFILE OF RESEARCHER

(As on February 25, 2010)

ACADEMICS

2010	Currently a candidate for the degree of Doctor of Philosophy at Delhi University, Delhi, India.
1996	Post-Graduated from SGS Institute of Technology, DAVV Indore, India, with a Masters' degree in Industrial Engineering & Management.
1994	Graduated from MMMEC, Gorakhpur, India, with a Bachelors' degree in Mechanical Engineering.

EXPERIENCE

2009- Till Date	Teaching & Administrative Experience in P.M. College of Engineering, Kami, Sonepat, Haryana, India.
2006 - 2009	Teaching Experience in GPM College of Engineering, New Delhi, India.
2000 - 2006	Teaching Experience in Maharaja Agrasen Institute of Technology, New Delhi, India
1999 - 2000	Teaching Experience in R.V. College of Engineering, Bangalore, India.
1996 - 1999	Industrial Experience in Alpine Industries Limited, Neemuch, Madhya Pradesh, India.

Address

V.C. Pandey, Dy Director,
P.M. College of Engineering
Kami, Sonepet, Haryana, 131001
INDIA

STUDY OF SELECT ISSUES IN THE SUPPLY CHAIN MANAGEMENT OF ADVANCED MANUFACTURING SYSTEM

SYNOPSIS OF THE THESIS

Submitted by

VIVEK CHANDRA PANDEY

For the award of the degree of

DOCTOR OF PHILOSOPHY

DEPARTMENT OF PRODUCTION ENGINEERING
DELHI COLLEGE OF ENGINEERING, DELHI UNIVERSITY
NEW DELHI – 110007, INDIA
FEBRUARY 2010

Table of Contents

SYNOPSIS

1. INTRODUCTION

Since the globalization and economical reforms in India that started in early nineties, cost quality and responsiveness have assumed an important role in the survival of an organization. Further short product life cycle is a common phenomenon now, which has resulted into creating uncertainty in the business environment. Many companies have identified supply chain management as a way to effectively tackle these situations.

Supply chain management is the integration of the key business processes from end user through original supplier that provides product, service and information that add value for customer and other stake holder (Lambert et al. 1998).

SCM is a set of approaches utilized to efficiently integrate suppliers, manufacturer, ware houses and stores so that merchandise is produced and distributed at the right quantities to the right locations, and at the right time in order to minimize system wide costs while satisfying service level requirements (Agrawal and Shankar, 2003). So a typical supply chain consists of suppliers and manufacturers, who convert raw materials into finished products and distribution centers and warehouses, from where finished products are distributed to customers

SCM focuses on information sharing and better collaboration among the supply chain partners. Some of the benefits of SCM, include, lower inventory levels, better responsiveness, and lower throughput time. Firms may also achieve volume, design, and technology flexibilities through SCM (Pagel, 1999). These benefits are the source of motivation for the companies in embracing the concept of SCM.

The objective of every supply chain is to maximize the overall value generated in the delivery of products or services. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request. For most commercial supply chain, value will be strongly correlated with supply chain profitability, the difference between the revenue generated from the customer and overall cost across the supply chain. The higher the supply chain profitability, the more successful the supply chain. The cash transfer adds to the supply chain's costs. All flows of information, product, generate costs within the supply chain.

2. ADVANCED MANUFACTURING SYSTEMS AND SUPPLY CHAIN

Manufacturing industry has been undergoing through a substantial technological growth since the introduction of numerical control machines about 55 years ago (Mukundan, 2003). Changes due to this growth are primarily because of the use of computers and automation. Computers have assisted in the development of numerous innovations in manufacturing including miniaturization and automation. In large manufacturing industries like the automotive industry, heavy machines industry, computer hardware industry etc product design and development are now done completely by the computers. Computer Aided Design workstations have replaced drafting tables. Product designers and engineers use CAD and Computer aided Engineering (CAE) systems to create three-dimensional geometrical objects that can be shaded, analyzed, and optimized to refine the product design. Manufacturing engineers use Computer-Aided Manufacturing (CAM) systems for process planning, tool design, and machine programming. Robots are used to weld structural frames, and computerized numerical processors are guiding manufacturing tools. Information technology is used in production planning, production and inventory control, sales, market research and forecasting, and after sales service The sweeping changes in the computer-related technologies in the late 1990s have brought paradigm shift in the business environment and strategic thinking of the organizations. To remain competitive in this ever-changing business scenario, the organizations are focusing more and more on the globalization of businesses and collaboration in the product development across the value chain i.e. supply chain. Manufacturing is the central activity that encompasses product, process, resources and plant. Manufacturing activities across the enterprises with real time exchange of information result in the optimization of design, resources and processes, which is in the true spirit of collaborative product commerce globally for maximum profitability. Redesigned best practices are requisite for the continued health and growth of the industry. Key factors contributing to this need include:

- Customers demand greater product variety, as well as shorter delivery times.
- Outsourcing and supplier relationships are becoming increasingly strategic to overall business plans.
- Fast time-to-market with new products is a requirement.
- Manufacturing and aftermarket support must be considered not at only at local level but, globally for maximum profitability.

3 SOME RELATED ISSUES OF SCM OF THE AMS

The literature related to different aspects of SCM is quite extensive. The same is true for AMS. This section gives a brief overview of literature in the area of SCM and AMS. SCM literature can be classified into three broad categories based on methodology:

- Conceptual and non-quantitative models including framework, taxonomies and literature reviews
- Case and empirical studies, and

- Quantitative models.

However, content wise there are some issues (such as information sharing, use of technology in supply chain, logistics related issues, performance measurement of a supply chain etc.), which are widely discussed in the literature and have figured in each of the above three categories. These issues are presented under the following subsections.

3.1 Information sharing related issues*:* The integration and optimization of information flow is one of the core concerns of SCM (Lee and Whang, 2000). IT has a substantial impact on information sharing. The findings of KPMG 1997 global supply chain survey put IT as a major enabler of SCM (Freeman, 1998). In describing the role of IT in SCM, Chopra and Meindl (2001) state: "IT enables the gathering and analysis of information, which can be used to make a good decision. IT systems can be used to make the strategic, planning or operational decisions in a supply chain". IT systems enable companies to make decisions, which are based on real-time information sharing (Kwan, 1999). Regarding the use of IT in supply chains, Scala and McGrawth (1993) have observed that the way IT could be deployed in a supply chain is a crucial issues and depend on many factors such as maturity and compatibility of IT tools that supply chain partners use, level of costs involved, strategic alliances among supply chain partners, level of integration etc. The use of IT in a supply chain is not free from obstacles. Many authors (Kwan, 1999; Kadambi, 2000; Jharkharia and Shankar, 2000; Li, 2002) have identified the issues, which influence the IT-enablement of a supply chain. Some of these issues are: top management commitment, resistance to change and innovations, disparity in trading partners' capabilities etc. There are some technical, human and managerial issues, which need to be addressed during the formulation of a strategy for the IT-enablement of a supply chain (Williams *et al.*, 2002).

3.2 Logistics related issues: Logistics, which is often considered a subset of SCM has a key role in supply chain management. Realizing its importance, Heskett (1977) had predicted that globalization would have huge impact on the importance of good logistics design and developments within the corporate strategy. The outsourcing of logistics activities to a third party logistics service provider (3PL) is a common phenomenon these days. As IT has the capability to automate many routine logistics activities, Razzaque and Sheng (1998) argue that one of the most important reason for employing 3PL is their ability to support clients with expertise and experience that otherwise would be difficult to acquire or costly to have in house. In logistics outsourcing mutual trust and information sharing motivate the partner companies to collaborate further for mutual benefits (Bagchi and Virum, 1998). Virum (1993) analyzed the primary drivers for an organization to rely on logistics outsourcing and came up with some points in favor of logistics outsourcing. These are: better transportation solutions, cost savings and improved services, need for more professional and better equipped logistics services, development of necessary technological expertise and computerized systems which is beyond the scope of many companies, more flexible processes, simplification of administrative processes, and access to ready made logistics services when entering new markets. However, despite all these advantages of outsourcing two-thirds of the user companies (shipper) experience significant hurdles in logistics alliances (Lieb and Randall, 1996). According to Greco's (1997) survey one of the main reasons for problems in logistics outsourcing is that these decisions are not given the strategic attention that they deserve.

3.3 Partnership related issues: Supply chain partnership related issues have received greater attention in the past two decades. In this regard, Ho *et al.* (2002) have stated that integration of key business processes in a supply chain is best achieved through collaboration of business partners. Higher level of shared information and communications among the supply chain partners lead to improved collaboration and greater responsiveness in the supply chain (Daugherty *et al.*, 1995). Reduction in suppliers' base is an important aspect of SCM. The benefits of reduced supplier base are: lower price of the product, lower administrative costs and improved communications (Szwejczewski *et al.*, 2001). Many authors have stressed the need of an information sharing mechanism for the smooth functioning of these relationships (Ballou *et al.*, 2000). However, many a times the major stakeholder in the supply chain dictates its own terms and conditions on the other linkages of the supply chain. Munson *et al.* (2000) have observed that major stakeholder may exercise its power in the following ways: (i) pricing control, (ii) inventory control, (ii) information control etc. The exercise of such power by the major stakeholder (original equipment manufacturers, OEM) is often targeted at its own interest but many a time it is used to bring the supply chain linkage closer for collaboration.

3.4 Performance measurement related issues: Performance measurement of a supply chain is often not given due consideration in the design and analysis of the supply chains.) The impact of good or bad performance of any link of the supply chain is observed on the performance of the entire supply chain (Keebler, 2001). Beamon (1999) has provided a framework for supply chain performance measurement. In a survey by McMullan (1996) the most commonly used performance measures for a supply chain are identified as on-time delivery, customer complaints, back orders, stock outs etc. However, in India there seems to be no serious attempt towards the performance measurement of an integrated supply chain. The case studies and interaction with the managers also suggest that that supply chain performance measurement effort in India is at present targeted only at a small segment of the supply chain.

3.5 AMT related issues: In a SCM environment, AMT supported enablers such as flexibility, data sharing, data processing, training and education, communication, empowerment and job satisfaction Technological support can impact on Partnership, information technology, operational flexibility, performance measurement; management commitment; and demand characterization, the major dimensions of SCM. Considering the need for integrated business processes in SCM, AMT could play a major role in promoting effective integration of suppliers and customers along the value chain. Few studies can be found on AMT in SCM. Little has been done to explore what is needed in the way of successful implementation of AMT in the context of SCM.

There is a need for further research on the application of AMT in supply chain management. Some general areas for research have been identified, for further investigation:

- management's role related to AMT in SCM;
- information systems to support AMT in SCM;
- the nature of education and training in support of AMT in SCM;
- performance measures, metrics and costing in SCM and AMT,
- cultural and behavioral issues that influence the application of AMT in SCM.

3.6 Miscellaneous issues: There are various other issues involved for the effective management of a supply chain such as supply chain strategy, organizational changes required, top management commitment etc. McMullan (1996) has on the basis of a survey suggested that many firms will have to change their organizational structure to successfully implement SCM. The amplification of demand variability in the upstream of a supply chain is a common phenomenon, which is more visible in the consumer goods sector. This is known as bullwhip effect. Lee *et al.* (1997) have identified four major causes of bullwhip effect, which are (i) demand forecast updating, (ii) order batching, (iii) price fluctuation, and (iv) rationing and shortage gaming. It is observed and suggested by authors that real time information sharing in the supply chain and improved collaboration among the supply chain partners can effectively control the bullwhip effect (Lee *et al.*, 1997; Lee and Whang, 2000)

4 SUPPLY CHAIN CHARACTERISTICS OF AMS

Supply chain management concerns diverse areas such as demand forecasting, procurement, manufacturing, distribution, inventory, transportation, and customer services. All these areas may be dealt under strategic, tactical, or operational perspective. Issues like strategic partnership, flexibilities, responsiveness, and supply chain performance are contemporary research issues in the domain of effectiveness of supply chain. In coming paragraph we discuss few characteristics of competitive supply chain of AMS.

4.1 Supply chain agility

Agility is the business-wide capability that embraces organizational structures, information systems, logistics processes, mindsets etc. (Subash, 1999, Power et al., 2001). Agility is defined as the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety (Figure 1.1). Thus agility maximize profit through providing exactly what the customer requires and reducing costs while not impeding the ability to meet customer service requirements. On the other hand, leanness will maximize profit through cost reduction and providing service suitable for a level schedule (Christopher, 2000)

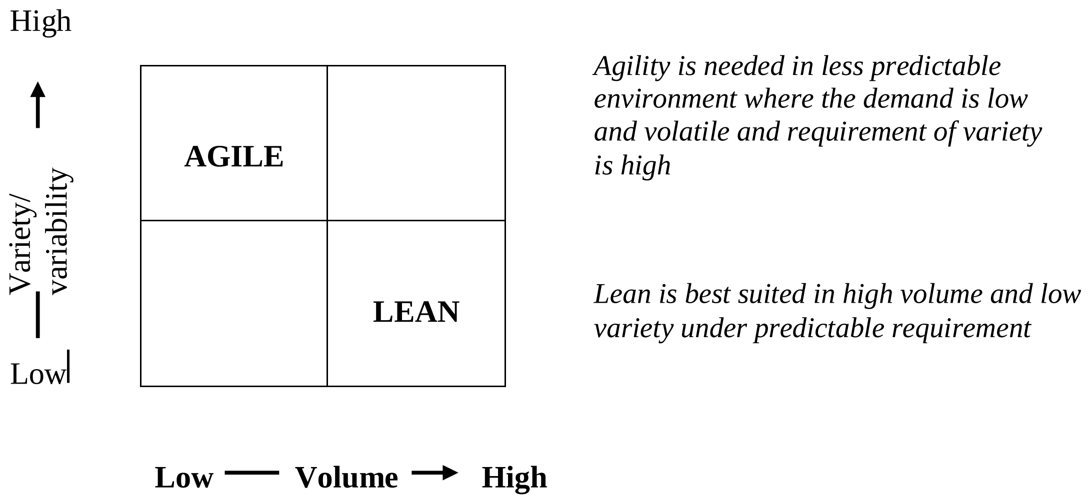


Figure 1.1; Agile or Lean (Adapted from Mason-Jones et al., 2000a)

The lean and agile paradigms, though distinctly different, can be and have been combined within successfully designed and operated total supply chains (Christopher, 2000; Mason- Jones and Towill, 1999). Some past studies discuss the dependance of agility and leanness and supply chain strategy, particularly considering market knowledge, though information enrichment, and positioning of decoupling point combining agility and leanness in a supply chain through strategic use of a decoupling point has been termed as “le-agility” (Naylor et al., 1999). The Decoupling point (represented by ▼ in Figure 1.2) is the position in the material flow stream s at which the customer order penetrates. Therefore leagile is a combination of the lean and agile paradigms within a total supply chain strategy by strategically positioning the decoupling point so as to best suit to the need of responding to a volatile demand downstream yet providing level scheduling upstream from the market place (Mason-Jones et al. 2000b; van Hoek et al., 2001).

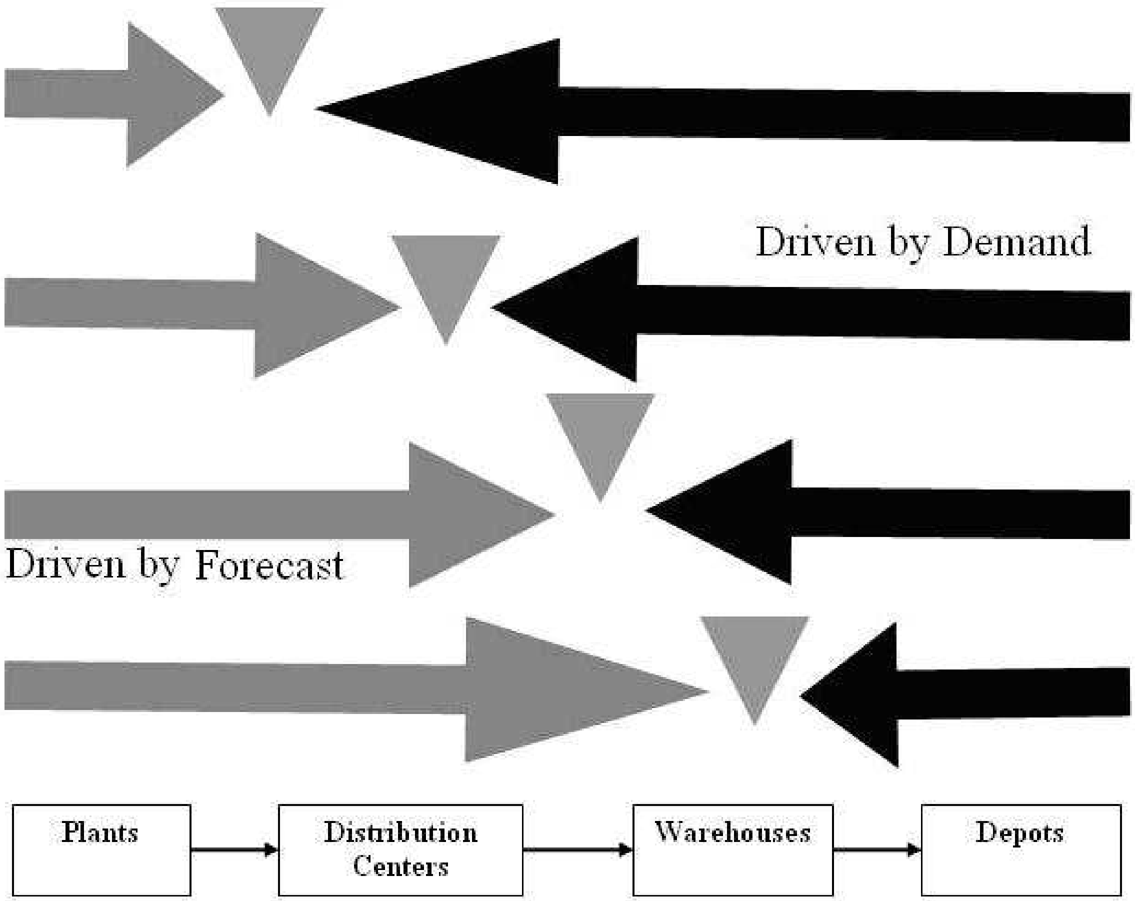


Figure 1.2: Material flow Decoupling points (Adapted from Mason-Jones et al., 2000b)

4.2 Supply Chain Integration

In order to achieve lean or agile supply chain, all the entities of the supply chain need to be integrated. The difficulty in achieving a total integration is due to dynamic and conflicting objectives employed by different supply chain partners. However in today's competitive market most companies have no choice; they are forced to integrate their supply chain and engage in strategic partnering (Simchi-Levi et al., 2008). Strategic partnership is one of the important ingredients to facilitate the integration and performance of a supply chain. A general trend characterizing buyer-supplier relationships is a shift from an arm's length relationship to a partnership approach (Lamming, 1986; Ellram, 1990). Literature on buyer-supplier relation describes the advantages of a close collaboration between buyer and supplier along the entire supply chain. Strategic partners share risks and benefits, exchange operational and financial information, and make joint investments in facilities and systems. In that sense, trust becomes a significant factor in the supply chain integration.

4.3 Supply Chain Flexibility

A key characteristic of an agile supply chain is its ability to remain flexible to cope-up with the changes in its environment and also within (Vickery et al., 1999; Prater et al., 2001; Olhager, 2003). The performance dimensions of flexibility for a supply chain partner may be broken down into two capabilities: the promptness with and degree to which a partner can adjust to its supply chain speed, destination and volumes (Prater et al., 2001). A supply chain partner's agility is determined by how its physical components (i.e. sourcing, manufacturing and delivery) are configured to incorporate speed and flexibility. As the levels of speed and, more importantly, flexibility increase, the stage of supply chain agility improves. The firm can, to some degree, make up deficiencies in the speed or flexibility of one of the supply chain parts by excelling in the other parts (Garg et al., 2001). For example, the delivery part of supply chain may be inherently inflexible, such as the one found in sea transportation. Supply chain agility may be increase if the firm is able to compensate for these shortcomings by setting up its inbound logistics (i.e. sourcing) or manufacturing operations to be faster or more flexible. Similarly, if the speed in outbound logistics is inflexible, higher speed and flexibility in manufacturing and sourcing could help in compensating for the slow outbound operations (Simchi-Levi et al., 2008).

4.4 Responsiveness in Supply Chain

Responsiveness of a supply chain is its ability to cope up with the changes in customer demand and yet remain efficient in its operations. Responsiveness, competency, quickness and flexibility help in improving agility of a supply chain (Christopher 2000; Goh and Ling, 2003). The development of strategies for competing on the basis of agility is crucial for the management of a total supply chain (Power et al., 2001). Towill (1996) expresses this in terms of creating architecture for "seamless supply chain" where territorial boundaries between trading partners are eliminated and they effectively operate as if they are part of the same organization.

4.5 Trust in Supply Chain

Trust is perceived as a state of readiness for unguarded interaction with someone or something (Ba, 2001). Trust is frequently defined as a willingness to take risk (Mayer et al., 1995) and a willingness to rely on an exchange partner in whom one has confidence. However, in many research works, trust has been more commonly stated as "perceived trustworthiness" or confidence (Mayer et al., 1995; Moorman et al., 1993). Handfield and Bechtel (2002) have stated that the primary relational requirement for improved responsiveness is the development of greater levels of trust between purchasing organizations and their suppliers. The nature of trust and the nature of the business transaction often temper the relationships. Trust among the trading partners in inter-organizational relationships improves communication and dialogue and creates common strategic visions (Sahay, 2003).

Now a days supply chain, enabled with latest ICT tools, primarily the internet, provide opportunity for cost reduction while improving the agility and integration of supply chain. But using the internet as a platform for managing the supply chain trading partner inherits a risk of insecure transaction as websites can be counterfeited, identities can be forged and nature of the transaction can be altered. Geographic dispersion of trading partners creates new and unprecedented opportunities for consumer abuse through fraud and deception. The use of digital signature has yet not fully guaranteed that the message has come from the person signing it. This can be due to fact that the institution issuing the signature has inadequate administrative routine (Ba, 2001). Therefore, one of the most prevalent issues in the introduction of e-commerce system along the supply chain is its ability to establish dynamic and flexible structures for buyer-supplier relationships and on-line trust that deterministically drive both parties towards strategic partnerships sand cooperation (Agrawal and Shankar, 2003).

5 SUPPLY CHAIN MANAGEMENT IN INDIA

Worldwide interest in supply chain management has increased steadily since the 1980s when organizations began to see the benefits of collaborative relationships. This management concept is however, relatively new in India (Vrat, 1998). Prior to 'liberalization', India has a policy of national sufficiency and non-reliance on imports or foreign economic investments that has designed to protect domestic markets from competitions. Protected tariffs, import quotas, exchange rate controls and regulated licensing for capital goals discouraged innovation, cost reduction and acquisition of technological capabilities, causing inefficiencies, sluggish export performance, and slow economic growth. By the mid 1990s the Indian government had liberalized foreign exchange and equity regulations to encourage foreign direct investment. As the country settled down to the realities of liberalization, there was a quantum leap in economic growth, which was reflected in Indian industries (Sahay et al. 2003). Liberalization efforts also increased disposal income of middle class families by stimulating credit purchases. Indian consumers became more demanding for quality products and services forcing enterprises to enhance product quality, increase variety, shorten product development process and improve services. To remain competitive, Indian industries found that existing supply chain systems were not configured to meet the increasing requirements of consumers in a newly liberalized economy (Kapoor and Ellinger, 2004). Increasing uncertainty of supply networks, globalization of business, proliferation of product variety and shortening of product life cycles have forced Indian industries to look beyond their four walls for collaboration with supply chain partners (Sahay, 2003). With a gross domestic product (GDP) of over US $ 474.3 billions, the Indian Industries spends 14% of GDP on logistics (Sahay and Mohan, 2003). Considering this scenario, it is necessary to study supply chain practices being followed by Indian industries and to suggest areas for improvement.

6 MOTIVATION FOR THIS RESEARCH

Enterprises have now realized that management of supply chain is essential for the survival in the global market and so they focused on improving the customer service level, reducing operating expenses and increasing revenue growth by effectively managing their supply chains. Studies have revealed that companies that have completed supply chain project related to performance improvement typically enjoy improvements in individual supply chain functions (Cross, 2000).

Following are some of the ground realities that point out the significance of SCM in current market scenario and motivated to pursue research in this area:

- Leading international journals like *Academy of Management Journal*, *Assembly Automation*, *Business process management Journal*, *California Management Review*, *European Journal of operation Research*, *European Journal of purchasing and* *supply Management, Harvard Business Review, Human Systems Management, IBM Systems Journal, IIE Solutions, Industrial and commercial Training, Industrial management & data systems, Industrial marketing research, Information & management, Information & software Technology, Information management & computer security, Integrated Manufacturing systems, International Journal of Agile Management Systems, International Journal of Information Management, International Journal of logistics management, International Journal of production and operational management, International Journal of physical distribution and logistics management, International Journal of production Economics, International Journal of Quality and reliability management,* etc. are exclusively covering various issues related to supply chain.

- Special issues have been published on SCM by reputed journals such as Production Planning and Control, International Journal of Operations and Production Management, IEEE Transactions on Engineering Management, International Journal of Technology Management, etc.
- Seminars and workshops are being organized globally to address the issues related to SCM. A number of international conferences addressing various issues , related to SCM have been held during past few years.
- All over the world companies are streamlining their supply chains and improving their relationship with supplier and customers.
- Companies are focusing on integration of their supply chain activities in order to become more agile.
- Companies are attempting to minimize bullwhip effect by using advanced IT tools

7 RESEARCH OBJECTIVES

The main objectives of this research are:

- identification of issues governing enablers and inhibitors for the effectiveness of advanced manufacturing system's supply chain,
- study of supply chain issues in advanced manufacturing systems through a questionnaire based survey,
- development of mathematical models of supply chain issues for advanced manufacturing systems ,
- development of a framework for the IT-enablement of supply chain for AMS
- to model supply chain performance variables related to integration and agility to capture the effect of integration and responsiveness variables under different market scenario.

8 RESEARCH METHODOLOGY

- *Questionnaire-based survey approach:* This is used to gain a broad insight of SCM practices in India (Figure 1.3).
- Various statistical tools have been used to analyze the data obtained from the questionnaire survey. Descriptive Statistics, inferential statistics.
- Regression analysis, gap analysis and cluster analysis has been done on the data related to information sharing and performance measures.
- Interpretive Structural Modeling (ISM) has been developed for Integration and Agility of the Supply Chain Management.

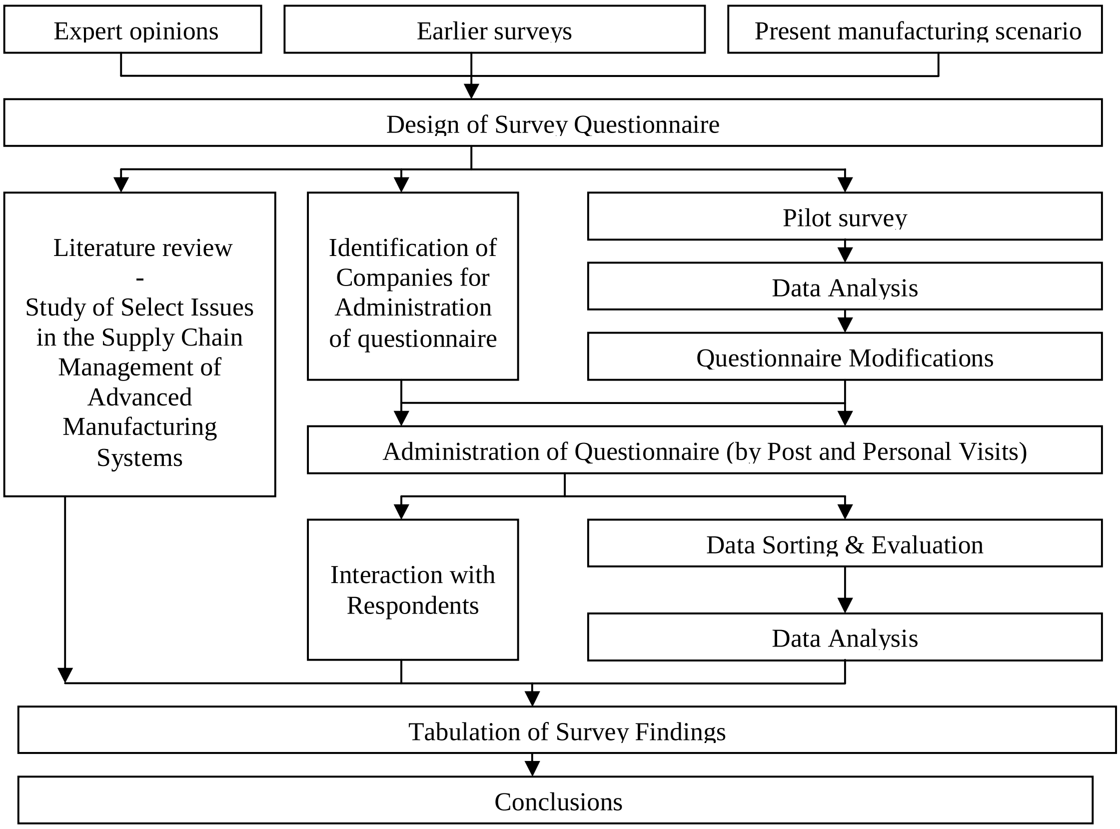


Figure 1.3: Schematic diagram of research Methodology

9 RESEARCH OVERVIEW

A structured questionnaire was developed for conducting a national-wide survey on select issues of supply chain management of AMS in Indian context. It was developed on a five-point Likert scale. The questionnaire was validated through a pilot survey and necessary modifications have been made to get the required information from manufacturing industries within the purview of this survey.

Results from descriptive analysis of the questionnaire survey have been used to focus on three important issues of supply chain management. These are technology enablement of SCM, Information sharing in SCM and Performance Measurement system in SCM. In

Advanced manufacturing systems, aforesaid issues have significant role similar to logistics related issues in FMCG sector.

Synthesis of the research finding helps to develop Interpretive Structural Model for Integration and agility of the Supply Chain in Indian perspective.

CHAPTER PLAN OF THE THESIS

The Organization of the research scheme is depicted in Figure 1.5. This is followed by brief description of different chapter, which embody this research.

Chapter 1

It contains an introduction to supply chain management. The growing importance and relevance of supply chain management in today's context have been discussed in this chapter. The issues related to supply chain of the advanced manufacturing system has been discussed. Some of the important characteristics of the supply chain of the advanced manufacturing systems that make it more competitive in the market discussed briefly. The issues related to agility, integration, supply chain performance measure, information sharing have also been discussed. The status of supply chain management being used in manufacturing systems in India has been presented. Motivation of research and objectives of this research have been presented. Finally overviews of the conducted research and the methodologies used for this research have been reported in this chapter.

Chapter 2

It provides the literature review on different aspects of the supply chain such as integration, agility, responsiveness, flexibility, trust, information sharing, and performance measurement system. The literature review on the features and technological requirements of advanced manufacturing system have been also included in the chapter. Though the literature review the limitation and gaps in the contemporary research will also be identified which provide the motivation for the current research work. The chapter presents literature on methodologies used in this research such as Questionnaire survey and Interpretive Structural Modeling (ISM).

Chapter 3

This chapter covers the development of the questionnaire, its structure, source and content validation. The questionnaire was administered in four sectors, namely automobile, machineries, machine tools, and electrical and electronics. A sample size of 1176 was selected for administering the questionnaire. In all 206 valid responses were received resulting in a response rate of 17.51 %. The respondent profile is also analyzed in this chapter. The respondents are categorized as original equipment manufacturers (OEM's) and suppliers, and the observations and results of the survey are reported in this chapter. Results of non-response bias test, factor loading, reliability analysis and descriptive statistics are reported.

Chapter 4

The objective of this chapter is to understand the similarity/ dissimilarity with respect to the issues related to adoption of AMT-enablement between original equipment manufacturer (OEMs) and suppliers, and among different sectors within the Indian. To assess the sectoral nature different hypothesis has been formulated. These hypotheses have been tested using t-test and ANOVA. Based on the results of hypothesis testing, various aspects of sectoral differences have been discussed and inferred.

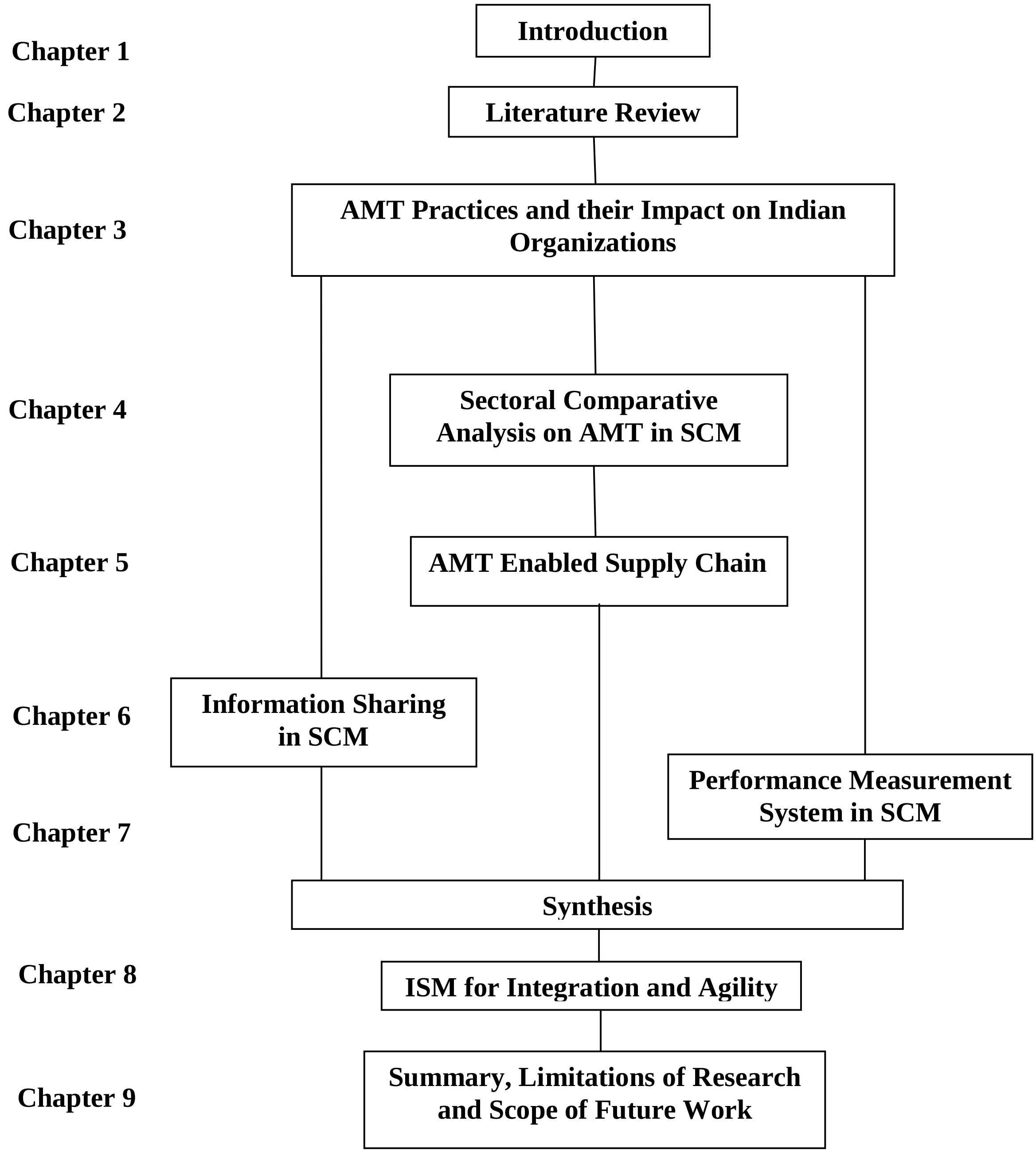


Figure 1.5 Chapter Plan of the thesis

Chapter 5

This Chapter focused on adoption of Advanced Manufacturing Technologies (AMT) and its effect on supply chain management in India. AMT have been classified into three categories (simple, complex and integrated) for the present analysis. A general conclusion can be reached that Indian firms surveyed have high adoption of simple technologies, are going to adopt complex technologies, and are not yet ready to invest much in integrated technologies. Factor Analysis is used to identify common components among 17 selected AMT that were surveyed. These technologies can be nicely interpreted by four common factors: “Expensive”, “production”, “Integration” and “quality”. Discriminant analysis is used to identify critical benefits of the AMT that contribute significantly to the success of supply chain.

Chapter 6

It presents the issue related to information sharing. This issue has been widely discussed, information sharing with customer and information sharing with supplier both presented with its impact on performance and competitive strength of the enterprises. Inferential statistics like t-test and Pearson correlation coefficient has been used to discuss the results of information sharing in supply chain. The data from the responses has been thoroughly used in this chapter. Different types of information sharing with its relative importance if share with customer and supplier has been presented in this chapter.

Chapter 7

This chapter presents the status of Supply Chain Management performance measures used by respondents in the questionnaire based survey. Different performance measures variables in four major categories have been included in the questionnaire. The respondents have been asked to rate different measures in the Likert scale on the basis of their frequency of use, perceived use value and ease of measurement. Linear regression model has been developed to establish the relationships among the three values of the each variable namely FoU, PUV and EoM. Gap analysis and Cluster analysis has been done to find the relative usefulness of the different performance measure in the sample of Indian manufacturing enterprises.

Chapter 8

Based on the literature review and survey results, different variables of supply chain integration and agility are identified. These variables have been modeled using Interpretive Structural Modeling to provide a framework for the effective deployment of management strategies towards and integrated and agile supply chain. On the basis of driving and dependence power these variable are further categorized as independent, dependent, linkage and autonomous variable. Managerial implications of the results are also discussed in this chapter.

Chapter 9

It contains the summary of the conducted research in this thesis, research findings, key insights from the survey and major implications of this research have also been presented in this chapter. This chapter concludes with the limitations of this research work and directions and scope for further research.

11 CONCLUSION

In this chapter, an overview of context related to the research has been presented. The motivation and objectives of the research have also been presented in this chapter. A brief description of research methodology to be used in this research has also been presented. In the research overview, a summary of the entire research reported in this thesis has been presented.

REFERENCES

1. Agarwal, A. and Shankar, R. 2003, On-line trust building in e-enabled supplies chain, *Supply Chain Management: an International Journal*, 8 4, 324-34.
2. Ba, S., 2001, Establishing on-line trust through a community responsibility system, *Decision Support System*, 31, 3,323-336.
3. Bagchi, P.K. and Virum, H. 1998, Logistical Alliances: Trends and Prospects in Integrated Europe, *Journal of Business Logistics*, 19, 1, 191-213.
4. Ballou, R. H., Gilbert, S.M. and Mukherjee, A. 2000, New managerial challenges from supply chain opportunities, *IEEE Engineering Management Review*, Third quarter, 7-16.
5. Christopher, M. and Towill, D. 2001, An integrated model for the design of agile supply chains, *International Journal of Physical Distribution & Logistics Management*, 31, 4, 235-46.
6. Cross, G. J., 2000, How E-business is transforming supply chain management, *IEEE Engineering Management*, 6, 67-83.
7. Daugherty, P.J., Ellinger, A.E. and Rogers, D.S. 1995, Information accessibility: customer responsiveness and enhanced performance, *International Journal of Physical Distribution and Logistics Management*, 25, 1, 4-17.
8. Freeman, B. 1998, Highlights of KPMG's global supply chain survey, http://www.infochain.org/quarterly/spring98/survey_figures.htm
9. Garg S., Vrat P., and Kanda A., 2001, Equipment flexibility vs. Inventory: A simulation study of manufacturing system, *International Journal of Production Economics,* 70,125-143.
10. Goh M., and Ling C., 2003, Logistics development in China, *International Journal of Physics Distribution and Logistics Management,* 33, 10, 886-913.
11. Heskett, J.L. 1977, Logistics-Essential to Strategy, *Harvard Business Review*, 55, 85-96.
12. Jharkharia, S. and Shankar, R. 2000, Information Technology: A competitive weapon in supply chain management, *Proceedings of International conference on Flexible systems management*, Dec. 17-20, New Delhi, 599-610.

13. Kadambi, B. 2000, IT-Enabled supply chain management- A preliminary study of few manufacturing companies in India, http://www.xlri.ac.in/cltm/LogistiX-2-2000.HTM.
14. Kapoor, V., and Ellinger A. E., 2004, Transforming supply chain operations in response to economic reform: the case of a motorcycle manufacturer in India , *Supply Chain Management: An International Journal* 9, 1, 16-22.
15. Keebler, J.S.2001, *Measuring Performance in the Supply Chain*, In Mentzer, John, T. (Ed.), Supply Chain Management, Response Books, New Delhi.
16. Kwan, A.T.W. 1999, The use of information technology to enhance supply chain management in the electronics and chemical industries, *Production and Inventory Management Journal*, third quarter, 7-15.
17. Lamming, R., 1986, For better or worse: Technical Change and buyer-supplier relationship assessment programs, *European Journal of Purchasing and Supply Management*, 2, 4, 173-181.
18. Lee, H. and Whang, S. 2000, Information sharing in a supply chain, *International Journal of Technology Management*, 20, 3/4, 373-387.
19. Lee, H. L., Padmanabhan, V. and Whang, S. 1997, The Bullwhip effect in supply chains, *Sloan Management Review*, spring, 93-102.
20. Li, Lodi 2002, Information sharing in a supply chain with horizontal competition, *Management Science*, 48, 9, 1196-1212.
21. Lieb, R. and Randall, H. 1996, A comparison of the use of third party logistics services by large American manufacturers, 1991, 1994, and 1996, *Journal of Business Logistics*, 17, 1, 305-320.
22. Mason-Jones and D.R. Towill, 1999, Total cycle time compression and the agile supply chain, International *Journal of Production Economics*, 61–73.
23. Mason-Jones, R., Naylor, J. and Towil, D. 2000, Engineering the leagile supply chain, *International Journal of Agile Manufacturing Systems*, Spring.
24. Mayer, M.B., Daugherty, P.J. and Autry, C.W., 2000, The Effectiveness of Automatic Inventory Replenishment in Supply Chain Operations: Antecedents and Outcomes, *Journal of Retailing*, 76, 4, 455-481.

25. Mukundan, G., 2003, Virtual Manufacturing, *Journal of Advanced Manufacturing System* www.worldscinet.com
26. Naylor, J.B., Naim, M.M., Berry, D., 1999, Legality: interfacing the lean and agile manufacturing paradigm in the total supply chain, *International Journal of Production Economics,* 62, 107-18.
27. Olhager J., 2003, Strategic positioning of the order penetration point, *International Journal of Production Economics*, 85, 319-329.
28. Pagel, D., 1999, Managing for optimal performance through effective coordination of the supply chain, *Production and Inventory Management Journal,* first quarter, 66-70.
29. Power, M., 1985, Competitive Advanced Supply Chain Management: How to Build a Sustained, Berrett-Koehler, San Francisco, CA.
30. Prater, E., Biehl, M. and Smith, M.A. 2001, International supply chain agility – tradeoffs between flexibility and uncertainty, *International Journal of Operations & Production Management*, 21 5/6, 823-39.
31. Sahay B.S. and Mohan, R., 2003, Supply chain management practices in Indian Industry, *International Journal of Physical Distributions and Logistics Management,* 33, 7, 582-606.
32. Sahay, B.S., Cavale, V. and Mohan, R.2003, The Indian supply chain architecture, *Supply Chain Management: an International Journal*, 8, 2, 93-106.
33. Scala, S. and McGrawth, R., 1993, Advantages and Disadvantages of Electronic, *Data Interchange, Information and Management*, 25, 8, 85-91.
34. Simchi-Levi D., Kaminski P., Simchi-Levi E. and Shankar R., 2008, *Designing and managing Supply chain*, Tata McGraw-Hill, New Delhi.
35. Subash Babu A., 1999, Strategies for enhancing agility of make-to-order manufacturing system, *International Journal of agile Management System,* 1, 1, 23-29.
36. Szwejczewski, M., Goffin, K. and Lemke, F. 2001, Supplier management in German manufacturing companies: an empirical investigation, *International Journal of Physical Distribution and Logistics Management*, 31, 5, 354-373.
37. Van Hoek, R.I., 2001, The rediscovery of postponement: a literature review and directions for research, *Journal of Operations Management,* 19, 2, 161-84.

38. Vickery S.K. Calantone r., and Droge C., 1999, Supply chain flexibility: an empirical study, *Journal of Supply Chain Management,* 35, 3, 16-24.

39. Vrat, P. 1998, Supply chain management in India: problems and challenges, *Supply Chain Management: for Global Competitiveness*, Macmillan India, New Delhi, 10-24.

40. Williams, L.R., Esper, T.L. and Ozment, J. 2002, The electronic supply chain: its impact on the current and future structure of strategic alliances, partnerships and logistics leadership, *International Journal of Physical Distribution and Logistics Management,* 32 8, 703-719.

DECLARATION

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

DATE :	SIGNATURE:
PLACE:	NAME :
	REGISTRATION NO.:

REFERENCES

1. Achabal, D.D., Mcingtyre, S.H. and Smith, S.A., and Kalyanam, K, 2000, A decision support system for vendor managed inventory, *Journal of Retailing*, 76, 4, 430-454.
2. Adler, P.S., 1988, Managing flexible automation, *California Management Review*, 30, 334-56.
3. Agarwal, A. and Shankar, R. 2003, On-line trust building in e-enabled supply chain, *Supply Chain Management: An International Journal*, 8, 4, 324-34.
4. Aitken, J., Christopher, M., and Towill, D.R., 2002, Understanding, Implementing and Exploiting Agility and Leanness, *International Journal of Logistics: Research and Application*, 5, 1, 59-74.
5. Akintoye, A., McIntosh, G. and Fitzgerald, E., 2000, A survey of supply chain collaboration and management in the UK construction industry, *European Journal of Purchasing and Supply Management*, 6, 159-168.
6. Akkermans, H., Bogerd, P. and van Doremalen J., 2004, Travail, transparency and trust: A case study of computer-supported collaborative supply chain planning in high-tech electronics, *European Journal of Operation Research*, 153, 445-456.
7. Akkermans, H., Bogerd, P. and Vos, B., 1999, Virtuous and vicious cycles on the road towards international supply chain management, *International Journal of Operations and Production Management*, 19, 5, 565-582.
8. Alber, K.L., and Walker, W.T., 1998, *Supply Chain Management Principles and Techniques for the Practitioner*, APICS Educational and Research Foundation, Falls Church, VA.
9. Al-Mudimigh A.S., Zairi M., and Ahmed M., 2004, Extending the concept of supply chain: The effective management of value chains, *International Journal of Production Economics*, 87, 309-320.
10. Andersen, B., Fagerhaug, T., Randmael, S., Schuldmaier, J., and Prenninger, J., 1999, Benchmarking supply chain management: finding best practices, *Journal of Business and Industrial Marketing*, 14, 5, 378-389.

11. Angeles, R., 2000, Revisiting the role of internet EDI in the current electronic commerce scene, *Logistics Information Management*, 13, 1, 44-57.

12. Angulo, A. and H. Nachtmann, 2004, Supply Chain Information Sharing in a Vendor Managed Inventory Partnership, *Journal of Business Logistics*, 25, 1, 101-120.

13. Arend R. J., and Wisner J. D., 2005, Small business and supply chain management: is there a fit? *Journal of Business Venturing*, 20, 403-436.

14. Arlbjørn, J.S., Freytag, P.V. and Damgaard, T., 2008, The beauty of measurements, *European Business Review*, 20, 2, 112-27.

15. Armstrong, J.S., 1977, Estimating non-response bias in mail surveys, *Journal of marketing research*, 14, 3, 396-402.

16. Ayers, J. B., 2001, *Handbook of Supply Chain Management*, APICS, St. Lucie Press, Virginia.

17. Ba, S., 2001, Establishing on-line trust through a community responsibility system, *Decision Support System*, 31, 3, 323-336.

18. Bagchi, P.K. and Larsen, T.S., 2002, Organizational Integration in Supply Chains: A Contingency Approach, *Global Journal of Flexible Systems Management*, 3, 1, 1-10.

19. Bagchi, P.K. and Virum, H. 1998, Logistical Alliances: Trends and Prospects in Integrated Europe, *Journal of Business Logistics*, 19, 1, 191-213.

20. Bagchi, P.K., Ha, B.C., Skjoett-Larsen, T. and Soerensen, L.B., 2005, Supply chain integration: a European survey, *The International Journal of Logistics Management*, 16, 2, 275-94.

21. Bal, J. and Gundry, J., 1999, Virtual teaming in the automotive supply chain, *Team Performance Management: An International Journal*, 5, 6, 174-193.

22. Bal, J., Wilding R., and Gundry, J., 1999, Virtual teaming in the agile supply chain, *International Journal of Logistics Management*, 10, 2, 71-83.

23. Ballou, R. H., Gilbert, S.M. and Mukherjee, A. 2000, New managerial challenges from supply chain opportunities, *IEEE Engineering Management Review*, Third quarter, 7-16.

24. Banerjee, S. and Golhar, D.Y., 1993, EDI Implementation in JIT and non-JIT Manufacturing Firms: A comparative Study, *International Journal of Operation and Production Management*, 13, 3, 25-37.
25. Basnet, C., Corner, J., Wisner, J., and Tan, K.C., 2003, Benchmarking Supply Chain Management Practice in New Zealand, *Supply Chain Management: An International Journal*, 8, 1, 57-64.
26. Beamon, B.M. and Ware, T.M., 1998, A process quality model for the analysis, improvement and control of supply chain systems, *International Journal of Physical Distribution and Logistics Management,* 28, 9/10, 704-15.
27. Beamon, B.M., 1999, Measuring supply chain performance, *International Journal of Operations and Production Management*, 19, 3, 275-92.
28. Behenzhad, A.R., 2000, New developments in Supply Chain Management, *Proceedings of the 12th Annual CSU-POM Conference, California, California State University, Sacramento,* February 25-26.
29. Bergeron, F., and Raymond, L., 1992, The advantages of electronic data interchanger, *Data Base*, 23, 4, 19-31.
30. Berry, D., Naim, M.M. and Towill, D.R., 1995, Business Process Reengineering and Electronics Products Supply Chain, *IEEE Proceedings Science, Measurement and Technology*, 142, 5, 395-403.
31. Berryman, K., Harrington, L., Layton-Rodin, D. and Rerolle, V., 1998, Electronic Commerce: three emerging strategies, *The McKinsey Quarterly*, 1, 152-159.
32. Bhateja, A., and Banwet, D.K., 1999, Computer aided collaborative working: A case for the Indian automotive industry, *Proceedings of the International Conference on Operational; Management for Global Economy: Challenges and Prospects*, Phoenix Publishing, New Delhi, 323-331.
33. Bhimani, A., 1993, Performance measures in UK manufacturing companies: the state of play, *Management Accounting*, 71, 11, 20-32.
34. Birtwistle, G., Siddiqui, N., and Fiorito, S.S., 2003, Quick response perceptions of U.K. fashion retailers, *International Journal of Retail and Distribution Management*, 31, 2, 118-128.

35. Bititci, U.S., Mendibil, K., Martinez, V. and Albores, P. 2005, Measuring and managing performance in extended enterprises, *International Journal of Operations and Production Management*, 25, 4, 333-353.

36. Boddy, D., and Macbeth, D., 2000, Prescription for managing change: a survey of their effects in projects to implement collaborative working between organizations, *International Journal of Project Management*, 18, 5, 297-306.

37. Boddy, D., Charles, M., Frase-Kraus, H. and Macbeth, D., 1998, Success and Failure in implementing supply chain partnering: An empirical study, *European Journal of Purchasing and Supply Management*, 4, 2, 114-151.

38. Boone, T., Ganeshan, R., Geunes, J., Pardalos, P.M. and Romejin, H.E., 2002, The Benefits of Information Sharing in a Supply Chain: An Explanatory Study, *Kluwer Academic Publisher*, 368-381.

39. Bourgeois, L. and Eisenhardt, K., 1988, Strategic decision processes in high velocity environments: four cases in the microcomputer industry, *Management Science*, 34, 7, 816-835.

40. Bower, J.L., Hout, T.M., 1988, Fast cycle capability for competitive power, *Harvard Business Review*, 110-118.

41. Bowersox, D.J. and Closs, D.J., 1996, *Logistics Management: the integrated supply chain process*, McGraw-Hill, New York.

42. Bowersox, D.J., Daugherty, P.J., Droge, C.L., Rogers, D.S., and Wardlow, D.L., 1989, *Leading edge logistics: Competitive positioning for the 1990s*, Council of Logistics Management, Oak Brook, IL.

43. Boyson, S., Corsi, T., Dresner, M. and Rabinovich, E., 1999, Managing Third Party Logistics Relationships: What does it take?, *Journal of Business Logistics*, 20, 1, 73-100.

44. Boyson, S., Corsi, T.M., Dresner, M. E., Harrington, L.H., and Rabinovich, E., 2000, *Logistics and the extended enterprise: benchmarks and the best practices for the manufacturing professional*, John Wiley and Sons, NY.

45. Brabler, A., 2001, E-Supply Chain Management- Results of an Empirical Study, *Proceedings of the Twelfth Annual Conference of the Production and Operation Management Society, POM-2001*, March 30 – April 2, Orlando. FI.

46. Brewer, J., Lee T. N., and Fawcett, S. E.., 2004, Benchmarking challenges to supply-chain integration: Managing quality upstream in the semiconductor industry, *Benchmarking: an International Journal*, 11, 2, 143-155.

47. Bruce, M., Daly, L. and Towers, N., 2004, Lean or agile: A solution for supply chain management in the textiles and clothing industry, *International Journal of Operations and Production Management*, 24, 2, 151-170.

48. Bulent Sezen, 2008, Relative effects of design, integration and information sharing on supply chain performance, *Supply Chain Management: An International Journal*, 13, 3, 233-240.

49. Bultema, P., 2000, Getting the big picture on operational CRM, *Proceedings of DCI Customer Relationship Management Conference*, Boston, MA, pp. 27-29.

50. Burges, T.F., Gules, H.K., and Tekin, M., 1997, Supply-chain collaboration and success in technology implementation, *Integrated Manufacturing System*, 8, 5, 323-332.

51. Cachon, G.P. and Fisher M., 1997, Campbell Soup's continuous replenishment program: evaluation and enhanced inventory decision rules, *Production and Operations Management*, 6, 3, 266-76

52. Cachon, G.P. and Fisher, M., 2000, Supply chain inventory management and value of shared information, *Management Science*, 46, 8, 1032-48.

53. Cagliano, R., Caniato, F, and Spina, G., 2003, E-business strategy: How companies are shaping their supply chain through Internet, *International Journal of Operations and Production Management,* 23, 10, 1142-1162.

54. Cagliano, R., Caniato, F., Spina, G., 2006, The linkage between supply chain integration and manufacturing improvement programmes, *International Journal of Operations & Production Management*, 26, 1, 283-99

55. Carr, A.S. and Smeltzer, L.R., 1999. The relationships of strategic purchasing to supply chain management, *European Journal of Purchasing and Supply Management*, 5, 1, 43-51.
56. Carr, A.S., and Pearson, J.N., 1999. Strategically managed buyer-supplier relationships and performance outcomes, *Journal of Operations Management*, 17, 497-519.
57. Carr, A.S., and Smeltzer, L.R., 2002, The relationship between information technology use and buyer supplier relationships: An exploratory analysis of buying firms perspective, *IEEE Transactions on Engineering Management*, 49, 1, 85-102.
58. Carter, C.R., 2000, Ethical issues in informational buyer-supplier relationships: a dyadic examination, *Journal of Operations Management*, 18, 2, 191-208
59. Carter, C.R., Smeltzer, L.R., and Narasimhan, R., 1998. The role of buyer and supplier relationships in integrating TQM through the supply chain, *European Journal of Purchasing and Supply Management*, 4, 4, 223-234.
60. Cartwright, S.D., 2000, Supply chain interdiction and corporate warfare, *IEEE Engineering Management Review*, Third quarter, 30-35.
61. Casadesus, M. and Rodolfo de Castro, 2005, How improving quality improves supply chain management: empirical study, *The TQM Magazine*, 17, 4, 345 - 357.
62. Chan J.W.K. and Burn, N.D., 2002, Benchmarking manufacturing planning and control systems: An empirical study of Hong Kong supply chains, Benchmarking: An International Journal, 9, 3, 256-277.
63. Chan, F.T.S., Qi, H.J., Chan, H.K., Lau, H.C.W. and Ip, R.W.L., 2002, A conceptual model of performance measurements of supply chain. *Management Decisions*, 41, 7, 635-642.
64. Chan, Felix T.S. and Qi H.J., 2003, An innovative performance measurement method for supply chain management, *Supply Chain Management: An International Journal*, 8, 3, 209-223.
65. Chen, F., Drezner, Z., Ryan, J.K., and Simchi-Levi, D., 2000, Quantifying the bullwhip effect in a simple supply chain: The impact of forecasting, lead-times and information, *Management Science*, 46, 3, 436-443.

66. Chen, F., Injazz J.S. and Michael H., 1996, Planning for advanced manufacturing technologies: A research framework, *International Journal of Production and Operation Management*, 16, 5, 4-24.

67. Childerhouse, P., Hermitz, R., Mason-Jones, R., Popp, A. and Towill, D.R., 2003, Information flow in automotive supply chains – present industrial practice, *Industrial Management and Data System* , 103, 3, 137-149.

68. Childerhouse, P., Towill, D.R., 2003, Simplified material flow holds the key to supply chain integration, *Omega*, 31, 17-27.

69. Choobineh, F. 1986, Justification of flexible manufacturing systems, *Flexible Manufacturing Systems: Current Issues and Models*, IIE Press, Atlanta, GA, 269-91

70. Chopra, M. and Meindl, P., 2001, *Supply Chain Management: Strategy Planning and Operation, 1st Indian reprint*, Pearson Education Asia, New Delhi.

71. Christe, I. and Goldie-Scot, D., 1999, E-case is more interesting than you think. What are the key issues?, *European Business Review*, 99, 4, 207-210.

72. Christensen, W., Germain, R.N. and Birou, L. 2007, Variance and average: supply chain lead time as a predictor of financial performance, *Supply Chain Management: an International Journal*, 12, 5, 349-357.

73. Christopher, M. and Towill, D. 2001, An integrated model for the design of agile supply chains, *International Journal of Physical Distribution and Logistics Management*, 31 4, 235-46.

74. Christopher, M., 1998, Logistics and Supply Chain Management, Pitman Publishing, London.

75. Christopher, M., and Jittner, U., 2000, Developing strategic partnerships in the supply chain: a Practitioner perspective, European Journal of Purchasing & Supply Chain Management, 6, 117-127.

76. Christopher, M., and Towill, D.R., 2000, Supply Chain migration from lean and functional to agile and customized, Supply *Chain Management: An International Journal*, 5, 4, 206-213.

77. Christopher, M., Lowson, R., Peck, H. 2004, Creating agile supply chains in the fashion industry, *International Journal of Retail & Distribution Management*, 32, 8, 367-76.

78. Clarke, P. 1995, Non-financial measures of performance in management, *Accountancy Ireland*, 27 2, 22-34.

79. Clemons, E.K. and Row, M.C., 1993, Information, power, and control of the distribution channel, *Chief Executive*, 85, 64-67.

80. Closs, J.C., Goldshy, T.J., and Clinton, S.R., 1997, Information technology influence on world class logistics capabilities, *International Journal of Physical Distribution and Logistics Management*, 27, 1, 4-17.

81. Cooper, M.C., Lambert, D.M., and Pagh J.D., 1997, Supply chain management more than a new name for logistics,. *International Journal of Logistics Management*, 8, 1, 1-14.

82. Copacino, W.C., 1997, *Supply Chain Management: The Basics and Beyond*, St. Lucie Press, Boca Raton, Florida.

83. Cousins, P.D., Menguc, B. 2006, The implications of socialization and integration in supply chain management, *Journal of Operations Management*, 24, 5, 604-20.

84. Cross, G.J., 2000, How E-business is transforming supply chain management, *IEEE Engineering Management Review*, Third quarter, 17-19.

85. D'Amours, S., Montreuil, B., Lefrancois, P. and Soumis, F., 1999, Networked Manufacturing: The Impact of Information Sharing, *International Journal of Production Economics,* 58, 63-79.

86. Dangayach G.S., 2001, Some issues in manufacturing strategy: a select study of Indian manufacturing companies, *Unpublished PhD thesis*, submitted to Indian Institute of Technology Delhi, New Delhi.

87. Dangayach, G.S. and Desmukh S.G. 2005, An exploratory study of manufacturing strategy practices of machinery manufacturing companies in India, *Omega*, 34, 254-273.

88. Dapiran, P., Lieb, R., Millan, R. and Sohal, A., 1996, Third party logistics sevices usage by large Australian firms, *International Journal of Physical Distribution and Logistics Management*, 26, 10, 36-45.

89. Daugherty, P.J., Ellinger, A.E. and Rogers, D.S., 1995, Information accessibility: customer responsiveness and enhanced performance, *International Journal of Physical Distribution and Logistics Management*, 25, 1, 4-17.

90. De Toni, A., Nassimbeni, G., Tonchia, S., 1994, Service dimensions in the buyer supplier relationship: A case study, *International Journal of Physical Distribution and Logistics Management*, 24, 8, 4-14.

91. Dean, J.W., and Bowen, D.E., 1994, Management theory and total quality: improving research and practice through theory development, *Academy of Management Review*, 19, 3, 392-418.

92. Derocher, R.P. and Kilpatrick, J., 2000, Six supply chain lessons for the new millennium, *Supply Chain Management Review*, 3, 4, 34,-41.

93. Directory of ISO 9000/14000 and QS 9000 certified companies in India, 2005, Indian Product Promotion Centre, New Delhi.

94. Disney, S.M., and A.T. and Gardner, B.M., 2003, The impact of vendor managed inventory on transport operations, *Transportation Research*, 39, 363-380.

95. Disney, S.M., and Towill, D.R., 2003, Vendor-managed inventory and bullwhip reduction in a two-level supply chain, *International Journal of Operations and Production Management*, 23, 6, 625-651.

96. Dobler, D.W. and Burt, D.N., 1996, *Purchasing and Supply Management*, The McGraw-Hill Companies, New York, NY.

97. Donovan, R.M, 1999, *Flow manufacturing is essential to competitive supply chain management*, *Flow*.

98. Dove, R. 1999, Knowledge management, response ability and the agile enterprise, *Journal of Knowledge Management*, 3, 1, 1-17.

99. Dove, R., Nagel, R., Goldman, S. and Preiss, K., 1991, 21st Century Manufacturing Enterprise Strategy: An Industry Led View, Iacocca Institute, Lehigh University, Bethlehem, PA.

100. Drucker, P.E., 1990, The emerging theory of manufacturing, *Harvard Business Review*, 3, 94-102.

101. Duclos, L.K., Vokurta, R.J., and Lummus, R. R., 2003, A conceptual model of supply chain flexibility*, Industrial Management and Data Systems*, 103, 6, 446-456.

102. Dyer, J.H., 1997, Effective inter-firm collaboration: how firms minimize transaction costs and maximize transaction value, *Strategic Management Journal*, 18, 7, 535-56.

103. Edum-Fotwe, F.T., Thorpe, A. and McCaffer, R., 2001, Information procurement practices of key actors in construction supply chains, *European Journal of Purchasing and Supply Chain Management,* 7, 3, 155-164.

104. Elliman, T. and Orange, G, 2000, Electronic Commerce to support construction design and supply chain management: a research note, *International Journal of Physical Distribution and Logistics Management*, 30, 3, 345-360.

105. Ellinger, A.E., Daugherty, P.J., and Plair, Q.J., 1999, Customer satisfaction and loyalty in supply chain: role of communication, *Transportation Research Part-E*, 35, 2, 121-134.

106. Ellram, L.M. 1995, Partnering pitfalls and success, *International Journal of Purchasing and Materials Management*, 31, 2, 36-44.

107. Ellram, L.M. and Cooper, M.C., 1990, Supply chain management, partnerships, and the shipper- third party relationship, *The International Journal of Logistics Management*, 1, 2, 1-10.

108. Ellram, L.M., 1991, A managerial guide for development and implementation of purchasing partnerships, *International Journal of Purchasing and Materials Management*, 26, 4, 8-14.

109. Ellram, L.M., and Cooper, M., 1993, Characteristics of supply chain management and the implications for purchasing and logistic strategy, *International Journal of Logistics Management*, 4, 2, 1-10.

110. Ellram, L.M., and Zsidisin, G.A., 2002, Factors that drive purchasing and supply management's use of information technology, *IEEE Transactions on Engineering Management*, 49, 3, 269-281.

111. Ellram, L.M., LaLondo, B.J. and Weber, M.M., 1999, Retail Logistics, *International Journal of Physical Distribution and Logistics Management*, 29, 7, 477-494.

112. Eng, T., 2004, The role of e-marketplace in supply chain management, *Industrial Marketing Management*, 33, 2, 97-105.

113. ENGIMACH Souvenir, Indian Machine Tool Show 2007, New Delhi.

114. Evans, G.N., Towill, D.R. and Naim, M. M. 1995, Business process reengineering the supply chain, *Production Planning and Control*, 6, 3, 227-237.

115. Evans, P.B., and Wurster, T.S., 1997, Strategy and the new economics of information, *Harvard Business Review*, 75, 2, 71-82.

116. Exhibitor Catalogue, 7th Auto Expo 2006, New Delhi.

117. Fabbe-Costes, N. and Jahre, M. 2006, Logistics integration and disintegration – in search of a framework, *International Conference on Information Systems, Logistics and Supply Chain (ILS'06), Proceedings, 2, FUCAM edition, Mons, Belgium*, May 14-17, 841-50

118. Fabbe-Costes, N. and Jahre, M. 2007, Supply chain integration gives better performance – the emperor's new suit? *International Journal of Physical Distribution & Logistics Management*, 37, 10, 835-55.

119. Feldmann, M. and Muller, S., 2003, An incentive scheme for true information providing in supply chain, *Omega: International Journal of Management Science*, 31, 2, 63-73.

120. Fisher, M.L., 1997, What is the right supply chain for your product?, *Harvard Business Review*, 75, 2, 105-16.

121. Flapper, S.D.P., Fortuin, L. and Stoop, P.P.M. 1996, Towards consistent performance management systems, *International Journal of Operations and Production Management,* 16, 7, 27-37.

122. Fliedner, G. 2003, CPFR: an emerging supply chain tool, *Industrial Management and Data Systems,* 103, 1, 14-21.

123. Fordor, G., 2000, Room to Grow, *Supply Chain Year Book,* 55-61.

124. Forker, L.B., and Stannack, P., 2000, Cooperation versus competition: do buyers and suppliers really see eye-to-eye? *European Journal of Purchasing and Supply Management,* 6, 1, 31-40.

125. Forza, C., 2002, Survey Research in operations management: A process-based perspective, *International Journal of Operations and Production Management*, 22, 2, 152-194.

126. Foster, T., 1999, Global e-procurement solutions, *Supply Chain Management Review Global Supplement,* Spring, 19-22.

127. Fransoo, J.C. and Wouters, M. J. F., 2000, Measuring the bullwhip effect in the supply chain, *Supply Chain Management: An International Journal*, 5, 2, 78-89.

128. Freeman, B. 1998, Highlights of KPMG's global supply chain survey, Available at http://www.infochain.org/quarterly/spring98/survey_figures.htm.

129. Frohlich, M., Dixon, J.R. and Arnold, P., 1997, A taxonomy of supply chain strategies, Proceedings of the 28th Annual Meeting of the Decision Sciences Institute, San Diago.

130. Frohlich, M.T. 2002, E-integration in the supply chain: barriers and performance, *Decision Sciences*, 33, 4, 537-56.

131. Frohlich, M.T. and Westbrook, 2001, area of Integration, An international study of supply chain strategies, *Journal of Operations Management*, 19, 2, 185-200.

132. Gandhok, T., Kulkarni, S. and Dwivedi, A., 2002, India’s largest business creators, *Business -Today*, February, 44-61, New Delhi.

133. Ganeshan, R., Jack, E., Magazine, M.J., and Stephens, P., 1999, *A taxonomic review of supply chain management*, Kluwer Academic Publishers, Boston.

134. Garcia-Dastugue, S.J. and Lambert, D.M., 2003, Internet enabled coordination in the supply chain, International Marketing Management, 32, 3, 251-263.

135. Garg S., Prem Vrat, and Kanda A., 2001, Equipment flexibility vs. inventory: A simulation study of manufacturing systems, *International Journal of Production Economics*, 70, 125-143.

136. Gassmann, O., Sandmeier, P. andWecht, C.H. 2006, Extreme customer innovation in the front-end: learning from a new software paradigm, *International Journal of Technology Management*, 33, 1, 185-200.

137. Gavirneni, S., Kapuscinski, R. and Tayur, S., 1999, Value of information in capacitated supply chains, *Management Science*, 45, 1, 16-25.

138. Gelders, L., Mannaert, P. and Maes, J, 1994, Manufacturing strategy performance indicators and improvement programs, *International Journal of Production Research*, **32,** 4,797–805.

139. Germain, R. and Iyer, K.N., 2006, The interaction of internal and downstream integration and its association with performance, *Journal of Business Logistics*, 27, 2, 29-52.

140. Gerwin, D., 1993, Manufacturing Flexibility: A Strategic Perspective, *Management Science*, 39, 4, 395-410.

141. Goh, M. and Ang, A., 2000, Some logistics realities in Indochina, *International Journal of Physical Distribution and Logistics Management*, 30, 10, 887-911.

142. Goldman, S.L., Nagel, R.N. and Preiss, K. 1995, Agile Competitors and Virtual Organisations, *Van Nostrand Reinhold*, New York, NY.,

143. Gomes, C.F., Yasin, M.M. and Lisboa, J.V. 2006, Performance measurement practices in manufacturing firms: an empirical investigation, *Journal of Manufacturing Technology Management*, 17, 2, 144-67.

144. Gowen III, C.R., and Tallon, W.J., 2003, Enhancing supply chain practices through human resource management, *The Journal of Management Development*, 22, 1, 32-44.

145. Grady, M.W. 1991, Performance measurement: implementing strategy, *Management Accounting*, 72 12, 49-53.

146. Graham, T.S., Dougherty, P.J. and Dudley, W.N., 1994, The long term strategic impact of purchasing partnerships, *International Journal of Purchasing and Materials Management,* 30, 4, 13–18

147. Greco, J., 1997, Outsourcing the new partnership, *Journal of Business Strategy*, 4, 48-54.

148. Green, K.W. Jr, McGaughey, R. and Casey, K.M. 2006, Does supply chain management strategy mediate the association between market orientation and organizational performance?, *Supply Chain Management: An International Journal*, 11, 5, 407-14.

149. Greg W. Marshall, Felicia G. Lassk and William C. Moncrief, 2004, Salesperson job involvement: do demographic, job situational, and market variables matter? *Journal of Business & Industrial Marketing*, 19, 5, 337-343.

150. Grieger, M., 2003, Electronic Marketplaces: A literature review and a call for supply chain management research, *European Journal of Operational Research*, 144, 280-294.

151. Gripsrud, G., Jahre, M. and Persson, G., 2006, Supply chain management – back to the future?, International *Journal of Physical Distribution and Logistics Management*, 36, 8, 643-59.

152. Groover M.P. 2001, *Automation, Production Systems, and Computer - Integrated manufacturing, second edition*, Pearson Education, Inc.

153. Gules, H.K., and Burgess, T. F., 1996. Manufacturing technology and the supply chain: Linking buyer-supplier relationships and advanced manufacturing technology, *European Journal of Purchasing and Supply Management*, 12, 1, 31-38.

154. Gunasekaran, A., Patel, C. and Tirtiroglu, E., 2001, Performance measurement and metrics in a supply chain environment, *International Journal of Operations and Production Management*, 21, 1/2, 71-87.

155. Gunasekaran, A., Patel, C.,and. McGaughey, R., 2004, A framework for supply chain performance measurement, *International Journal of Production Economics,* 87, 333-347.

156. Gunasekaran, A. and McGaughey R.E., 2003, TQM is supply chain management, *The TQM Magazine*, 15, 6, 361-363.

157. Gunasekaran, A and Ngai, E.W.T., 2004, Information systems in supply chain integration and management, European Journal of Operation Research, 159, 269-95.

158. Gupta, Y.P. and Somers, T.M., 1992, The measurement of manufacturing flexibility, *European Journal of Operational Research*, 60, 166-82.

159. Gupta, Y.P., Somers, T.M., 1992, Factory automation and integration of business functions, *Journal of Manufacturing Systems*, 12 1, 15-23.

160. Handfield R.B., and Bechtel C., 2002, The role of relationship structure in improving supply chain responsiveness, *Industrial Marketing Management*, 31, 367-382.

161. Handfield R.B., and Pannesi R.T., 1992, An empirical study of delivery speed and reliability, *International Journal of Operations and Production Management*: 12, 2, 58-72.

162. Handfield, B.R. and Nichols L.E. 1999, *Introduction to Supply Chain Management*, Prentice-Hall India.

163. Harland C., 1997. Supply chain operational performance roles, *Integrated Manufacturing Systems*, 8, 2, 70-78.

164. Harland, C., 1996, Supply network strategies: the case of health suppliers, *European Journal of Purchasing and Supply Management*, 2, 4, 183-192.

165. Harrington, L.H., 1996, New tools to automate your supply chain, *Transport and Distribution*, 38, 12, 39-42.

166. Hayes, R.H., Jaikumar, R., 1988, Manufacturing's Crisis: New Technologies, Obsolete Organizations, *Harvard Business Review*, 66, 5, 77-85.

167. Helper S.R., and Sako M., 1995. Supplier Relations in Japan & United States: Are they converging?, *Sloan Management Review*, 36, 3, 77-84.

168. Hill, C.A. and Scudder, G.D., 2002, The use of electronic data interchanger for supply chain coordination in the food industry, *Journal of Operations Management*, 20, 4, 375-387.

169. Hoffman, R.C. and Hagerty, H., 1994, Top management influence on innovation: effects of executive characteristics and social culture *Journal of Management*, 19, 3, 549-74.

170. Holweg, M. and Pil, F.K., 2001, Successful build-to-order strategies start with the customer, *Sloan Management Review*, 43, 1, 74-83.

171. Houlihan, J. B., 1988, International supply chains: a new approach, *Management Decision*, 26, 3, 13-19.

172. Huang, P.Y., Sakuari, M., 1998, An Assessment of Factory Automation in Japan: A General Mail Survey. *Manufacturing Review*, 2, 3, 162-168.

173. Huang, Z. and Gangopadhyay, A., 2004. A Simulation Study of Supply Chain Management to Measure the Impact of Information Sharing, *Information Resources Management Journal*, 17, 3, 20-32.

174. Hult, G.T.M., Ketchen D.J. Jr and Slater, S.F. 2004, Information processing, knowledge development, and strategic supply chain performance, *Academy of Management Journal*, 47, 2, 241-54.

175. Humphreys, P.K., Li W.L. and Chan L.Y. 2004, The impact of supplier development on buyer supplier performance, *Omega*, 32, 131-43.

176. Hunter, L.M., Hasouf, C.J., Celuch, K.G. and Curry, K.A., 2004, A classification of business- to- business benefits, *Industrial Marketing Management*, 33, 145-154.

177. Husain, Z., Sushil, and Pathak, R.D., 2002, A technology management perspective on collaborations in the Indian automobile industry: a case study, *Journal of Engineering and Technology Management*, 19, 167-201.

178. Jharakharia, S. and Shankar, R., 2000, Information Technology: A Competitive weapon in Supply Chain Management, *Proceedings of International Conference on Flexible Systems Management*, December 17-20, New Delhi, 599-610.

179. Jharkharia, S. and Shankar, R., 2004, IT enablement of supply chains: modeling the enablers, *International Journal of Productivity and Performance Management*, 53, 8, 700-712.

180. Johne, A. and Snelson, P., 1989, Product development approaches in established firms, *Industrial Marketing Management*, 18, 2, 113-24.

181. Johnson, P.F., Klassen, R.D., Leenders, M.R. and Fearson, H.R., 2002, Determinants of purchasing team usage in the supply chain, *Journals of Operations Management*

182. Kadambi, B. 2000, IT-Enabled supply chain management- A preliminary study of few manufacturing companies in India, http://www.xlri.ac.in/cltm/LogistiX-2-2000.HTM.

183. Kalakota, R. and Whinston, A.B., 1997, *Electronic Commerce: A Managers Guide*, Addison-Wesley.

184. Kannabiran, G. and Bhaumik, S., 2005, Corporate turnaround through effective supply chain management: the case of a leading jewellery manufacturer in India, *Supply Chain Management: An International Journal*, 10, 5, 340-348

185. Kaplan, R.S. 1983, Measuring manufacturing performance: a new challenge for managerial accounting research, *Accounting Review*, 58, 4, 686-703.

186. Kaplan, R.S. and Norton, D.P, 1996, Using the balanced scorecard as a strategic management system, *Harvard Business Review*, 74, 1, 75-85.

187. Kaplan, R.S. and Norton, D.P., 1992, The balanced scorecard – measures that drive performance, *Harvard Business Review*, 70, 1, 71-99.

188. Kapoor, V., and Ellinger A.E., 2004, Transforming supply chain operations in response to economic reform: the case of a motorcycle manufacturer in India, 9, 1, 16-22.

189. Keebler, J.S. 2001, *Measuring Performance in the Supply Chain*, In Mentzer, John, T. (Ed.), Supply Chain Management, Response Books, New Delhi.

190. Kehoe, D. and Boughton, N., 2001, Internet based supply chain management: A classification of approaches to manufacturing planning and control, *International Journal of Operations and Production Management*, 21, 4, 516-524.

191. Khan, A.K. and Pillania, R.K., 2008, Strategic sourcing for supply chain agility and firms' performance: A study of Indian manufacturing sector, *Management Decision*, 46, 10, 1508-30.

192. Kidd, J., Richer, F., and Li., X., 2003, Learning and trust in supply chain management, *Management Decision*, 41, 7, 603-612.

193. Kim B.J., and Michael P., 1999, Relationship marketing in Japan: Buyer-supplier relationships of automakers, *Journal of Business and Industrial Marketing*, 14, 2, 118-129.

194. Kim, S.W. 2006a, The effect of supply chain integration on the alignment between corporate competitive capability and supply chain operational capability, *International Journal of Operations & Production Management*, 26, 10, 1084-1107

195. Kim, S.W. 2006b, Effects of supply chain management practices, integration and competition capability on performance, *Supply Chain Management: An International Journal*, 11, 3, 241-248

196. Kim, S.W. and Narasimhan, R., 2002, Information system utilization in supply chain integration efforts, *International Journal of Production Research*, 40, 18, 4585-4609.

197. King, J.R.,1980, Machine-Component Grouping in Production Flow Analysis an Approach Using a Rank Order Clustering Algorithm, *International Journal of Production Research*, 18, 213-222.

198. Kleindorfer, P.R., and Partovi, F.Y., 1990, Integrating manufacturing strategy and technology choice, *European Journal of Operational Research*, 47, 214-224.

199. Koh, S.C.L., Simpson, M., Padmore, J., Dimitriadis, N. and Misopoulos, F., 2006, An exploratory study of enterprise resource planning adoption in Greek companies, Industrial Management and Data Systems, 106, 7, 1033-1059.

200. Krause, D.and Ellram, L. 1997, Critical elements of supplier development: the buying firm perspective, *European Journal of Purchasing & Supply Management*, 3, 1, 21-31.

201. Kulp, S.C., Lee H.L. and Ofek, E. 2004, Manufacturer benefits from information integration with retail customers, *Management Science*, 50, 4, 431-44.

202. Kumar, K. and Brittain, J.C. 1996, Cost of quality: evaluating the health of British manufacturing industry, *The TQM magazine,* 7, 2, 50-72.

203. Kumar, N., 1996, The Power of trust in manufacturer-retailer relationship, Harvard Business Review, 74, 6, 92-106.

204. Kwan, A.T.W. 1999, The use of information technology to enhance supply chain management in the electronics and chemical industries, *Production and Inventory Management Journal*, third quarter, 7-15.

205. Lambert, D.M., and Cooper, M.C., 2000, Issues in supply chain management, *Industrial Marketing Management*, 29, 1, 65-83.

206. Lambert, D.M., Cooper, M.C. and Pagh, J.D., 1998a, Supply chain management: implementation issues and research opportunities, *The International Journal of Logistics Management*, 9, 2, 1-19.

207. Lambert, D.M., García-Dastugue, S.J. and Croxton, K.L. 2005, An evaluation of process-oriented supply chain management frameworks, *Journal of Business Logistics,* 26, 1, 25-51

208. Lambert, D.M., Stock, J.R. and Ellram, L.M., 1998b, *Fundamentals of Logistics Management*, Irwin, McGraw-Hill, Homewood, IL, New York.

209. Lamming, R., 1986. For better or worse: Technical Change and buyer-supplier relationships, *International Journal of Operations and Production Management*, 6, 5, 20-29.

210. Lamming, R., Cousins P D.,and Notman D.M., 1996, Beyond vendor assessment: relationship assessment programs, *European Journal of Purchasing and Supply Mnagement*, 2, 4, 173-181.

211. Lancioni, R.A, Smith, M.P. and Schau, H.J., 2003, Strategic Internet application trends in supply chain management, *Industrial Marketing Management*, 32, 3, 211-217.

212. Lancioni, R.A., Smith, M.F. and Oliva, T.A., 2000, The role of the internet in supply chain management, *Industrial Marketing Management*, 29, 1, 45-56.

213. Landaros, R, reck, R. and Plank, R.E., 1995, Maintaining buyer–supplier partnerships, *Journal of Purchasing and Materials Management*, 31, 3, 3-11.

214. Laptde, L., 2001, What about measuring supply chain performance, available at http;//lapide.ASCET.com

215. Larsen, T.S.,Kotzab, H. and Grieger, M., 2003, Electronic marketplaces and supply chain relationships, *Industrial Marketing Management*, 32, 3, 199-210.

216. Larson, P.D., 1994. Buyer-Supplier Co-operation, Product Quality and Total Costs. *International Journal of Physical Distribution and Logistics Management*, 24, 6, 4-10.

217. Larson, P.D., and Kulchitksy, J.D., 1999, Logistics improvement programs the dynamics between people and performance, *International Journal of Physical Distribution and Logistics Management*, 29, 2, 88-102.

218. Lau H.C.W., Wong C.W.Y., Pun K.F., and Chin K.S., 2003, Virtual agent modeling of an agile supply chain infrastructure, *Management Decision*, 41, 7, 625-634.

219. Lau, H.C.W. and Lee, W.B., 2000, On a responsive supply chain information system, *International Journal of Physical Distribution and Logistics Management*, 30, 7, 598-610.

220. Lee H.L., So, K.L. and Tang, C.S., 2000, Value of information sharing in a two level supply chain, *Management Science*, 46, 5, 626-643.

221. Lee, G. and Oakes I. 1996, Templates for change with supply chain rationalization, *International Journal of Operations and Production Management*, 16, 2, 197-209.

222. Lee, H. and Whang, S. 2000, Information sharing in a supply chain, *International Journal of Technology Management*, 20, 3, 373-387.

223. Lee, H. and Whang, S., 1999, Decentralized Multi-Echelon Supply Chain: Incentives and Information, *Management Science*, 45, 5, 633-640.

224. Lee, H. L. Padmanabhan, V. and Whang, S., 1997, Information distortion in a supply chain: the bullwhip effect, *Management Science*, 43, 4, 546-58.

225. Lee, H.L., 2000, Creating value through supply chain integration, *Supply Chain Management Review*, 4, 4, 30-36.

226. Lee, H.L., and Billington, C., 1992, managing supply chain inventory: pitfalls and opportunities, *Sloan Management Review*, 65-73.

227. Leenders, M.R., and Fearson, H.E., Flynn, A.E., and Jhnson, P.F., 1997, *Purchasing and Supply Management*, New York: McGraw-Hill/Irwin.

228. Lei, D, Goldhar, J.D, 1991, Computer-Integrated manufacturing (CIM): redefining the manufacturing firm into the global service business, *International Journal of Operation and Production Management*, 11, 10, 5-18.

229. Levary, R.R., 2000. Better supply chains through information technology, *Industrial Management*, 42, 3, 24-30.

230. Levy, D.L., 1997, Lean production in an international supply chain, *Sloan Management Review*, 94-102.

231. Li, D. AND O'Brien, C. 2001, Product types-SCS, *International Journal of Production Economics*, 73, 1,29-39.

232. Li, L. 2002, Information sharing in a supply chain with horizontal competition, *Management Science*, 48, 9, 1196-1212.

233. Lieb, R. and Randall, H. 1996, A comparison of the use of third party logistics services by large American manufacturers, 1991, 1994, and 1996, *Journal of Business Logistics*, 17, 1, 305-320.

234. Lim, D. and Palvia, P.C., 2001, EDI in strategic supply chain: impact on customer service, *International Journal of Information Management*, 21, 3, 193-211.

235. Lin Ching-Torng, Chiu H., Chu Po-Young, 2005, Agility index in the supply chain, *International Journal of Production Economics,* available at www. Sciencedirect.com.

236. Lin, F., Huang, S. and Lin, S., 2002, Effects of information sharing on supply chain performance in electronic commerce, *IEEE Transaction on Engineering Management*, 49, 3, 258-268.

237. Lummus, R.R and Alber, K.L., 1997, Supply chain management: Balancing the supply chain with customer demand, *The Educational and Research Foundations of APICS*, Falls Church, VA.

238. Lummus, R.R., Vokurka, R.J., 1999, Defining supply chain management: a historical perspective and practical guidelines, *Industrial Management and Data Systems*, 99, 1, 11-17.

239. Mabert, V., Soni, A. and Venkataramanan, M., 2000, Enterprise resource planning survey of US manufacturing firms, *Production and Inventory Management Journal*, 41, 2, 52-8.

240. Mabert, V.A., and Venkataramanan, M.A., 1998, Special Research Focus on Supply Chain Linkages: Challenges for Design and Management in the 21st Century, *Decision Sciences*, 29, 3, 537-552.

241. Mahmoud, Y., Correia, E., and Lisboa, J., 2004, e-profitability of customer-targeted quality improvement efforts: an empirical examination, *The TQM Magazine*, 16, 1, 45-49.

242. Malone, T.W., Yates, J.A., and Benjamin, R.I. 1994, Electronic markets and electronic hierarchies, in: T.J. Allen, and M.S.S. Morton (Eds.), *Information technology and the corporation of the 1990s*, New York: Oxford University Press.

243. Maloni, M.J., and Benton, W.C., 1997, Supply chain partnerships: Opportunities for operations research, *European Journal of Operations Research* **101**, 419–429.

244. Mandal, A., Deshmukh, S.G. 1994, Vendor selection using interpretive structural modeling (ISM), *International Journal of Operations & Production Management*, 14 6, 52-59.

245. Manoochehri, G. 1999, The road to manufacturing excellence: using performance measures to become world-class, *Industrial Management*, March/April, pp.7-13.

246. Manzini, R., Gamberi, M. and Regattieri, A., 2006, Design and control of AS/RS, *The International Journal of Advanced Manufacturing Technology*, 28, 7-8, 766-774.

247. Marri H.B., Irani Z., and Gunasekaran A., 2007, Advance Manufacturing Technolology implementation in SME's: a framework justification criteria. *International Journal of Electronic Business*, 5, 2, 124-140.

248. Mason S.J., Cole M.H., Ulrey B.T., and Yan L., 2002, Improving electronics manufacturing supply chain agility through outsourcing, *International Journal of Physical Distribution and Logistics Management*, 32, 7, 610-620.

249. Mason-Jones, R., Naylor, B. and Towill, D.R., 2000b, Lean, agile or leagile? Matching your supply chain to the marketplace, *International Journal of Production Research*, 38, 17, 4061-4070.

250. Mason-Jonnes R., Naylor, B., and Towill, D.R., 2000a, Engineering the leagile supply chain, *International Journal of Agile Management Systems*, 2, 1, 54-61.

251. Mason-Jones and D.R. Towill, 1997, Enlightening supplies, *Manufacturing Engineering*, 3, 156 – 160.

252. McLaughlin, J., Motwani, J., Madan, M.S. and Gunasekaran, A., 2003, Using information technology to improve downstream supply chain operations, Business Process Management Journal, 9, 1, 69-80.

253. McMullan, A. 1996, Supply chain management practices in Asia Pacific today, *International Journal of Physical Distribution and Logistics Management*, 26 10, 79-95.

254. McBeth, D.K. and Ferguson, N, 1994, *Partnership Sourcing: An Integrated Supply Chain Management Approach*, Pitman Publishing, London.

255. Medori, D., Steeple, D. 2000, A framework for auditing and enhancing performance measurement systems, *International Journal of Operations & Production Management*, 20 5, 520-33.

256. Mentzer J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G., 2001, Defining supply chain management, *Journal of Business Logistics*, 22, 2, 1-24.

257. Mentzer J.T., Foggin J.H., and Golicic S.L., 2000, Collaboration: the enablers, impediments, and benefits, *Supply Chain Management Review*, September/October, 52-58.

258. Mentzer, J. T., 2004, *Fundamentals of Supply Chain Management: Twelve Drivers for Competitive Advantage*. Thousand Oaks, CA: Sage Publications, Inc.

259. Meredith, J.R., 1988, Automating the factory theory versus practice, *International Journal of Production research*, 25, 10, 493-510.

260. Metz, P.J., 1998, Demystifying Supply Chain Management, *Supply Chain Management Review*, winter, 46-55.

261. Milgate, M., 2001, Supply chain complexity and delivery performance: an international exploratory study, *Supply Chain Management*, 6, 3, 106-118.

262. Mishra, B.K., Raghunathan, S. and Yue, X. 2001, Demand Forecast Sharing in Supply Chain, School of Management, The University of Texas, Dallas, TX, available at: www.personal.psu.edu/users/z/o/zoz102/S3.pdf

263. Mittal, K. and Shankar, R., 2002, Information Technology in Transportation Systems, *Proceedings of National Conference on Transportation Systems,* April 24-26, New Delhi, 571-580

264. Moberg, C.R., Culter, B.D., Gross, A. and Speh, T.W., 2002, Identifying antecedents of information exchange within supply chains, *International Journal of Physical Distribution and Logistics Management*, 32, 9, 755-770.

265. Mohanty, R.P., and Deshmukh, S.G., 2001, *Essentials of supply chain management*, Phoenix Publication House Pvt. Ltd., New Delhi.

266. Mohr, J., Nevin, J.R. 1990, Communication strategies in marketing channels: a theoretical perspective, *Journal of Marketing,* 54 4, 36-51.

267. Mollenkopf, D. and Dapiran, G.P. 2005a, The importance of developing logistics competencies: a study of Australian and New Zealand firms, *International Journal of Logistics: Research and Applications*, 8, 9, 1-14.

268. Mollenkopf, D. and Dapiran, G.P. (2005b), World-class logistics: Australia and New Zealand, *International Journal of Physical Distribution & Logistics Management*, 35, 1, 63-74.

269. Monczka, R., Trent, R. and Handfield, R., 1998, *Purchasing and Supply chain Management,* Cincinnati, OH, South-Western College Publishing.

270. Monczka, R.M. And Morgan, J.P., 1997, What's Wrong with Supply Chain Management?, *Purchasing*, 122, 1, 69-73.

271. Monczka, R.M., Trent, R.J. and Callahan, T.J., 1994, Supply Chain Strategies to maximize supplier performance, *International Journal of Physical Distribution and Logistics Management*, 23, 4, 42-54.

272. Motwani, J. and Ahuja, S., 2000, International purchasing practices of US and Indian managers: a competitive analysis, *Industrial Management and Data Systems*, 100, 4, 172-179.

273. Mukundan, G., 2003, Virtual Manufacturing, *Journal of Advanced Manufacturing System*, available at: www.worldscinet.com

274. Munson, C. L., Rosenblatt, M. J. and Rosenblatt, Z. 2000, The use and abuse of power in supply chains, *IEEE Engineering Management Review*, 2, 81-91.

275. Murphy, P.R. and Daley, J.M., 1999, EDI benefits and barriers, *International Journal of Physical Distribution and Logistics Management*, 29, 3, 207-216.

276. Myers, M.B., Daugherty, P.J. and Autry, C.W., 2000, The effectiveness of automatic inventory replenishment in supply chain operations: Antecedents and outcomes, *Journal of Retailing*, 76, 4, 455-481.

277. Nagel, R. and Dove, R., 1991, *21st Century Manufacturing Enterprise Strategy*, Iacocca Institute, Leigh University.

278. Narasimhan, R. and Das. A., 1999, Manufacturing agility and supply chain management practices, *Production and Inventory Management Journal*, 40, 1, 4-10.

279. Narasimhan, R. and Nair, A. 2005, The antecedent role of quality, information sharing and supply chain proximity on strategic alliance formation and performance, *International Journal of Production Economics*, 96, 3, 301-13.

280. Narasimhan, R., Swink, M., Kim, S.W., 2006, Disentangling leanness and agility: an empirical investigation, *Journal of Operations Management*, 24, 5, 440-57.

281. Naylor, J.B., Naim, M.M. and Berry, D., 1999, Leagility: interfacing the lean and agile manufacturing paradigm in the total supply chain, *International Journal of Production Economics*, 62, 107-18.

282. Neely, A., Richards, H., Mills, J., Platts, K. and Bourne, M. 1997, Designing performance measures: a structured approach, *International Journal of Operations and Production Management*, 17, 11, 1131-52.

283. Nielson Charles C., 1998, An empirical examination of the role of closeness in industrial buyer-seller relationship, *European Journal of Marketing*, 22, 5/6, 441-463.

284. Norina, L.V. and Bailey, W.C., 2001, *Quantitative approach to supply chain relationship, 11th annual food and agribusiness symposium*, June 27, Sydney, Australia.

285. Nunally, J.C. 1978, *Psychometric Methods*, McGraw Hill, New York.

286. Ogden, J.A., and Caarter, P.L., 2008, The supply base reduction process: an empirical investigation, International Journal of Logistics Management, 19, 1, 5-28.

287. Olhager J., 2003, Strategic positioning of the order penetration point, *International Journal of Production Economics*, 85, 319-329.

288. Olhager J., and Selldin, E., 2004, Supply chain management survey of Swedish manufacturing firms, *International Journal of Production Economics*, 89, 3, 353-361.

289. Olson, J.R. and Boyer, K.K., 2003, Eactors influencing the utilization of internet purchasing in small organizations, Journal of Operations Management, 21, 2, 225-245.

290. Oliver, R, 1993, Cognitive, affective, and attribute bases of the satisfaction response, *Journal of Consumer Research*, 20, 418-30.

291. Owens, S. F. and Levary, R.R., 2002, Evaluating the Impact of Electronic Data Interchange on the Ingredient Supply Chain of a Food Processing Company, *Supply Chain Management: An International Journal*, 7, 4, 200-211.

292. Padmanabhan, V. and Png, I.P.L., 1995, Return policies: make money by making goods, *Sloan Management Review*, Fall, 65-72.

293. Pagel, D. 1999, Managing for optimal performance through effective coordination of the supply chain, *Production and Inventory Management Journal,* first quarter, 66-70.

294. Patterson, K.A., Grimm, C.M. and Corsi, T.M., 2003, Adopting new technologies for supply chain management, *Transportation Research, Part-E*, 39, 2, 95-121.

295. Pawar, K.S. and Driva, H., 2000, Electronic trading in the supply chain: A holistic implementation framework, *Logistics Information Management*, 13, 1, 21-32.

296. Pearson, J.N. and Someijn, J., 1999, Service priorities in small and large firms engaged in international logistics, *International Journal of Physical Distribution and Logistics Management*, 29, 3, 181-191.

297. Peppers, D. and Rogers, M., 1999, *One to One Manager: Real-World Lessons in Customer Relationship Management*, Doubleday, New York, NY.

298. Perona, M., Cigolini, R., Adani, M., Biondi, R., Guzzatti, S., Jenna, R., Chessa, M. and Agellara, S., 2001, The integrated management of logistics chains in the white goods industry: a field research in Italy, *International Journal of Production Economics*, 69, 2, 227-238.

299. Phan, D.D., 2003, E-business development for competitive advantage: A case study, *Information and management*, 40, 581-590.

300. Pickernell, D., 1997, Less gain but what gain? A comparison of the effectiveness and effects of Japanese and non-Japanese car assemblers' buyer-suppliers relations in the UK automotive Industry, *Omega, The International Journal of Management science,* 25, 4, 377-395.

301. Pires, S.R.I. and Aravechia, C.H.M., 2001, *Measuring supply chain performance, Proceedings of the twelfth Annual Conference of the Production and Operations Management Society, POM-2001*, March 30- April 2, Orlando F1.

302. Poirier, C.C. and Bauer, M. J., 2001, *E-supply Chain: Using the Internet to revolutionize your business*, Emeryville, Berrett- Koehler Pub., C.A.

303. Poirier, C.C., 1999, *Advanced Supply Chain Management: How to Build a Sustained Competitive Advantage*, Berrett-Koehler, San Francisco, CA

304. Power, D., 2005, Supply chain management integration and implementation: a literature review, *Supply Chain Management: An International Journal*, 10, 4, 252-63

305. Power, D.J., Sohal, A.S. and Rahman, S., 2001, Critical success factors in agile supply chain management: An empirical study, *International Journal of Physical Distribution and Logistics Management*, 31, 4, 247- 265.

306. Power, D.J. and Singh, P., 2007, The Integration Dilemma: The linkages between Internal Technology application, trading partner relationships and structural change, Journal of operations Management, 25, 6, 1292-1310.

307. Prater, E., Biehl, M. and Smith, M.A., 2001, International supply chain agility – tradeoffs between flexibility and uncertainty, *International Journal of Operations & Production Management*, 21 5/6, 823-39.

308. Preiss, K., Goldman, S.L. and Nagel, R.N., 1996, *Cooperate to Compete: Building Agile Business Relationships*, Van Nostrand Reinhold, New York, N

309. Presutti Jr., W.D., 2003, Supply management and e-procurement: creating value added in the supply chain, *Industrial Marketing Management*, 32, 3, 219-226.

310. Prida, B. and Gutierrez, G., 1996, Supply management: From Purchasing to external factory management, *Production and Inventory Management Journal*, 37, 4, 38-43.

311. Primrose, P.L., 1991, *Investment in Manufacturing Technology*, Chapman and Hall, London.

312. Pyke, D., Farley, J. and Robb. D., 2000, Manufacturing Technology and Operations in China: A Survey of State-owned Enterprises, Private firms, Joint Ventures and Wholly-owned Foreign Subsidiaries. *European Management Journal*, 20, 4, 356-375.

313. Pyke, D.F., Johnson, M.E. and Desmond, P., 2001, e - fulfillment: It's Harder than it Looks, *Supply Chain Management Review*, January/February, 26-32.

314. Quayle, M., 2003, A study of supply chain management practice in UK industrial SMEs, *Supply Chain Management: An International Journal*, 8, 1, 79-86.

315. Quesada, G., Rachamadugu, Gonzalez, M. and Martinez, J.L., 2008, Linking order winning and external supply chain integration straegies, *Supply Chain Management: An International Journal*, 13, 4, 296-303.

316. Quinn, F.J., 1997, What is the fuzz, *Logistics Management*, 32, 2, 43-47.

317. Rabinovich, E., Windle, R., Dresner, M. and Corsi, T., 1999, Outsourcing of integrated logistics functions: An examination of industry practices, *International Journal of Physical Distribution and Logistics Management*, 29, 6, 353-373.

318. Raghunatahan, S., 2003, Impact of Demand Correlation on the Value of and Incentives for Information Sharing in a Supply Chain, *European Journal of Operational Research*, 146 634-649.

319. Ramdas, K. and Spekman, R.E., 2000, Chain or Shackles: Understanding What Drives Supply-Chain Performance, *Interfaces*, 30, 4, 3-21.

320. Rao, P., 2002, Greening the supply chain: A new initiative in South East Asia, *International Journal of Operations and Production Management*, 22, 6, 632-655.

321. Rassameethes, B., Kurokawa, S. and LeBlanc, L.J., 2000, EDI performance in the automotive supply chain, *International Journal of Technology Management*, 20, 3, 287-301.

322. Ravi, V. and Shankar, R. 2005, Analysis of interactions among the barriers of reverse logistics, *Technological Forecasting and Social Change*, 72, 1011-29.

323. Redmond, G.R. 1986, The evaluation of a flexible manufacturing system - a case study, *Flexible Manufacturing Systems: Current Issues and Models*, IIE Press, Atlanta, GA, 346-51.

324. Ross, J.W., Beath, C.W. and Goodhue, D.L., 1996, Develop long term competitiveness through IT assets, *Sloan Management Review*, 38, 2, 31-42.

325. Rudi, N. and Pyke, D.F., 2000, Product Recovery at the Norwegian Health Insurance Administration, *Interfaces*, 30, 3, 166-179.

326. Saad, M., Jones, M. and James, P., 2002, A review of the progress towards the adotion of supply chain management (SCM) relationships in construction, *European Journal of Purchasing and Supply Management*, 8, 3, 173-183.

327. Saad, M. and Patel, B., 2006, An investigation of supply chain performance measurement in the Indian automotive sector, *Benchmarking: An International Journal*, 13, 1/2, 36-53.

328. Sahay, B.S., Cavale, V., Mohan, R. and Rajni, R., 2003, The Face of Supply Chains in India, *Industrial Engineering Journal,* 32, 3, 2-28.

329. Sahin, F. and Robinson, E.P. Jr., 2005, Information sharing and coordination in make-to-order supply chains, *Journal of Operations Management,* 23, 6, 579-98.

330. Sako, M., 1992, *Prices, Quality and Trust,* Cambridge University Press, Cambridge.

331. Sanchez, A.M. and Perez, M.P., 2003, The use of EDI for inter organizational co-operation and co-ordination in the supply chain, *Integrated Manufacturing Systems*, 14, 8, 642-651.

332. Sanders, N.R. and Premus, R., 2002, IT applications in supply chain organizations: a link between competitive priorities and organizational benefits, Journal of Business Logistics, 23, 1, 65-83.

333. Santori, P. and Anderson, A.D., 1987, Manufacturing performance in the 1990s: measuring for excellence, *Journal of Accountancy*, 164, 5, 141-47.

334. Sauvage, T., 2003, The relationship between technology and logistics third-party providers, *International Journal of Physical Distribution and Logistics Management*, 33, 3, 236-253.

335. Sawhney, M. and Prandelli, E., 2000, Communities of creation: managing distributed innovation in turbulent markets, *California Management Review*, 42, 4, 24-54.

336. Saxena, J.P., Sushil and Vrat, P., 1992, Scenario Building: A critical study of energy conservation in the Indian Cement Industry, *Technological Forecasting and Social Change*, 41, 121-146.

337. Schonberger, R.J., 1990, *Building a Chain of Customer*, The Free Press, London.

338. Senge, P.M., 1990, The leader's new work: building learning organizations, *Sloan Management Review*, 32, 1, 7-23.

339. Senter Jr., R. and Flynn, M.S., 1999, Changing Inter-organizational Patterns in the North American Automotive Supply Chain, *Applied Behavioral Science Review*, 7, 1, 59-80.

340. Shankar, R. and Jaiswal, S., 1999, *Enterprise Resource Planning*, Galgotia Publications Private Limited, New Delhi.

341. Sila, I. and Ebrahimpour, M., 2005, Critical linkages among TQM factors and business results, *International Journal of Operations & Production Management*, 25 11, 1123-55.

342. Simatupang, T.M. and Sridharan, R., 2002, The collaborative supply chain: a scheme for information sharing and incentive alignment, *International Journal of Logistics Management*, 13, 2. 226-235.

343. Simchi-Levi D., Kaminski P., Simchi-Levi E. and Shankar R. 2008, *Designing and Managing Supply chain*, Tata McGraw-Hill, New Delhi.

344. Singh, M.D., Shankar, R., Narain, R. and Agrawal A., 2003, An Interpretive Structural Modeling of Knowledge Management in Engineering Industry, *Journal of Advances in Management Research*, 1, 1, 28-40.

345. Skjoett, T., Thernoe, C. and Andersen, C., Supply chain collaboration: Theoretical perspectives and empirical evidence, International *Journal of Physical Distribution and Logistics Management*, 33, 6, 531-549.

346. Slack, N., Chambers, S., Harland, C., Harrison, A., Johnston, R., 1995, *Operations Management*, Pitman Publishing, London.

347. Slack, N., Chambers, S. and Johnston, R., 1998, *Operations Management*, Prentice-Hall, New York, NY, .

348. Småros, J., Lehtonen, J.M.,, et al., 2003, The Impact of Increasing Demand Visibility on Production and Inventory Control Efficiency, *International Journal of Physical Distribution and Logistic Management*, 33, 4, 336-354.

349. Sohal, A.S., Moss, S. and Ng, L., 2001, Comparing IT success in manufacturing and service industries, *International Journal of Operations and Production Management*, 21 1, 30-45.

350. Spekman, R.E., Spear, J., and Kamau., J., 2002. Supply chain competency: Learning as a key component, *Supply Chain Management: An International Journal*, 7, 1, 41-55.

351. Spokman, R.E., Kamauff Jr, J.W. and Mohr, N., 1998, An empirical investigation into supply chain management: A perspective on partnerships, *International Journal of Physical Distribution and Logistics Management*, 28, 8, 630-650.

352. Stank, T., Michael, C. and Miren, A., 1999, Benefits of Inter-firm Coordination in Food Industry Supply Chains, *Journal of Business Logistics*, 20, 2, 21-41.

353. Stank, T.P., Daugherty, P.J. and Autry, C.W., 1999, Collaborative planning: supporting automatic replenishment programs, *Supply Chain Management: An International Journal*, 4, 2, 75-85.

354. Statistics Canada, Sabourin, D. and Beckstead, D., 1998, *Technology Adoption in Canadian Manufacturing: Survey of Advanced Technology in Canadian Manufacturing*, 88F0006XPB No. 05, ST-99-05.

355. Stern, L.W., El-Anshari, A.I. and Coughlan, A.T., 1996, *Marketing Channels, 5th ed.*, Prentice-Hall, Upper Saddle River, NJ.

356. Stevens, G., 1989, Integrating the supply chain, *International Journal of Physical Distribution and Materials Management*, 19, 8, 3-8.

357. Stewart, G., 1995, Supply chain performance benchmarking study reveals keys to supply chain excellence, *Logistics Information Management*, 8, 2, 38–44.

358. Stuart, F.L., 1997, Supplier alliance success and failure: a longitudinal dyadic perspective, *International Journal of Operations and Production Management*, 17, 6, 539-567.

359. Svensson, G. 2001, Perceived trust towards suppliers and customers in supply chains of the Swedish automotive industry, *International Journal of Physical Distribution & Logistics Management*, 31, 9, 647-62.

360. Swaminathan, J.M. and Tayur, S.R., 2003, Models for supply chain in E- business, *Management Science*, 49, 10, 1387-1406.

361. Swink, M., Narasimhan, R. and Wang, C., 2007, Managing beyond the factory walls: effects of four types of strategic integration on manufacturing plant performance, *Journal of Operations Management*, 25, 1, 148-64.

362. Szwejczewski, M., Goffin, K. and Lemke, F., 2001, Supplier management in German manufacturing companies: an empirical investigation, *International Journal of Physical Distribution and Logistics Management*, 31 5, 354-373.

363. Talluri, S., 2006, A benchmarking method for business-process reengineering and improvement, *International Journal of Flexible Manufacturing Systems*, 12, 4, 291-304.

364. Tan, K. C., 2001, A framework of supply chain management literature, *European Journal of Purchase and Supply Management*, 7, 1, 39-48.

365. Tan, K.C., Kannan, V.R., Handfield , R.B. and Ghosh, S., 1999, Supply chain management: an empirical study of its impact on performance, *International Journal of Operations and Production Management* , 19, 10, 1034-1052.

366. Tersine, R.J. and Hummingbird, E.A., 1995, The Lead-time reduction: the search for competitive advantage. *International Journal of Operations and Production Management*, 15, 2, 8-18.

367. Thakur, L.S., Jain, V.K., and Gupta, R., 2007, Successful strategies for AMT adoption in India: analyzing important variables via factor and discriminant analysis, *Journal of Advances in Management Research*, 4, 1, 7-18.

368. Thomas, D.J. and Griffin, P.M., 1996, Coordinated Supply chain management, *European Journal of Operational Research*, 94, 1, 1-15.

369. Toni, A.D. and Nassimbeni, G., 2000, Just-in-time purchasing: an empirical study of operational practices, suppler development and performance, *Omega: The International Journal of Management Science*, 28, 6, 631-651.

370. Toni, A.D., Nissimbeni, G. and S. Tonchia, S., 1994, New trends in supply environment, *Logistics Information Management*, 7, 4, 41–50.

371. Tracey, M. and Tan, C.L., 2001, Empirical analysis of supplier selection and involvement, customer satisfaction, and firm performance, *Supply Chain Management: An International Journal*, 6, 4, 174-188.

372. Tracey, M. and Vonderembse, M.A., 2000, Building supply chain: a key to enhancing manufacturing performances, *Mid American Journal of Business*, 15, 2, 11-19.

373. Turner, J.R., 1993, Integrated supply chain management: What is wrong with this picture? *Industrial Engineering*, 25, 12, 52-55.

374. Tynadall, G., Christopher, G., Wolfgang, P. and Kamauff, J., 1998, Supercharging Supply Chains , John Wiley & Sons Inc., New York, NY.

375. Vachon, S. and Klassen, R.D., 2006, Extending green practices across the supply chain: the impact of upstream and downstream integration, *International Journal of Operations & Production Management*, 26, 7, 795-821

376. Van Hoek, R.I., 2001, The rediscovery of postponement: a literature review and directions for research, *Journal of Operations Management*, 19, 2, 161-84.

377. Van-Hoek, R.I., 1998, Logistics and virtual integration: Postponing, outsourcing and the flow of information, *International Journal of Physical Distribution and Logistics Management*, 28, 7, 508-523.

378. Vickery, S.K., Jayanath, J., Droge, C. and Calantone, R., 2003, The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships, *Journal of Operations Management*, 21, 5, 523-539.

379. Vrat, P., 1998, Supply chain management in India: Problems and challenges, Proceedings of Supply chain management for global competitiveness (Ed.B.S. Sahay), November 20-21, MDI Gurgaon, India, MacMillan, 10-24.

380. Warfield, J.W., 1974, Developing interconnected matrices in structural modeling, *IEEE Transactions on Systems Men and Cybernetics*, 4, 1, 51-81.

381. White, A.G., 1996, *Internet enabled supply chain management*, EDI World, 6, 8, 10.

382. Wild, R., 1995, *Production and Operation Management*, Cassell Educational Limited, London

383. Williams, L.R., Esper, T.L. and Ozment, J. 2002, The electronic supply chain: its impact on the current and future structure of strategic alliances, partnerships and logistics leadership, *International Journal of Physical Distribution and Logistics Management*, 32 8, 703-719.

Study of Select Issues in the Supply Chain Management of Advanced Manufacturing Systems

VIVEK CHANDRA PANDEY

DEPARTMENT OF PRODUCTION ENGINEERING
DELHI UNIVERSITY
NEW DELHI – 110007, INDIA
FEBRUARY 2010

Study of Select Issues in the Supply Chain Management of Advanced Manufacturing Systems

by

VIVEK CHANDRA PANDEY

Department of Production Engineering

Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

DELHI UNIVERSITY

NEW DELHI – 110007, INDIA

FEBRUARY 2010

CHAPTER – 9

CONCLUSIONS, LIMITATIONS AND SCOPE FOR FUTURE WORK

9.1 INTRODUCTION

Since globalization and liberalization SCM has assumed a key position in the changing world order. Though various aspects of SCM have been extensively researched during the past few decades, the topic is still under considerable research. The rapid advancements in different technologies and its applications towards integration and efficient management of supply chain have attracted researchers to look into various aspects of technologies using in a supply chain. The use of AMT's in the Supply chain management will be a fertile and relatively new area as compare to Information technology for researchers. Therefore, it has motivated the researcher to pursue research on AMT- enabled SCM in the context of Indian industries through a questionnaire-based survey.

The motivation for this research is to understand the complexities in the SCM and offer some insight. The companies covered in the questionnaire survey belong to Auto, Machinery, Machine tools and Electrical & Electronics sectors. The outcome of literature review and questionnaire survey suggests that manufacturing activities constitute an important aspect of a supply chain. Many Indian companies are gradually following the world wide trend of outsourcing their manufacturing activities. This trend is getting momentum because of attractive AMT capabilities and SCM solutions offered by the global companies. These capabilities of the provider assist in further diffusing AMT in a supply chain. In the light of these features, the proper selection of partners in manufacturing is a strategic decision.

Therefore, a framework has also been proposed in this research for the integration and agility of the supply chain. Finally, ISM based framework has been presented to understand the integration and agility in the supply chain.

9.2 MAJOR CONTRIBUTIONS OF THE RESEARCH

The major contributions made through this research are as follows:

- This research provides a comprehensive review of the literature and identifies the contemporary research issues in SCM in general and technology-enabled SCM in particular.
- Sector-wise SCM practices have been identified and analyzed. An attempt is made to understand similarity/dissimilarity among different sectors of the Indian industry.
- Several questions related to information sharing has been answered through the statistical tools using data from Indian manufacturing enterprises.
- Various performance measures has been rated using different criteria's like their perceived usage value, frequency of use and ease of measurement. Finally a general relationship has been established among all these criteria using regression analysis.
- ISM has been used to understand the relationship among various enablers for integration and agility of supply chain. The ISM-based framework identifies the prioritization of the enablers for supply chain integration and agility. It helps to develop insights among practicing managers and entrepreneurs.

9.3 KEY FINDINGS FROM THE REASEARCH

The key findings which have emerged from this research are:

- More than half of the respondent companies strongly believe that well integrated supply chain improve the market share.

- The Indian manufacturing Enterprises are slowly but steadily following global trends of centralized and collaborative planning and information sharing among their trading partners in the supply chain.
- Supply chain performance measurement system is not a regular practice in the Indian Manufacturing Enterprises. There is still a need to develop much simplified PMS customized to Indian conditions.
- Awareness towards SCM and AMT has been significantly increased in last few years.
- In most of respondent companies the AMT are used partially. Still there is lack in integrated manufacturing system like FMS.
- Indian manufacturing enterprises are all set to adopt simple and complex technologies but they have still to exploit integrated manufacturing technologies.
- Information sharing practices are normally one to one that can be collaborative in order to strengthen total supply chain.
- The perceptions of OEM’s and supplier to OEM do not significantly differ in terms of the practices of performance measurement systems.
- The perceptions of the high profit making enterprises and low profit making enterprises are also not significantly differ in terms of the practices of performance measurement systems.
- The three widely used areas of information sharing have been identified. These are related to purchasing, order tracking and product development.
- Better responsiveness, inventory reduction, and order- fulfillment-time reduction are the three most important benefits of AMT- enabled supply chain management.
- ISM-based framework for integration and agility of supply chain have been developed

9.4 IMPLICATINS OF THE RESEARCH

The findings of this research contribute to the body of literature on SCM. These findings not only validate some important and widely discussed aspects of SCM but also set out interrelationships among many of these aspects. From a practical perspective, the analysis reveals that placing emphasis on information sharing and improving buyer supplier relationships with the help of advanced AMT tools can benefit the companies across the industries. The results of this research demonstrate that AMT-enablement of a supply chain improves its performance by the lowering of inventory and working capital. These evidences support the objective of SCM as a comprehensive and vital strategy that can build and sustain competitive advantage, which ultimately lead to good business performance.

9.4.1 Implication to Academicians

- The exhaustive study of various aspects related to AMT- enabled SCM, presented in this research, focuses on the Indian context. Therefore, it may serve as a trigger point for the further research in the area.
- The literature review presented in this research and identified gaps in the literature may prove as a basis for the future research.
- The comprehensive questionnaire developed in this research can be used as an instrument for further empirical studies in the areas of SCM and other similar areas.
- The sector-wise study of SCM encourages the academicians to do further research on other issues where sectors have some differences.

- In this research ISM has been used as a methodology to prioritize the enablers of integration and agility of SCM provider. The ISM has can be very effective tool in qualitative analysis of any problem or issue. Academician has an opportunity to use it in their research work.

9.4.2 Implications to Managers

Several important managerial implications emerge from this research.

- The state of AMT- enabled SCM in Indian industries and the perception of managers on various issues pertaining to it enablement of supply chains have been elicited.
- The managers may use the ISM-based model to decide sequential priorities to develop agility and integration of Supply chain. ISM may also used in strategic planning to decide relative importance of different enablers. Enablers may also be categorizes in four groups namely independent, dependent, autonomous and linkage Use of ISM can be very useful in various qualitative analysis.

9.5 LIMITATIONS OF THIS RESEARCH AND SCOPE OF FUTURE WORK

As with all the research, this study too has some limitations. In this section we identify limitations and offer some suggestions for future research.

As with many other empirical studies in SCM, only a small segment of the supply chains belongs to the respondent companies were covered in the survey.

Individual measures such as perceptions of the respondent company about SCM problems etc. reflect only the opinion of the respondent firm or individual representing the firm based on the based on the experiences from the entire upstream and downstream supply chain members. However, the direct effects of the higher order chain members, such as second or third tier suppliers or final customers or retailers were not directly observable.

Another limitation of the research is the sample is concentrated in northern and western part of India, Further; the survey instrument contained multiple items for each of the factor, which we attempted to measure. However, due to low factor loading some items were dropped during factor analysis.

Another limitation of this research is the relative homogeneity of the mangers in the response sample. The mangers who responded to the survey represent the top managements in their organization as most respondents are at the senior positions such as vice-president, general manger, senior manager etc in their firms. While a homogeneous response sample is acceptable in exploratory studies, the lack of variety in the firms and managers in the sample may explain some of the non-significant and erroneous result. For example, high – level managers may be the best source of the strategic information that is exchanged with the trading partner but lower level managers are more involved in exchanging operational information. Therefore, a better indication of the operational information exchange may come from lower level managers who are not represented much in the sample. Therefore, future research may also include lower level mangers in collecting the operations- related information

In this research, though ISM, a relationship model among the enablers for integration and agility in SCM has been developed. Yet, this model has not been statistically validated. Structural equation modeling (SEM), also commonly know as linear structural relationship approach has the capability of testing the validity of such hypothetical model.

Therefore, it may be applied in the future research to test the validity of this model.Future research may also look into the direness among various industries in their SCM practices. For example manufacturing industry may be compared with the service industry or agricultural industry etc. future research may also be targeted to quantify the impact of AMT on the performance of an organization and its supply chain practices.

9.6 CONSCULSION

In order to develop and maintain competitive advantage, Indian enterprise must enhance their AMT capabilities to design, manufacture, manage and control their products, services according to customer requirements. They are also need to be focus on their SCM practices. In this process many firms will have to change their organizational structures, relationship with supply chain members, use of technological tools and performance measurement systems. The challenge for the managers is to avoid stagnation and diffuse AMT along with supply chain practices further throughout their supply chains. The supply chain managers will have to decide which technological tools and policies offer the greatest strategic value for the supply chain.

Supply chain improvement using new technologies is a continuous process; therefore the research may continue to incorporate new challenges and the use of technologies in meeting these challenges. The organizations should continuously develop and adjust to the ever changing environment and technology to survive in the market. Indian Enterprises need to be focus on their supply chain agility. As Charles Darwin has rightly said, “It is not the strongest of the species that survives, not the most intelligent, but one most responsive to change.