CHAPTER I
INTRODUCTION

1.1 Present Scenario

Expanding global competition, rapidly changing markets and technology, increasing complexity and uncertainty are creating a new competitive environment. Organizations must adapt to market pressure and competitors’ innovations with increasing speed to deliver both efficiency and effectiveness. From a combined business and functional strategy viewpoint, competitiveness and profitability call for improved organizational adaptability and more flexible and advanced systems (relative to manufacturing, engineering, supply chain, information and process technology, etc.) to improve manufacturing competence. The manufacturing organizations have also experienced an unprecedented degree of change in the recent times, involving drastic changes in management approaches, product and process technologies, customer expectations, supplier attitudes as well as competitive behavior.

The basic competitive priorities generally considered by academician and professionals are quality, delivery, price and flexibility. However, the past decade has witnessed an increased interest in flexibility, which bestows on a firm the ability to respond promptly to market opportunities and changing technologies and most likely to continue with ever increasing changes in the marketplace. The investigation of strategic choice of aligning flexibility development with the external environment that manufacturing manager’s face, considering uncertainties in demand, material supply, competition and new product technology, indicates the need of matching the manufacturing flexibility with environmental uncertainty to ensure profit and sales performance (Chang et al., 2002).

Manufacturing flexibility has been heralded as a major competitive weapon for manufacturing organizations operating in increasingly uncertain environments and turbulent markets. It has been considered in the literature that manufacturing flexibility has the capability to provide organizations with the ability to change levels of production rapidly, to develop new products more quickly and more frequently, and to respond more rapidly to competitive threats.
Past research on manufacturing flexibilities has mainly tended to focus on newer technologies as a means for achieving manufacturing flexibility goals. Various researchers have concluded that there is a positive relationship between newer technologies and flexibility (Singh et al., 1996; Dangayach and Deshmukh, 2005; Narasimhan et al., 2004). It has also been found and presented by many researchers that manufacturing technology represents just one method of delivering flexibility (Jaikumar, 1986; Gerwin, 1993; Upton, 1995; Das, 2001). Researchers have begun to look beyond advanced manufacturing systems to alternative methods of delivering flexibility. Sourcing is mentioned as an alternative strategy for coping with demand uncertainties. Other coping strategies include demand management through effective manufacturing–marketing schedule sharing, improved forecasting efficiencies and other demand influencing programmes (McCutcheon et al., 1994). However, there has been a growing recognition of the contribution of sourcing practices to the attainment of competitive excellence and better potential to influence an organizations’ flexibility in responding to market demands. The system has witnessed a transformation in which suppliers and customers are inextricably linked throughout the entire sequence of supply chain. Considerable anecdotal evidence exists to suggest the use of sourcing practices as an alternative strategy for obtaining manufacturing flexibilities (Tully, 1994). Some studies have found positive relationships between sourcing and different kind of manufacturing flexibilities (Olhager, 1993; Suarez et al., 1996; Narasimhan and Das, 2000; and Gupta, 2005), but are incomplete in their examination of the different dimensions and specific of such relationships. Moreover, there is also lack of any organized attempt to understand how these activities are being carried out in Indian manufacturing industry.

This research is intended to understand the complexities involved in managing manufacturing flexibility at firm level, and their linkages with technology and sourcing practices in manufacturing industry. The purpose of this work is to understand and explicate the interaction between new technology, sourcing practices and manufacturing flexibilities and assess their relative impact on different flexibilities.

1.2 Concept of Flexibility

The concept of flexibility in an organizational context refers to the ability to precipitate intentional changes, to continuously respond to unanticipated changes, and to adjust to the unexpected consequences of predictable changes (Bahrami, 1992). At a broad level, flexibility can be understood as an absorber of environmental uncertainty and variability.
Flexibility is regarded as a positive feature since it contributes to the organization’s ability to absorb or even benefit from variations in its environment. Upton’s (1994) oft-quoted definition is “flexibility is the ability to change or react with little penalty in time, effort, cost or performance”. Upton (1995) discusses different strategies that an organization may employ to become flexible and suggests that flexibility is both a multidimensional and multilevel attribute. Upton’s arguments suggest that flexibility is enacted as a response to different classes of problems and that there are usually multiple responses to the same set of problems. Sushil (1997) advocates the concept of systemic flexibility, which is defined as the exercise of free will or freedom of choice on the continuum to synthesize the dynamic interplay of thesis and antithesis in an interactive manner, capturing the ambiguity in the systems, and expanding the continuum with minimum time and effort. Sushil (2000) identified strategic, organizational, financial, information systems and manufacturing flexibility as the cornerstones of enterprise flexibility. Zhang et al. (2006) perceives flexibility as the organization’s ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses. Boppana et al. (2007) captured the complexities from the flexibilities and fit them into entity-relationship model and also gives an idea of how the developed individual models can be used to evaluate the flexibility options in a manufacturing system.

1.3 Manufacturing Flexibility

Manufacturing flexibility, the focus of the study, is defined as the ability of the system to adjust to environmental changes/ market fluctuations and process requirements with little penalty in time, effort, cost or performance. (Gerwin, 1993; D’Souza and Williams, 2000; Koste and Malhotra, 1999; Barad and Sipper, 1988). Manufacturing flexibility can be viewed as a multi-dimensional concept rather than as an independent variable that can be defined and measured in isolation. It is considered as the strategic element of business, along with price (cost), quality, and dependability. Priorities assigned to each of these factors determine how an organization positions itself relative to its competitors.

A great deal of research in defining various types of flexibilities in manufacturing has occurred over the last two decades. Despite this, there is no general agreement on how to define flexibility. At the outset, this is due to the multidimensional nature of flexibility and the various views of flexibility that result: flexibility has been viewed and studied as
a physical property, an attribute of decision making, an economic indicator, and a strategic tool. Understanding the constituent dimensions of manufacturing flexibility and their interrelationships would be of value to the firms whose competitive strength depends on flexible manufacturing. Its dimensions addressed in the literature mainly include equipment flexibility, material flexibility, routing flexibility, material handling flexibility, program flexibility, mix flexibility, volume flexibility, modification flexibility, new product flexibility, delivery flexibility and market flexibility.

The development of a generic categorization is likely to remain elusive in the previous research as manufacturing flexibility manifest itself in many forms at various levels in an organization. Yilmaz and Davis (1987) have examined manufacturing flexibility through different dimensions of time. Carlson (1989) goes on to distinguish three types of flexibility: operational (short term), tactical (medium term) and strategic (long term). Operational flexibility corresponds to built-in procedures that permit a large range of responses to operational variables including sequencing and scheduling. While tactical flexibilities relate to the embodiment in technological and organizational routines of responses in how to deal with changes in rates of production, product mix over the course of a business cycle, strategic flexibilities are external in application and relates to how the organization is positioning itself with respect to future challenges and opportunities. D’Souza and Williams (2000) categorized manufacturing flexibility as external and internal driven dimensions. This study focuses on the generalization of hierarchical taxonomy of manufacturing flexibilities based on the insights of the available literature.

Volume flexibility, in context to this study, corresponds to the ability of manufacturing system to be operated profitable (in the short term) with various amount of volume for several products without incurring negative effects (e.g. time delays, changes in performance outcomes) when switching from one operation to another (Sethi and Sethi, 1990, Koste and Malhotra, 1999, Hyun and Ahn, 1992). However, the issues related to ease of producing minor alterations in product design to meet customization or differentiation requests have been addressed by modification flexibility (Gerwin, 1993). Modification flexibility is useful for product and market differentiation efforts and overall market share growth. Delivery flexibility further strengthens the capabilities of manufacturing system to respond to or influence market changes & enables the rapid delivery of innovativeness, customized products for new market creation (Narasimhan and Das, 2000).
1.4 Technology

The word ‘technology’ comes from two Greek words ‘Techne’ and ‘Logos’. ‘Techne’ means the skill or craft needed to make something and ‘Logos’ mean discussion or knowledge of something (Rao, 1996). Technology is defined as the practical knowledge, know-how, skill and artifacts that can be used to develop a new product or service and/or a new production/delivery system (Moriarity et al., 1990). ‘Technology refers to a system of components which act on or change an object from one state to another’. The components include hardware, software and programs to transform materials or information from one state to another (Goodman and Griffith, 1991). Technology is purposeful application of knowledge developed in various areas that include hardware or software; general or firm specific; and alternative, intermediate or appropriate.

1.4.1 New Technology

New technology is a set of productive techniques which offers a significant improvement (whether measured in terms of increased output or savings in costs) over the established technology for a given process in a specific historical context. Also, new technology is a product or process that an organization has not previously used in their operation. In the field of manufacturing generally termed as advanced manufacturing technology (AMT), application of new technologies can result in reduction the cost, improvement in quality and flexibility, more responsiveness to market demands and introduction of new products more rapidly, at the same time (Hayes, 1991).

1.4.2 Advanced Manufacturing Technology

Manufacturing has been evolving over the years as different needs and technologies arise. The customer of the twenty-first century demands products and services that are fast, right, cheap and easy (Dangayach and Deshmukh, 2001). The quest for lower operating costs and improved manufacturing flexibility has forced a large number of manufacturing firms to embark on advanced manufacturing technologies (AMTs) projects of various types. AMT include a group of integrated hardware-based and software-based technologies which, when properly implemented, monitored and evaluated, can improve the operating efficiency and effectiveness of the adopting firms.

The overall potential of AMT is immense and several problem issues in design, manufacturing or administrative activities could be solved through increased use of it. Improvements in product quality, manufacturing flexibility, increased profitability, and
improvements in productivity due to a reduction in the rejection rates are the most often-cited benefits from technology adoption. Introduction of new products can occur more frequently through use of computer-aided design and manufacturing (CAD/CAM), since the design lead times may be shortened. Flexible manufacturing systems (FMS), use of robots and automated materials handling systems reduce set-up times and other interruptions so that products flow more smoothly and faster through the plant. Integrated production control systems, such as manufacturing resource planning (MRP II) and enterprise resource planning systems (ERP), reduce inventories and raw materials, work-in-progress and finished goods. Tighter control and flexible manufacturing smooth flow through plant make the flow more predictable and cut the overall throughput time, allowing accurate delivery performances to be achieved.

Koh et al. (2005) examines how and to what extent uncertainty affects small and medium scale enterprise manufacturers who plan and schedule their production using MRP, MRPII or ERP systems. Kanungo and Savla (2004) related soft technology investments and organizational productivity through an empirical study and found a positive relation. Mora-Monge et al. (2007) investigated the issue of strategic fit between AMTs and its impact on performance in developing countries. Stohr and Zhao (1997) studied the workflow management systems, designed to make work more efficient, integrate heterogeneous application systems, and support inter-organizational processes. Narain et al. (2007) reviewed a wide range on literature on the investment justification of AMT. They provided an updated and comprehensive perspective of the issues surrounding the problem of investment justification of AMT and provide some direction for future research. Agrawal et al. (2005) further identified the effect of culture and environmental pressures on the rate of change in the requirements of in-house software professionals.

1.5 Sourcing Practices

There is a growing recognition of the contribution of sourcing to the attainment of manufacturing flexibility capabilities. The need for sourcing to be supportive of corporate competitive priorities has been stressed by Watts et al. (1992) in their framework linking sourcing practices to corporate competitive priorities. Sourcing is seen somewhat narrowly as finding sources of supply, guaranteeing continuity in supply, and ensuring alternative sources of supply and gathering knowledge of procurable resources. A rather broader definition of sourcing views it as “the entire set of business processes required to
purchase goods and services including the selection of suppliers, design of supplier contracts, product design collaboration, procurement of material and evaluation of supplier performance” (Chopra and Meindl, 2003).

Oberoi and Khamba (2005a) aim to develop the buyer-supplier typology for strategic archetypes of sourcing relationships. The typology reflects a buyer perspective ranging from arm’s length relationship to strategic partnerships and represents a supplier segmentation tool which helps identify what types of competence and capability relate to each individual sourcing strategy. The four sourcing strategies are classified in light of research literature as: make-or-buy, outsourcing, insourcing and strategic sourcing.

Outsourcing has been viewed as a form of predetermined external provision with another enterprise for the delivery of goods and/or services that would previously have been offered in-house (Elfing and Baven, 1994; Domberger, 1998; Kliem, 1999; Finlay and King, 1999). Although outsourcing is playing a predominant role in today’s business environment, companies obviously have alternative sourcing strategies to consider. These sourcing strategies are largely determined by the companies’ position in the supply chain and sectoral pattern, and they all influence corporate identity (Fine and Whitney, 1996). Narasimhan (1999) describe strategic sourcing as a way to obtain manufacturing capabilities without capital investments and defines strategic sourcing as the use of supplier competencies to achieve flexibility goals through: a strategic alliance with suppliers; and formal incorporation of supplier capabilities into a firm’s manufacturing strategies. In this study, from sourcing perspective, the impact of various facets of ‘outsourcing’ and ‘strategic sourcing’ have been mainly investigated for managing manufacturing flexibilities and termed as ‘sourcing practices’ or ‘supplier based sourcing practices’.

Preceding studies have found varied relationships between sourcing and different manufacturing flexibilities (Suarez et al. 1996, Narasimhan and Das, 2000 and 2004). Haleem (2004) evaluated the buyer supplier relations for manufacturing and service industries in North India and established a concern for long-term relationship with less number of high quality suppliers. Gupta et al. (1998) studied the impact of competitive priorities, process innovations and time-based competition in the manufacturing sector of industrializing economies on the cost, quality, flexibility and time and found manufacturing industry at an earlier, quality-dependent. Gupta et al. (2006) further analyses the current state of supply chain management practices followed by Indian
organizations and found that most of the Indian organizations have aligned their supply chain objectives with their business objectives. Bhardwaj et al. (2006) focuses on the partnership between Indian automotive vendors and vehicle manufacturers for product design activity and found a lot of variation with respect to this activity for different clusters.

From the viewpoint of various researchers, it is clear that sourcing has the potential to influence an organization’s flexibility in responding to market demands. What is not known is exactly which aspects of flexibility performance are affected by sourcing actions, and how these flexibilities, once attained, influence manufacturing performance.

1.6 Flexible Systems Methodology

Flexibility can be defined as the ability to respond effectively to the ever changing and increasing needs of the customer. For this demand to be satisfied, flexibility should be built into the total chain of acquisition, processing, and distribution stages. As a result, there is an increasing interest in flexibility and flexibility enabling mechanisms/parameters to achieve the best strategy for obtaining the right and desired. High speed and accuracy combined with flexibility and optimized throughput, are the goals of the next generation of machines.

The philosophy of integration of quantitative and qualitative tools is emerging very rapidly to cater to the need of diverse decision-making and managerial processes. There are number of end of the continuum paradoxes which have created separate schools of thought. A concept of flexibility can provide a solution to the paradox and advocates that it is not necessary to invent a new approach to each problem situation or to settle at an end of continuum.

In essence, flexible systems methodology states that for a problem situation an approach out of the existing well researched once or a suitable combination or innovation of them should be selected and integrated to match requirements of the problem situation. It thus integrates all the systems approaches and techniques into a family in which everyone either individually or collectively contributes meaningfully. Flexible system methodology is built on spectral and integrative paradigm. Sushil (1994) discusses this paradigm and concludes that this methodology is more realistic and by using this, more creativity will be applied to the problem solving.
It is planned in this research to use flexible system methodology for exploring and explicating the nature of interactions between manufacturing flexibility, new technology and sourcing practices in manufacturing industry.

1.7 Objective and Research Issues

1.7.1 Objective of the Study
The objective of this research work is to assess the relative impact of new technology and sourcing practices on different flexibilities for the trade off associated with the strategic choice between different methods of achieving manufacturing flexibilities.

1.7.2 Issues Covered
Following issues have been taken up during the research work.

i. To recognize manufacturing flexibilities as multi-dimensional and multilevel concept and define manufacturing flexibilities in this context.

ii. To understand and explicate the nature of interaction between new technology, sourcing practices and manufacturing flexibilities.

iii. To assess the impact of new technology vis-à-vis sourcing practices on manufacturing flexibilities.

iv. To explore and examine the relative impact of sourcing practices and new technology at different levels of manufacturing flexibilities.

v. Examine the implications of sourcing-flexibility and new technology-flexibility relationship.

vi. Consideration of related technical, social and environmental issues while achieving the manufacturing flexibilities.

vii. Establishing relationship between variables and parameters associated with manufacturing flexibilities.

1.8 Scope of the Work
The work shall be limited to those medium and large scale manufacturing enterprises of the region, which are in the process of achieving the manufacturing flexibilities at all or various levels by acquiring, developing or utilizing the advanced manufacturing technology or by the use of specific/different sourcing practices with different aspects of manufacturing flexibilities.
It is proposed to focus on three dimensions of manufacturing flexibility - volume flexibility, modification flexibility and delivery flexibility as sourcing will mostly influence these dimensions. Since operational-level flexibilities are primarily equipment-driven and occur at the shop floor level, it is unlikely that sourcing will have a major impact on flexibility at this level. Tactical and strategic flexibilities such as volume, modification and delivery flexibility appear at the plant or organization level. Suppliers mainly interface with their customers at the plant or organization level. Hence, it is more likely that sourcing will influence these dimensions of manufacturing flexibility. In addition, as Slack (1990) confirms, tactical and strategic level flexibilities, matter more to managers than lower-level operational flexibilities. There is some evidence in the literature that sourcing can influence modification, delivery and new product flexibility (Olhager, 1993; Suarez et al., 1996; Narasimhan, 2004).

1.9 Overall Methodology

The research has been carried out to assess the impact of new technology and sourcing practices in managing manufacturing flexibilities, using flexible system methodology. The literature on the nature, types and levels of manufacturing flexibility has been explored in detail. A methodical review on the concept, taxonomy and related facets of technology and sourcing practices, as a method to achieve the manufacturing flexibilities, has also been done. The literature has also been reviewed on the methodologies to be used in carrying out the research. The problem has been conceptualized as an S-A-P (Situation-Actor-Process) paradigm.

The survey has been conducted in the manufacturing organizations that are in the process of achieving the manufacturing flexibility at all or various levels by acquiring, developing or utilizing the advanced manufacturing technology or by the use of specific/different sourcing practices. Descriptive and empirical analyses of the data collected through the survey has been carried out to assess the status of new technology vis-à-vis sourcing practices and present level of manufacturing flexibility at tactical and strategic level. In data analysis, independent and dependent variables (constructs) have been formulated based on literature review and the objectives of this research. The convergent and discriminant validity of the constructs and their measures have been done and various statistical tools and techniques have been employed using SPSS software to predict the results. Since the research was focused on investigating the relationships between a set of
multiple dependent and multiple independent variables with little prior knowledge of such relationships, canonical correlation analysis was deemed the appropriate multivariate statistical technique to use. As a precursor to canonical correlation analysis, the pair-wise correlations between variables were examined and variables were selected to avoid problems of multicollinearity. For a closer examination of relationships between individual dimensions of dependent variables with the independent variables, the multiple regression analyses have been done using the enter and stepwise method.

The survey has been followed by critical assessment of four case studies in the surveyed manufacturing organizations. The objective of the case studies has been to look into and analyze various facets of working of the organizations concerning the research objective. The analyzed result of the case studies depicts the total industrial scenario in manufacturing sector about the achieved level of manufacturing flexibilities and assesses the relative impact of sourcing practices and new technology on different flexibilities for providing a basis for the trade off associated with the strategic choice between different methods of achieving manufacturing flexibilities. S-A-P analysis has been done in each case study and their learning issues have also been listed.

The learning issues of survey and case studies have been synthesized to bring out an implementation plan. For this, qualitative modeling techniques have been applied. Finally, the critical learning issues of the survey and case studies have been synthesized. In view of the insights gained from this synthesis and the literature available, the actions for implementation in the manufacturing sector have been recommended.

1.10 Organization of the Thesis

The write up of the thesis is divided into seven chapters: I. Introduction, II. Literature Review, III. Design of Study, IV. Survey Based Research Results, V. Case Studies, VI. Development of an Implementation Plan for Managing Manufacturing Flexibilities, and VII. Conclusions and Recommendations.

Chapter I highlights the need for managing manufacturing flexibility, and its association with technology and sourcing practices in the manufacturing industry. Further, the objectives and issues, scope of study, overall methodology and organization of research work has been covered in this chapter.

Chapter II reviews in detail the previous studies on the concept of flexibility, and nature, types and levels of manufacturing flexibility, advanced manufacturing technology,
sourcing practices and their relationships. Special emphasis has been laid on the impact of new technology and sourcing practices as a way to achieve manufacturing flexibilities at various levels. The literature has also been reviewed on methodologies to be used in carrying out the research.

Chapter III introduces overall design of study, which includes phases of research and the methodology adopted for carrying out the research work. The details of work done in each phase, tools, techniques and models used in the dissertation have also been presented in this chapter. Flexible system methodology, used for the purpose has been explained. Methodology of conducting empirical study (survey) and case studies has been explored. Use of qualitative modeling to develop a management process, and an implementation plan has also been discussed.

Chapter IV presents the results of detailed survey conducted in various manufacturing enterprises. A survey of various manufacturing organizations, involved in achieving manufacturing flexibilities at tactical and strategic level has been taken up by using a peculiarly designed questionnaire. Descriptive and empirical analyses of the data, collected through the survey, has been carried out to assess the status of present level of different dimensions of manufacturing flexibilities and impact of new technology and sourcing practices in managing it.

Chapter V describes the detailed case studies carried out in four manufacturing organizations. In each case study, the methods/techniques/approaches adopted for achieving manufacturing flexibilities, the success achieved, the modifications made in the future plans have been compiled and analyzed in detail. The case studies have been conducted in Maruti Suzuki India Limited (MSIL), Gurgaon; Sona Koyo Steering Systems Limited (SKSSL), Gurgaon; Moserbaer India Limited (Moserbaer), Noida; and Punjab Tractors Limited (PTL), Mohali. The preliminary information provided by the survey has been validated by these case studies and the synthesis of the two has provided the required results.

Chapter VI synthesizes the learning issues from survey and case studies and utilizes the same in the domain of qualitative model to select appropriate strategies and develop suitable plan for managing manufacturing flexibilities. The qualitative modeling involves the use of Options Field Methodology (OFM), Options Profile Methodology (OPM), Analytic Hierarchy Process (AHP) and Fuzzy Set Theory (FST). The learning issues of questionnaire survey and case studies have been converted to various options using OPM.
Various profiles or courses of actions, to achieve manufacturing flexibility have been decided based upon implementation of new technology and sourcing practices. Various objectives of the organizations as revealed by the survey were utilized in the qualitative model. The weightings of these objectives have been worked out by experts using AHP. Further, the expert opinion has been taken to assess the contribution of each profile towards each objective using FST. Utilizing the weightings of the objectives and the contribution of each profile towards each objective and subsequently making dominance matrices, preferred strategies for achieving the different manufacturing flexibilities under various situations of optimism, pessimism and realism were selected. Results of qualitative modeling, which are in fact an outcome of opinion of the experts, taken in structured way depict the relative impact of technology and sourcing based approaches in achieving the different tactical and strategic level manufacturing flexibilities.

Chapter VII covers the summary of the research work, its results, conclusions, and the recommendations. Further, the major learning’s results from the survey and the case studies have been presented. Based on the results and the findings, conclusions have been drawn and recommendations have been made. The limitations along with the scope for future work have been covered in the subsequent sections of this chapter.

1.11 Concluding Remarks

An organized attempt has been made to make this study exhaustive, intensive and broad based as possible, for investigating the role of new technology and sourcing aspects in achieving manufacturing flexibility. However, owing to the stupendous task of covering all the manufacturing organizations in almost all parts of a country, the study has been limited to the manufacturing organizations of North India only. North India is covered by different definitions differently. A broad based view of north India was taken for this study that included the states of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Delhi, and Union territory of Chandigarh. Parts of Rajasthan, and Uttar Pradesh near the above states were also included. There have been limitations of time and resources, but still, by and large, this study has covered almost all types of manufacturing industries. To the best of my knowledge, this study has not left out any important factor or parameter relating to the impact of new technology and sourcing practices in managing manufacturing flexibility.

Review of the literature is the first logical step in a research effort and the next chapter is devoted to the same.