Analysis and Design of a Strategic Technology Development Program for Small Scale Manufacturing Industry

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Dedicated

To

My

Loving Father

CERTIFICATE

Certified that the thesis entitled, **'ANALYSIS AND DESIGN OF A STRATEGIC TECHNOLOGY DEVELOPMENT PROGRAM FOR SMALL SCALE MANUFACTURING INDUSTRY',** being submitted by Tarun Nanda, to Department of Mechanical Engineering, Thapar University, Patiala, in fulfillment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY**, is a record of bonafide research work carried out by him under my guidance and supervision. The matter presented in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree.

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Tarun Nanda

CONTENTS

CHAPTER - VI SYNTHESIS AND DESIGN OF TECHNOLOGY DEVELOPMENT PROGRAM **183-223**

ABSTRACT

In today’s competitive business environment, global competition is forcing companies to perpetually seek ways to improve their products and services. Technological changes and demanding customers are creating a more knowledge intensive, turbulent, complex, and uncertain environment. The intense competition requires that firms excel simultaneously in several areas without trade-off, including innovativeness and responsiveness to their customers. These formidable changes have forced the organizations around the world to adopt innovative and state of the art strategies to suitably address the all-important issues of organizational growth and excellence. It is high time that industries wake up and gear up for research initiatives to develop cutting edge technologies.

Amongst the several problems faced by small scale manufacturing organizations in the country, technology obsolescence is one major predicament. There has been a lack of any organized attempt to understand how technology upgradation activities are being carried out in the Indian small scale sector. The objective of present research work is to analyze the indigenous technology development capabilities of small scale manufacturing industry and develop a strategic technology development program for the same.

The work has been carried out under the overall framework of ‘Flexible Systems Methodology’. The research problem has been conceptualized as a SAP-LAP (Situation-Actor-Process; Learnings-Action-Performance) paradigm. In this framework, the ‘situation’ aspect comprises of the present industrial situation in small scale manufacturing sector, whereas manufacturing organizations constitute the ‘actor’ aspect. The role of in-house research and innovation initiatives in building technological capabilities constitutes the ‘process’. The work has been carried out in four distinct phases. The first phase of research work comprises of an extensive literature review concerning economic, technical, regulatory and other related issues regarding technology development capabilities of manufacturing industry. The second phase assesses the status of technology development initiatives and resulting performance improvements in the industrial sector, through a questionnaire based survey of manufacturing units. This phase of work consists of questionnaire development, its validation and pre-testing, sampling and data collection. It also includes descriptive and empirical analysis of data to assess

the status of various research issues and evaluate the inter-relationships between dependent and independent research constructs. The statistical tools used include t-test, canonical factor analysis and multiple regression analysis. The third phase of research work describes the detailed case studies carried out in manufacturing organizations, which are actors in the present context. The objective of case studies has been to look into and critically analyze various facets of the working of organizations, including the need for technology development, the role of technology input success factors and resulting developments accrued as a result thereof. In each case study, the techniques and approaches adopted by organizations for technological improvements, success achieved and modifications made in future plans have been compiled and analyzed in detail. The main tools used in case studies include SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, SAP (Situation, Actors, Process) interplay, and LAP (Learnings, Actions, Performance) synthesis. The case studies have been conducted at Super Hobs and Broaches Private Limited, Patiala and; Pye Hand Tools Private Limited, Ludhiana. The last phase of research work presents a synthesis of learning issues of survey and case studies to bring out a systematic implementation plan for effectively managing technology input success factors for performance improvements in the manufacturing sector. For this, a qualitative modeling technique has been applied using options field methodology (OFM), options profile methodology (OPM), analytic hierarchy process (AHP) and fuzzy set theory (FST). Five main profiles have been planned in this phase of work to meet various dimensions of the research problem. These profiles include strategic stimulation based approach, technology based approach, regulatory environment based approach, nucleus based approach and a mixed approach. The actions for implementation of various strategies in the manufacturing sector have been recommended through the qualitative model. Finally, a conceptual framework showing the preferred strategies to meet the objectives of research problem in the Indian context has been developed, presented and discussed.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

NOMENCLATURE

AHP	Analytic Hierarchy Process
ASA	American Standards Association
ASO	American Standards Organization
BIS	Bureau of Indian Standards
BS	British Standards
CAD	Computer Aided Designing
CGTMSE	Credit Guarantee Trust for Micro and Small Enterprises
CNC	Computer Numerical Controlled
CST	Central Sales Tax
CT	Central Tendency
CTR	Central Tool Room
DCW	Diesel Component Works
DI	Development Indicators
DIC	District Industrial Centre
DIN	Deutsches Institut fuer Normung
DT	Dynamic-Tight Well Limited, Rohtak
EME	Emerging Manufacturing Economies
FDI	Foreign Direct Investment
FEA	Finite Element Analysis
FST	Fuzzy Set Theory
GDP	Gross Domestic Product
GOST	Gosudarstvennyy Standart (Russian State Standard)
GST	Goods and Service Tax
HSS	High Speed Steel
IIMT	Indian Institute of Machine Tool Technology
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
JIS	Japanese Institute of Standardization
LAP	Learnings-Actions-Performance
MNC	Multinational Corporations
NGO	Non-Government Organizations
NPA	Non Performing Assets
NSIC	National Small Industries Corporation

OEM	Original Equipment Manufacturer
OFM	Option Fields Methodology
OGL	Open General Licence
PPS	Percent Point Score
PRTC	Pepsu Roadways Transport Corporation
QR	Quantitative Restrictions
R&D	Research and Development
RIS	Regional Innovation Systems
RTC	Regional Testing Centres
SAP	Situation-Actor-Process
SCX	Sub-Contracting Exchanges
SD	Standard Deviation
SFC	State Financial Corporation
SIDBI	Small Industries Development Bank of India
SIDC	State Industrial Development Corporation
SIDO	Small Industries Development Organization
SISI	Small Industries Service Institutes
SKSSL	Sonakoyo Systems Steering Limited, Gurgaon
SSMI	Small Scale Manufacturing Industry
STC	Super Tools Corporation
SWOT	Strengths, Weaknesses, Opportunities and Threats
TD	Technology Development
TISF	Technology Input Success Factors
TPS	Total Points Scored
TRIPS	Trade Related Intellectual Property Rights
WTO	World Trade Organization
MSMED	Micro, Small & Medium Enterprises Development
TBSE	Technology Bureau for Small Enterprises
LDC	Less Developed Countries
UIC	University-Industry Collaborations

LIST OF RESEARCH PUBLICATIONS

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CHAPTER - I

INTRODUCTION

1.1 General

Today the world is moving from an era of separate national economies to a networked global economy. The advent of liberalization, privatization and globalization has brought forth profound economic, social, environmental and technological pressures on manufacturing organizations. Markets have become more open, competitive and the customers more demanding. Competition is fierce in all aspects of business such as technology, cost, product quality and service. The changes in current business environment are characterized by intense competition on the supply side, and heightened volatility in customer requirements on the demand side.

The increasing global competition, coupled with rapidly changing technologies, and shortening of product life cycles have made corporations vulnerable to failure more than at any time in the past. Post-industrial organizations are now knowledge-based organizations and their success and survival depend upon creativity, innovation, ability for discovery and inventiveness (McFadzean, 1998; Martins and Terblanche, 2003; Yang, 2007). Technological changes and demanding customers are creating a more knowledge intensive, turbulent, complex, and uncertain environment (Singh *et al.*, 2008; Muhammad *et al.*, 2010). Firm's competitiveness is dependent on its ability to provide goods and services more efficiently than others involved in the market place. The intense competition requires that firms excel simultaneously in several areas without trade-off, including innovativeness and responsiveness to their customers. Therefore, organizations should develop core competencies, which give them a competitive advantage over others. Organizations, which are able to continually build new strategic assets faster and cheaper than those of their competitors, create long-term competitive advantages (Ajitabh and Momaya, 2004).

These formidable changes have forced the organizations around the world to adopt innovative and state of the art strategies to suitably address the all-important issues of organizational growth and excellence. Thus organizations are left with no choice but to upgrade the existing systems, products and technologies for survival (Barton 1991; Yang, 2007).

1.2 Technology

The word 'technology' comes from two Greek words *'Techne'* and *'Logos'*. *'Techne'* means an art, skill or craft and *'Logos'* means the study of something, or the branch of knowledge of a discipline. Technology is defined as the practical knowledge, know-how, skills and artifacts that can be used to develop a new product or service and/or a new production/delivery system (Moriarty and Kosnik, 1990). It is defined as the quantum of knowledge by which inputs such as scientific principles, patent information, R&D etc are converted into production of marketable industrial materials, components and products. It is also defined as a body of knowledge, tools, equipments and work techniques derived from both science and practical experience that are used in the development, design, production and application of products, processes, systems, and services (Palaniswami and Bishnu, 1992; Steensma, 1996). It 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). Thus, technology is the purposeful application of information in the design, production, and utilization of goods and services, and in the organization of human activities.

1.3 Need of Technology Upgradation

Technology and its management are today matters of global primacy. In this modern age, technology is the most important resource to any nation. It is the main driver of a nation's economic development.

While the nature of competition among the firms is highly dependent on industry structure, at a high level of abstraction, there are two ways of competing. The first way is through the optimization of production resources in order to gain the market-allowed margins of profit. In a way, this is 'competition through efficiency'. A second way is to disrupt the market through the introduction of new technology products, which gives to the innovative firm a temporary absolute advantage (granted by formal patent or secured by secret) over every other firm. This is ‘competition through innovation’. For ‘competition through innovation’ (i.e. technology upgradation of a firm), there are two options:

- *‘Technology Acquisition’*, in which technology is acquired by the organization from an external source within the country or abroad. This is ‘*innovation from outside*’ or ‘*technology transfer’*.
- *‘Technology Development’*, in which technology is developed indigenously by the organization through in-house research and development efforts. This is *‘innovation from within’* (Ven, 1986; Conceica *et al.*, 2002).

The first option of acquiring technology from an external source may be desirable in the initial stages or even necessary in the high technology areas, but no organization can prosper in the long run if it does not build up a self reliant base for developing technology through in-house research initiatives. Technology acquisition from an external source may lead to a comfortable initial phase because technology accumulation is done in a short time without much R&D effort, but acquisition is a temporary solution to technological problems, which gives only short-term advantages (Myhrvold, 1997). The better option to compete is through indigenous technology development. It is not only the means to increase production, improve product quality and develop new products but also increases international competitiveness, expands exports and ultimately ensures uninterrupted economic growth (Choi, 1989).

The fierce competition situation is forcing the organizations across the globe to realize that their survival is not feasible in the absence of R&D and innovation practices. It is high time that industries wake up and gear up for research initiatives to develop cutting edge technologies for sustained competitive advantage in the global market place. Technology upgradation has become mandatory for economic development, industrial growth, enhanced corporate image, more flexible responses and strategic self-reliance of an enterprise (Momaya and Ajitabh, 2005). Technology upgradation efforts must be placed within the context of market opportunities, customer needs and strategic direction, thereby leading to improving the product and technology portfolio. Without continuous technology upgradation, no enterprise can ever remain competitive and the basis of technology creation and upgradation is research and development (Choi, 1989).

1.4 Status of Technology Development in India

The industrial scenario in the country has undergone a sea-change consequent to globalization and liberalization of economy that began in early nineties. After liberalization was initiated, leading international players targeted India as a key investment opportunity in all areas (Sethi and Sushil, 2000). Fierce competition has come in both from local and global markets. This competition is marked by rapid technological developments and unprecedented obsolescence rates. Today, the biggest challenge before Indian industry is to generate the knowledge base for producing technologies and core competencies to remain competitive globally. This requires extensive research and development efforts for indigenous technology development. In the pre-liberalized Indian economy, organizations had not bothered to invest in research and development. Even after opening up of the economy, they relied and are still relying heavily on external acquisition of technology. The Indian industry has to move away from its complacent approach towards technology upgradation initiatives and start managing innovation in research and development activities to develop cutting edge technologies and products.

According to the Global Competitiveness Report (2010) published by World Economic Forum, India ranks fourth in the world on availability of scientific and technical manpower yet ranks at 43 (out of 133 nations) in *overall technology sophistication*. The paradox is very stark. On one hand, the country has developed nuclear capabilities and has shown a lot of strength in areas of satellite communication, missile technology etc. but on the other hand, performs badly in the export of engineering artefacts. The extent and excellence of capital goods industry is crucial for a nation’s technological leadership and competitive advantage. The country’s export share in the world capital goods market has remained marginal at 0.8 percent (OECD, 2008; Global Competitiveness Report, 2010).

The research and development scenario in the country is not very encouraging. R&D spending as a percentage of GDP in India is only 0.7 percent as compared to China’s 1.42 percent. There are a few countries which already spend more than 3% of their GDP on R&D. For India to reach this league not only must it increase its investment by 30-50 times but its number of R&D workers by 40-80 times. The research and development investments in manufacturing sector in the country are very low, ranging between 0.2-0.5

percent of the total turnover (Prathap, 2010). Also, the pattern of technology funding by the government, does not reflect priorities inferred from economic development and growth objectives. An analysis of R&D expenditure shows that funding for technology in specific sectors is not in consonance with the size of their domestic or global markets. Too much of research and development effort is expended in the public sector. Over 80 percent of the funding for R&D comes from government and most of it is spent in the public sector. Only less than 20 percent of the R&D funding comes from private organizations. In U.S and China, the public sector share is only 30 percent each while in Japan it is only 18 percent. All high technology businesses across the globe have academic ties wherever they are located. This type of industry–institute interaction is missing in the country. India stands at number 46 on university-industry research collaborations. Further, the role of government in providing an environment conducive for development of manufacturing sector in the country is also not very effective. India ranks at 89 in quality of overall physical infrastructure (transportation and communication), 106 in quality of electricity, and 95 (out of 133 countries) in burden of government regulations. The number of patents obtained by Indian firms is almost negligible when compared with developed countries of the world. The country ranks at 58 in the world in use of IPRs and obtaining patents. The record of Indian manufacturing sector in the introduction of new products and processes that have come out with indigenous research is very poor (Chandrashakar, 1995; Jouhari and Mishra, 2000; Global Competitiveness Report, 2010).

1.5 Small Scale Manufacturing Sector in India

Small scale sector has emerged as a dynamic and vibrant sector of Indian economy. According to the Micro, Small and Medium Enterprises Development Act, 2006, ‘small scale enterprises are undertakings having investments in fixed assets in plant and machinery whether held on ownership terms or by lease or hire purchase not exceeding ₹50 million (MSMED Act, 2006). Small sector has played an important role in the industrial development, economic growth and distribution of income in the country. It has performed a vital role in mobilization of capital, generation of employment and minimization of regional disparities of income and value addition (Sardana and

Dasanayaka, 2007). A report prepared by the ‘All India Association of Industries’ (2002) points out that small sector accounts for 40% of the value added in the manufacturing sector, 34% of national exports and 7% of GDP. A major advantage of small units is their very low capital-output and capital-labour ratios. This means that capital investment required per unit of output and per unit of employment is very low. This is of particular importance to a labour abundant and capital scarce economy like India.

Though the development of small scale sector has been an important component of India’s industrial policy over the last five decades, the sector has been suffering because of many factors. The main reasons include inadequacy of working capital, lack of support from financial institutions, lack of technological support, poor leverage to deal with suppliers, lack of managerial expertise, problems related to non-availability of raw materials, inadequate demand and marketing problems, erratic power supply, labour problems, infrastructural constraints, inadequate attention to R&D and inability to face growing competition (Sardana, 2001; Sardana, 2004; Dasanayaka and Nelson, 2007).

The aftermath of 1991 (introduction of globalization and liberalization policies by the government) has impacted the small scale sector in the country in a major way. The key elements of Indian policy for SSI, which included small scale industry reservations, fiscal concessions by way of lower excise duties, preferential allocation of and subsidization of bank credit, and preferential procurement by the government, have ceased to be operative. Quantitative restrictions have been entirely removed effective from 2001-2002, thereby permitting large enterprises (both foreign and domestic) to produce and to import to India (Mohan, 2001). Cheaper imports are available from large multinationals which enjoy the benefits of economy of size. Even the domestic large scale industry which sourced parts, components, finished products from this sector is switching over to foreign manufacturers from China, Hong Kong, Thailand, Malaysia and Taiwan (Sardana and Dasanayaka, 2007).

The over dependence of small firms on external technology acquisition has rendered their available technologies and skills inefficient and outdated. Thus, there is a need to evolve a strategic technology development program for core competency building in small scale manufacturing industry.

1.6 Objective and Research Issues

Amongst the several problems faced by small scale manufacturing organizations in the country, technology obsolescence is one major predicament. There is a lack of any organized attempt to understand how technology upgradation activities are being carried out in the Indian small scale industry.

1.6.1 Objective of the Study

The objective of the present research work is, *'to analyze the indigenous technology development capabilities of small scale manufacturing industry and develop a strategic technology development program for the same'*.

The research is planned to understand the complexities involved in technology development initiatives at organizational level and their linkages with technology capability building and manufacturing performance enhancements.

1.6.2 Issues Covered

The following issues have been taken up in the research work:

- Status of main factors and problems impairing performance of small scale manufacturing industry.
- Status of technology upgradation initiatives in the industrial sector with regard to policies adopted, infrastructural facilities, investments in research function, regulatory support, interaction with other agencies, and management support issues.
- Status of industry with regard to existence of facilities and programs for technology development through indigenous research.
- Status of each component of technology development program in the industry and overall standing of manufacturing organizations in different components of technology development.
- Contributions of technology development initiatives (*Technology Input Success Factors*) towards achieving manufacturing performance improvements (*Development Indicators*).

- Prevalent strategies for technology capability building in the industrial sector with an aim to bridge the gap.

1.7 Scope of Research Work

The study has been carried out in small scale manufacturing units in the state of Punjab located in the northern region of India. Punjab is one of the major industrial states of the country. The main products of small scale industrial sector in the state include cycle parts, auto-components, cutting tools, machine and hand tools, sewing machines and hosiery.

The present research has been limited to the tool industry and auto-component manufacturing units which have direct customers in market and are not just ancillaries to larger corporations. Further, the industrial units included in the study have at least one large scale manufacturing organization or an *original equipment manufacturer* (OEM) as a major customer. The study does not include micro organizations (tiny units) in which the investment limit in plant and machinery is limited to ₹2.5 million. The study has been carried out in industrial units that have successfully implemented or are in the process of implementing proactive technology innovation initiatives. In the present research work, a reasonably large number of manufacturing organizations have been extensively surveyed. The approach has been directed towards justification of strategic technology development implementation program for its support to competitive manufacturing in the Indian industry.

1.8 Research Methodology

The present work has been carried out with a purpose to analyze the technology development capabilities of manufacturing industry through indigenous research initiatives. Taking into view the complexity of the theme and the fact that such studies can be carried out primarily by closely analyzing the approaches adopted by various organizations and the results thereof, it has been considered appropriate to carry out the present work under the overall framework of ‘*flexible systems methodology*’.

1.8.1 Flexible Systems Methodology

Flexible systems methodology involves the use of an optimal mix of qualitative and quantitative techniques of system analysis and design (Sushil, 1993). The philosophy of integration of quantitative and qualitative tools is emerging very rapidly to cater to the needs of diverse decision-making and managerial processes. There are a number of end of continuum paradoxes which have created separate schools of thought. The concept of flexibility provides 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 the end of continuum. In essence, flexible systems methodology states that for a problem situation, an approach out of the existing well researched approaches or a suitable combination 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 systems methodology is built on spectral and integrative paradigm. This methodology is more realistic and by using this, more creativity is applied to problem solving (Sushil, 1994).

There are three basic components that define the dynamic interplay of reality in flexible systems management paradigm. These include *situation*, *actor* and *process*. These components interact flexibly on multiple planes in the ambiguous reality and ultimately melt together into one at the enlightened stage. Thus the research problem is conceptualized as a SAP-LAP (Situation-Actor-Process; Learnings-Action-Performance) paradigm (Sushil, 1997a; 1997b; 2000). In this framework, the 'situation' aspect comprises of the present industrial situation in manufacturing industry, whereas the manufacturing organizations constitute the 'actor' aspect. The role of in-house research and innovation initiatives in building technological capabilities constitutes the 'process'.

It is planned in this research to use flexible systems methodology for exploring and explicating the nature of interactions between technology development initiatives (referred as, *Technology Input Success Factors*) and manufacturing performance improvements (*Development Indicators*) in the industrial sector.

1.8.2 Phases of Research

The present study comprises of two major parts namely ‘analysis’ and ‘design’. Analysis includes all relevant information and data regarding the status of research subject in the engineering industry, reasons thereof and corrective actions that can be profitably applied. Design deals with developing a technology development program using the information as collected and analyzed in the first part. Based on flexible systems methodology, the research work has been carried out in four phases: *clarifying the context*; *understanding and assessing the situation*; *assessing the actor’s capability* and; *evolving a management process*.

The first phase comprises of an extensive literature review regarding economic, technical, regulatory and other related issues regarding technology development capabilities of manufacturing industry. Tactical issues for managing innovations and strategies for bridging the technology capability gap have also been reviewed.

The second phase assesses the status of technology development initiatives and resulting performance improvements in the industrial sector, through a questionnaire based survey of manufacturing units. This phase consists of questionnaire development, its validation and pre-testing, sampling and data collection. It is followed by descriptive and empirical analysis of data to assess the status of various research issues and evaluate the interrelationships between dependent and independent research constructs. Several statistical tools and techniques have been employed in this phase of research work. The convergent and discriminant validities of constructs and their measures have been carried out. ‘*Cronbach’s Alpha coefficient’* has been used for convergent validity to assess the degree to which measures of the same concept (construct) are correlated. Pearson’s correlation coefficient values and ‘*t-values’* have been calculated through t-test to find relationships between various issues of inputs and output performance parameters. The significant correlations obtained as a result of t-test have been validated through ‘*Canonical Factor Loading analysis*’. Canonical loadings measure the correlation between an original observed variable in the dependent or independent set and the set’s canonical variate. Finally, *‘multiple regression analysis’* has been used. It analyzes the relationship between a single dependent variable and several independent variables. This technique has been used to identify a set of variables which conjointly contribute significantly towards the criterion variable.

This third phase of research work describes detailed case studies carried out in manufacturing organizations, which are actors in the present context. The objective of case studies has been to look into and critically analyze various facets of the working of organizations including the need for technology development, the role of technology input success factors and resulting developments accrued as a result thereof. In each case study, the techniques and approaches adopted by organizations for technological improvements, success achieved and modifications made in the future plans have been compiled and analyzed in detail. The main tools used in case studies have been SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, SAP (Situation, Actor, Process) interplay, and LAP (Learnings, Actions, Performance) synthesis.

The last (fourth) phase of research work presents a synthesis of learning issues and outcomes of survey and case studies and their utilization through a qualitative model to evolve a technology development program for small scale industry. Qualitative modeling used in this study involved deriving expert opinion and using this along with findings of previous phases in a structured manner. The critical learning issues of the survey and case studies have been synthesized. From this synthesis and the literature available, the actions for implementation in the manufacturing sector have been recommended through the qualitative model. Guidelines for effective strategic measures to be taken to overcome barriers in technology development implementation program have also been evolved.

1.9 Organization of Thesis

The write up of the thesis has been organized into seven chapters:

Chapter I (Introduction) highlights the need of developing a strategic technology development program for Indian small scale manufacturing industry. Further, the objective and issues, scope of the study, overall methodology and organization of research work has been covered in the chapter.

Chapter II (Literature Review) attempts to record in brief, the findings from literature on various components of technology development initiatives and elucidates their interaction with manufacturing performance enhancements. A methodical review of the concepts, taxonomy and related facets of technology input success factors in the manufacturing sector has been carried out. Based on the description of all related concepts and models proposed by various researchers, a conceptual framework has been developed and explained.

Chapter III (Design of the Study) introduces overall design of the study, which includes methodology adopted for carrying out the research work as well as various phases of the study. The details of work done in each phase; the tools, techniques and models used in the work have also been covered.

Chapter IV (Survey based Research Results) presents the results of detailed survey conducted in small scale organizations in the state of Punjab (northern region of India). The chapter discusses designing of the questionnaire, its validation and pre-testing, questionnaire administration and data collection. It presents the descriptive and empirical analysis of data. Descriptive analysis for various research parameters has been carried out to assess their status in the manufacturing organizations. The correlation and regression analysis has been carried out to evaluate contributions of technology development initiatives towards achieving manufacturing performance improvements.

Chapter V (Case Studies) describes the detailed case studies carried out in manufacturing units. The general framework of case studies includes chronological account of development of manufacturing units (*milestones & business strategy decisions*) along with efforts made from time to time for technology development; product range and customer details; SWOT analysis, S-A-P interplay, and L-A-P synthesis. The case studies have been conducted at Super Hobs and Broaches Private Limited (STC), Patiala and; Pye Hand Tools Private Limited (PHTL), Ludhiana.

Chapter VI (Synthesis and Design of Technology Development Program) synthesizes the learning issues obtained through survey and case studies and utilizes them through a qualitative model to evolve a suitable plan for managing technology development program in the industrial sector. The chapter discusses the main techniques used for qualitative modeling. These include Options Field Methodology (OFM), Options Profile Methodology (OPM), Analytic Hierarchy Process (AHP) and Fuzzy Set Theory (FST). It presents the utilization of these techniques to prepare dominance matrices under various situations of cautious optimism. Finally, a conceptual framework showing the preferred strategies to meet the objectives of research problem has been developed, presented and discussed.

Chapter VII (Results and Conclusions) covers the summary of research work and presents the results and conclusions. The summary has covered the methodology, tools and techniques used in the work. The results of survey, case studies, and qualitative modeling along with major inferences and learnings drawn from them have been presented. Based on the results and findings, conclusions have been drawn and recommendations made. The chapter also discusses the main limitations of the present study and lists various areas which can be taken up for further research.

1.10 Concluding Remarks

In the current dynamic world, 'change' is the only permanent thing. Technology and knowledge have become the buzzwords of the new millennium. Enormous activities are underway in research and development areas paving ways for newer technologies. This rapid pace of developments is also leading towards a new class of technology driven enterprises, which are being considered as an important factor for economic development of nations and a source of value added employment generation. At the same time, the process of globalization, establishment of World Trade Organization (WTO), stricter quality and environmental considerations, imposition of trade barriers by developed nations, and information technology revolution continue to adversely affect the conventional competitive advantage of small units in developing countries and threaten their survival in the marketplace. Technology upgradation has become mandatory for industrial growth, more flexible responses and strategic self-reliance of an enterprise.

The present work has been carried out to analyze the technology development capabilities of small scale units in the country through indigenous research initiatives. There have been limitations of time and resources but an organized attempt has been made to make this study exhaustive, intensive and as broad based as possible. However, the study has been limited to tool and auto-component manufacturing units only in the state of Punjab.

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

Chapter - II

LITERATURE REVIEW

2.1 Introduction

The results of any research are useful when relevant previous literature has been reviewed and analyzed. This chapter attempts to record in brief, the findings from literature on various aspects of technology development initiatives in the manufacturing sector and elucidates their interaction with performance enhancements. A methodical review of the concepts, taxonomy and related facets of Technology Input Success Factors in organizations has been carried out. The interfacing issues, current practices, limitations of existing approaches, future directions and areas of further study have also been discussed.

2.2 Need for Technology Development

In today's competitive business environment, global competition is forcing companies to perpetually seek ways to improve their products and services. The pressure on manufacturing units to adapt to new technologies and external threats requires resourcefulness, creativity and innovation. The decision to innovate must be backed by actions that create an environment in which people are so comfortable with innovation that they create it. Enormous research has taken place to explain why certain organizations are more innovative than others. Drawing on earlier work, this chapter reviews relevant writings to address the means of encouraging technological innovations in working environments. The study presents a detailed analysis of various factors and issues affecting technology development initiatives of industry and their relative significance in affecting improvements.

The literature reported has been organized into the following broad headings:

- Manpower Competence and Management Commitment
- Technology Infrastructure
- Regulatory Support
- Interaction with Others

Based on the description of all related concepts and models proposed by various researchers, a conceptual framework has been developed and explained.

2.3 Manpower Competence and Management Commitment

Literature highlights that top management support and competency of employees is critical to the success of technology development initiatives of manufacturing organizations. Innovative organizations believe that the bottom line difference between success and failure is finding, developing and nurturing the right people (Ahmed, 1998a; Harney and Dundon, 2006; Paauwe and Boselie, 2005; Nunes *et al.,* 2006). Such organizations explicitly strive towards the attraction, development and retention of creative talent. Many innovation champions are identified, recruited, developed, trained, encouraged and acknowledged throughout the organization. Their strategies include effective manpower planning, realistic performance plans, development oriented performance appraisal, effective learning systems, performance guidance and other mechanisms such as mentoring (Cook, 1998; Wang *et al.*, 2007; Neely, 2009).

The important issues under this key area are discussed as follows:

2.3.1 Availability of Skilled Workforce

Both technology use and innovation increase the need for highly skilled employees. Firms which adopt advanced technologies, continually work to improve the quality of their products, and strive to be first-to-market with new products require a workforce that is adaptable, skilled, and educated (Baldwin and Da Pont, 1996).

Skills development is a crucial element of any strategy which aims at upgrading technology within a firm. A highly skilled workforce is the key to increased competitiveness and sustainable growth. It is commonly acknowledged that an increase in productivity of labour may result from acquisition of relevant skills (Booth and Snower, 1996; Godfrey and Peter, 1997; Sternberg *et al.*, 1997; Aderemi *et al.,* 2009). Basic and strategic management skills are crucial for the success of manufacturing organizations (Keogh and Stewart, 2000; Al-Madhoun and Analoui, 2003; Temtime and Pansiri, 2005).

Innovative organizations have adequate strength of multi-skilled workforce. Strategies range from identification of areas of skills in which shortfalls either occur or can occur and efforts are made to generate those skills. Often innovative organizations encourage their employees to work in various departments and divisions in order to gain a well founded experience. The varied exposure helps them to appreciate the problems and pressures of different parts of the organization, and to become better managers of the multifaceted innovation process (Gupta and Singhal, 1993).

2.3.1.1 Skill Development in Small Firms

Lack of proper human resource is one of the major impediments to small manufacturing organization's efforts in the development of new industrial technology and such organizations have to increasingly rely on external knowledge sources to build up technological competence (Sugasawa and Liyanage, 1999). Pressures faced by SMEs come from a number of different sources. Primary concerns are often financial, including the need for seed and expansion capital. As companies grow, they may well seek large scale financing for growth, or become a target for acquisition. It is vital that employees are appropriately experienced and trained to evaluate threats and opportunities. The environments in which these companies work are dynamic, and the technology they work with is often transient. Successful exploitation of technology in a dynamic environment depends crucially upon a skill base capable of identifying opportunities for, and managing, technological development (Oakey, 1995; Scott *et al.*, 1996).

Small scale manufacturing enterprises are found unwilling to explore external resources, as they associate this with a loss of control or as an embossing indictment of the value of their in-house expertise. This suggests deeply rooted obstacles to the further acquisition of technological and organizational expertise. Small firms often rely on their own experiential know-how, and train up their own operative and intermediate level skills. The firms generally remain insular and autonomous and fail to recognize the underlying or latent skill deficiencies. The increased propensity for jobs to be created and/or maintained via the use of temporary contracts rather than permanent employment affords employers the flexibility they desire. However, the resultant increase in job insecurity may cost them both the skills and knowledge that are gained from longer terms of employment and the likelihood of individuals receiving formal skills development. Although the skills and knowledge of each staff member can be of critical importance to a small firm, there can be a lack of contact with appropriate facilitators (training organizations). Smaller companies often do not have the capacity to undertake skills forecasting and strategic analysis. While this may well hinder a firm's ability to manage the problems and barriers they face, it has wide-reaching consequences as skill shortages in small firms can have an adverse effect on competitiveness (Lange *et al.,* 2000). The main barriers to skills development are summarized in Table 2.1.

Table 2.1 Barriers to Skills Development in Small Units, (Lange et al., 2000)

BARRIERS TO SKILLS DEVELOPMENT	**DESCRIPTION**
Cultural Barriers	*Include primarily attitudes towards skills development*
Financial Barriers	*refer to those barriers directly relating to the cost or perceived cost of training and learning*
Access and Provision Barriers	*refer to problems which either prevent interested parties from accessing skills development opportunities or manifest themselves in the lack of suitable provision of learning*
Awareness Barriers	*which relate to the knowledge of learning opportunities*

In recent years, particular emphasis has been placed on the development of new skill initiatives aimed at small and medium sized enterprises. Historically, government strategies have focused on promoting formal skills development to businesses while businesses have often bypassed this by recruiting, or selectively buying in, individuals with the required skills set. Government has been chasing businesses to develop their workforce through training yet businesses have been seeking to recruit a 'final product'. Individuals in turn appear to be unable or unwilling to purchase the skills required due to financial constraints or the perceived insecurity in the labour market which questions any significant personal investment in skills. Unless these constraints and misperceptions are removed, the skill gap and/ or shortages are likely to continue (Lange *et al.,* 2000; Taxell, 2009).

2.3.2 Education Level of Employees

Technological developments and growing competition in the market ask for continuous improvement of knowledge of employees, not only for securing their work places but also for increasing the companies' competitiveness and economic development of society. As a consequence more importance should be attached to the educational system of continuous professional training. Well educated people with better qualification adapt more rapidly to technological changes and assure economic adaptiveness and growth of productivity in the long run (Carmen, 2008). Employee education increases the formation of new ventures, the likelihood of developing new products, and increases the sales growth rates of emerging firms (Charney and Libecap, 2000; Indarti and Langenberg, 2004).

In tomorrow's business world success will be critically influenced by the degree to which firms utilize new knowledge to support innovation. The foundation of organizational competitiveness has shifted from physical and tangible resources to knowledge (Lei *et al.,* 1999; Wong and Aspinwall, 2005, Yang *et al.,* 2009). As market trends evolve and core business activities shift into new territories, there is a need for organizations to facilitate a corresponding change in the skill base and education level of the workforce. High-performing organizations spend more time on education and training – not just on technical, task-related skills, but also on communication and team skills (Leede *et al.,* 2002). Education is linked to higher entrepreneurial performance and productivity (Keogh and Stewart, 2000; Lange *et al.,* 2000; Dickson *et al.,* 2008).

The benefits of education and training, which result in gain in skills by individuals, also have the effect of increasing adaptability. Better educated workers provide the flexibility needed to switch production between sectors and branches, and to restore external balance through innovation, retraining and relocation. This adaptability is essential for keeping labour and capital employed and maintaining competitiveness (Booth and Snower, 1996; Godfrey and Peter, 1997).

2.3.2.1 Employee Education in Small Firms

Small scale organizations do not exploit recruitment to the same degree as larger firms and tend not to recruit from higher education sector because of financial reasons. As such graduates and post graduates are perceived as more expensive to hire. Further, these organizations prefer to external recruitment of experienced staff rather than training the staff internally. Training in such organizations is usually adhoc and underlines poor attitude towards learning (Cook and Nixson, 2000; Abor and Quartey, 2010).

2.3.3 Training of Employees

The pace at which education and training systems transmit knowledge and skills of requisite quality directly affects the pace of technological developments. Training greatly compresses the time to acquire skills over earlier methods, such as apprenticeship. It achieves this condensation through a process involving careful analysis of job requirements, determination of skill needs, specification of objectives, and design, delivery and evaluation of an instructional program (James and Roffe, 2000). Studies evaluating creative training find that trained subjects perform better than untrained subjects at using instructions to defer judgment and there is a moderate to large effect on creativity (Rose and Lin, 1984; McFadzean, 1998). Training interventions that teach managers how to foster their subordinate's creativity are more valuable than training interventions directed at the subordinates themselves (Williams, 2001).

Innovative organizations create and maintain a learning environment by keeping knowledge and skills of employees' up to date. Such organizations continually educate and train their employees in various skills, matching employee's professional career goals with organization's needs (Bessant, 1993; Locke and Kirkpatrick, 1995; Samaha, 1996; Arad *et al.,* 1997; Holbeche, 1998; Goncalo and Staw, 2006). Innovative organizations empower their employees more, study the marketplace regularly and provide more training to their managers than in less innovative organizations. Innovators and advanced technology users train their workers in response to skill shortages. They provide training when introducing new technologies and prefer training that is highly firm-specific (Barnett and Storey, 2000; Chandler *et al.,* 2000; Georgellis *et al.,* 2000; Beaver and Prince, 2002; Salavou *et al.,* 2004; Laforet and Tann, 2006).

A brief account of various training techniques is presented in Table 2.2.

Table 2.2 Techniques to Stimulate Creative Thinking

Technique	Description	Supporting Literature
Brain storming	Writing ideas and gaining stimulus from others' ideas. Uses a five-stage approach: *Fact Finding, Problem Finding, Idea Finding, Solution Finding* and *Acceptance Finding.* Another five-step approach includes *Preparation, Orientation, Idea Generation, Evaluation* and *Post-Session Follow Up.* Emphasis is on combining the ideas generated. Output of brainstorming sessions can be improved through a technique called 'IDEAS'	***Osborn, 1957; VanGundy, 1997; McFadzean, 1998, 2000; Williams, 2001***
Productive Thinking Program	Presents the participants with several instructional units consisting of a mystery story that leads them through problem-solving using various techniques	***Covington et al., 1972***
Purdue Creative Thinking	Uses a series of tape-recorded presentations and narratives integrated with problem-solving exercises. The presentations contain instructions and persuasive statements on creative thinking, followed by stories about famous leaders, inventors and discoverers	*Feldhusen et al., 1970*
Self-Statement Creativity	Teaches participants to use self-instruction statements believed to enhance creative performance by making the participants more aware of their internal monologue and sensory imagery	*Meichenbaum, 1975; Williams, 2001*
Synectics	Synectics is guided by two principles: make the strange familiar (through metaphors and analogy) and make the familiar strange (by finding new ways of viewing the problem)	*Amabile, 1996; Williams, 2001*
Object Stimulation	Group members are asked to develop a list of objects that are completely unrelated to the problem. Each individual then needs to select one object and describe it. Each description is used as a stimulus to generate novel ideas	*McFadzean, 1998*
Wishful Thinking	Forces participants to look at a perfect future with the assumption that everything is possible. Group members examine each fantasy statement and develop ideas on how these can be achieved. The new ideas developed are explored and linked back to the present problem situation	*McFadzean, 2000; Morris, 2005*
Rich Pictures	Participants are asked to write a brief statement of the problem. The facilitator then asks each individual to draw two pictures. The first drawing is a picture of how each participant likes to see the situation in the future. The second picture is a drawing of how the participants see the present situation. From the descriptions given, new ideas are generated	*McFadzean, 2000*
Idea Competition	Bridges the innovation gap existing between R&D department and operational units. Builds a communication bridge over the innovation gap. This bridge can be used routinely to feed new ideas into the recently implemented innovation process, which thus becomes part of the daily business	*Schepers et al., 1997*
Other Miscellaneous Techniques	Mutating Metaphors, Role Playing, Visualization, Need Finding, Transforming Perceived Problems into Opportunities, Assessment of Strategies, Transcendental Exploration, Brain Skill Management Programme, Reward-for-Creativity Programme, Team Evaluation and Management System Model, Fisher Association Lists, Game Playing, Requisite Variety, Wandering Incubation, Hexagons, Force Field Analysis, Word Diamond, Role-storming, Heuristic Ideation	*Markley,1988; Watson,1988; Edwards,1989; Plunkett, 1990; Tulenko and Kryder, 1990; Agor, 1991; Thompson, 1991; McFadzean, 1998*

Training techniques differ on several dimensions, whether the training takes place on-the-job or off-the-job, whether the trainee performs as an individual or as a part of group, how the problems are presented and whether the trainee's performance is written or behavioral (Williams, 2001). Many theorists and practitioners advocate use of a number of different techniques that can stimulate and encourage creative thinking (McFadzean, 1996; VanGundy, 1988).

Training techniques are broadly classified into three categories: paradigm-preserving, paradigm-stretching and paradigm-breaking. Paradigm-preserving techniques do not tend to change a participant's perspective. No new elements or relationships are introduced in the problem space. Paradigm-stretching techniques encourage users to stretch the boundaries of the problem space. Paradigm-breaking techniques encourage participants to break down the boundaries of the problem space and look at something entirely new (McFadzean, 1996; 2000).

2.3.3.1 Employee Training in Small Units

Innovative organizations operate training programs for their managers to make them aware of organization's competition, and to identify strategies to face the competition. These organizations ensure that each manager spends at least some fraction of his/her payroll on training (Business Week, 1987; 1988; William, 1990). Apart from blue-collar workers who receive on-the-job training; supervisors, middle and senior managers receive outside and in-house training. However, training is more limited in less innovative small scale manufacturing enterprises. This seems to be consistent with the literature suggesting small manufacturing organizations have shortage of skills and technology and face training problems (Scott *et al.,* 1996; Westhead and Storey, 1997; Marlow, 1998; Hill and Stewart, 2000; Lange *et al.,* 2000; Matlay, 2004; Storey, 2004; Holden *et al.,* 2006). Maintaining competitiveness relies not only on job-specific training or on-the-job training, but also on a greater degree of formal training. The advantage of formal training is the gain of accredited experience and knowledge from other sources (Lange *et al.,* 2000). SMEs that conduct management training show a statistically significant advantage in terms of both employee and turnover growth, compared with those that either do not conduct training, or prefer to invest in informal training. It is important to distinguish between what is practiced (due to resource scarcity) and what is appropriate. There is a clear and significant finding that formal training is associated with performance over and above that provided by informal training in small manufacturing firms (Jayawarna *et al.,* 2007). Further, highly innovative organizations place great emphasis on employee development training through industrial education of young people in locality through modern apprenticeships, student placement, and school visits – a clear contrast with SMEs in general (Barnett and Storey, 2000).

Today, the time is of discontinuous change, in which even the recent past may offer no clue to the immediate future in terms of technology or business. These qualitative shifts have revolutionized the ways of thinking, entailing a radical overhaul of concepts, attitudes and values. It follows that education and training must also change to meet the demands of a culture in which innovation becomes the universal norm (Handy, 1989). A broad strategy for technical education and training (at technician level and below) should be to develop a system which is flexible and responsive to economic changes, i.e. to mount courses quickly to meet specific scarcities as they arise. It is critical that any expansion be 'phased in' so as to avoid the creation of a surplus in the short term and that any additional facilities built to provide for expansion of training in one field should be sufficiently flexible to switch to other training courses, to reflect changing demand (Castley, 1996).

Organizations may invest a great deal in formal education and training of their employees, but a greater part of learning comes from participating theory on the job. This occurs on a day to day basis from working with mentors and coaches, and from acquiring tactic knowledge that cannot be obtained from theoretical learning. However, a balance is needed. Neither investing only in formal training and education, nor placing all the emphasis on informal training, is a good strategy. What is required is the best mix of formal and informal means. Further, an organization needs the correct mix of visionaries and doers in order to achieve creative success. Too many dreamers and it will get a lot of ideas that are not fulfilled (frustration), too many doers and there will be a tendency to continue to replicate how a task was last time.

2.3.4 Availability of Scientific Manpower

The values and beliefs of management are reflected in the type of people that are appointed. When human resource is competitive, it can push the boundaries of technical competence into the area of unknown or the new. Although innovation is often seen as a technological breakthrough, it is also very much the art of an individual who has triumphed over the status quo. This triumph requires personal initiative. Human factor in terms of skills, technical expertise, training involvement, and attitude has been found to be most significant for achieving technological advances (Frohman, 1994; Gourthy *et al.,* 1996).

Innovative organizations make strategic choices with regard to their human resources (McFadzean, 1998; Pihkala *et al.,* 2002). Personality traits for innovation include broad interests, attraction to complexity, high energy, independence of judgment, intuition, self-confidence, and ability to accommodate opposites. Persistence, curiosity, intellectual honesty, and internal locus of control (reflective/introspective) are also important. Personality traits like intelligence, knowledge, eagerness to learn, inquisitiveness, diversity, risk taking and strong desire to fulfill goals are also required for innovation (Amabile, 1988; Woodman and Schoenfeldt, 1990; Bresnahan, 1997; Brand 1998; Gardenswartz and Rowe, 1998; Martins and Terblanche, 2003; Dubina, 2005). Cognitive factors also appear to be associated with the ability to innovate. Cognitive parameters affecting idea production include associate fluency, speech fluency, word fluency, originality, flexibility and elaboration (Guildford, 1983).

Although there appears to be a general agreement that personality is related to creativity, attempts to try and use this inventory type of approach in an organizational setting as predictor of creative accomplishments is not always correct. Nevertheless it does highlight the need to focus on individual actors, and to try and nurture such characteristics or at least bring them out, if necessary, in an organizational setting.

2.3.4.1 Human Factor in Small Units

With small firms, problems arise when attempting to attract and retain good quality experienced staff. These units find themselves competing against the employees' packages offered by larger organizations, including salary and bonus, perks and other non-financial rewards. In addition to this, the career options offered by large established firms might be seen as more stable and progressive than the relatively risky option of working for a small firm (Herbig and Palumbo, 1996; Keogh and Stewart, 2000).

2.3.5 Effective Reward Structure

In-house reward systems to motivate employees for achieving goals of innovation, productivity and profitability are widely used by corporations. In organizations where innovation is the driving force, an effective reward system motivates employees to take risks, generate new product ideas, experiment and develop new products. Employee reward systems include such practices as providing freedom for creativity, financial rewards, promotions, and other forms of recognition. Whatever form an award might take (peer recognition, banquet, plaque, letter of appreciation etc), its very existence can galvanize employee contributions (Badawy, 1978; Robert, 1988; Gupta *et al.*, 1991; Koning, 1998; Kiran and Jain, 2010). If creative behavior is rewarded, it becomes the general, dominant way of behaving with employees. The problem is that many organizations hope that personnel will think more creatively and take risks, but they are rewarded only for well-proven, trusted methods and fault-free work (Gupta and Singhal, 1993; Martins and Terblanche, 2003).

Extrinsic rewards include pay hikes and financial benefits (bonuses, shares and stock options). These rewards play an important role, especially in situations where an innovator might become dissatisfied if not adequately compensated. However, simply raising an employee's salary rarely makes him more innovative. The main purpose of pay hikes in innovative organizations is to reward creative performers just enough that they continue to excel, but not so excessively that the raise ceases to motivate. Pay raises for employees who are not as creative should be enough to keep them satisfied, but not large enough that creative performers become dissatisfied with the closeness of their respective pay scales. Some innovation based organizations have different pay raise policies for performers and non-performers (Business Week, 1987; Herbig and Palumbo, 1996). *Intrinsic rewards* are based on internal feelings of accomplishment by the recipient and include increased autonomy and improved opportunities for personal and professional growth. Innovation based organizations know how to manage, motivate and reward employees. These organizations rely heavily on personalized intrinsic rewards whereas less innovative organizations tend to place almost exclusive emphasis on extrinsic awards (Plunkett, 1990; Ahmed, 1998b; Morris, 2005).

Some of the important intrinsic motivation tools are presented in Table 2.3 and discussed as follows:

Bootlegging: Innovative organizations allow their employees time to think creatively, to experiment and to engage in their own research projects (Mumford and Gustafron, 1988; Rehfeld, 1990; Shalley, 1995). Time pressure is a real barrier to creativity. When people work under great pressure, a kind of time-pressure hang over exists. It stifles creativity because people can not deeply engage with the problem. Creativity requires an incubation period. When managers do not allow time for proper experimentation, they unwittingly stand in the way of the creative process (Anderson *et al.,* 1992; McFadzean, 1996; Filipczak, 1997; Amabile, 1998).

Employee Empowerment: Empowering to innovate is one of the most effective ways to mobilize the energies of employees to be creative. Combined with leadership support and commitment, empowerment gives people freedom to take responsibility for innovation (Dubina, 2005). Top management prescribes a set of strategic goals, but allows personnel great freedom within the context of goals. Employees have the freedom to do their work and determine procedures as they see fit within the guidelines provided (Judge *et al.,* 1997; McFadzean, 1998; Martins and Terblanche, 2003; Morris, 2005). A serious problem with empowerment occurs in organizations which do not have a strong value system. Such organizations are not capable of driving the activities in a unified and aligned manner. In these conditions, empowerment is little more than abdication of responsibility. Another problem in empowered innovation is that every one is encouraged to participate in cross-functional process involvement to an extent that almost everybody loses track of who is accountable for what. The result of unrestricted and uncontrolled empowerment is chaos. In innovative organizations, employees understand the primacy of innovation agenda and know how far they are being empowered to achieve those ends. Such organizations draw action boundaries through a process of explicitly defining the domain of action and priority, and the level of responsibility and empowerment provided to reach those ends (Ahmed, 1998b).

Table 2.3 Motivation Tools of an Effective Reward System

Technique	Description	Supporting Literature
Bootlegging	Employees know how much time and effort they can spend on their pet projects so that their routine operations are not made sub-optimal. Personnel are, for example, allowed to spend fifteen percent of their time on generating new ideas and working on favorite projects	*Anderson et al., 1992; McFadzean, 1996; Filipczak, 1997; Amabile, 1998*
Employee Empowerment	Freedom as a core value in stimulating creativity is manifested in empowerment and decision making. Top management prescribes a set of strategic goals, but allows personnel great freedom within the context of the goals. Employees have the freedom to do their work and determine procedures as they see fit within the guidelines provided	*Judge et al., 1997; Ahmed, 1998b; McFadzean, 1998; Martins and Terblanche, 2003; Dubina, 2005; Morris, 2005*
Balanced Autonomy	Have control over the means as well as the ends of one's work. Top management retains strategic autonomy and provides operational autonomy for individuals. A fine balance between operational and strategic autonomy leads to innovation	*Business Week 1990; Ahmed 1998b; Berglund and Hellstrom, 2002*
Fellowships	Reward the scientists and engineers by providing generous research budgets and a broad latitude to pursue projects without interference. Provide small in-house grants to ensure that good ideas do not languish due to a lack of resources	*Roberts,1980; Business Week, 1990*
Personal Idiosyncrasy	Accommodate personal idiosyncrasies. Allow employees some personal discretion to suggest that they are valued for their contributions	*Andriopoulos, 2001*
Promotion	Promote employees from within to fill the available non-entry-level positions. Also, install a dual track career ladder. Management and administrative employees move up a managerial track, while technical and professional employees move up the scientific track. Employees can switch tracks. Positions on both tracks are matched in proportion, pay, status, and influence.	*Sacco and Knopka, 1983; Wolf 1985, 1987, 1989; Alicia, 1986; Business Week, 1990*

Balanced Autonomy: Giving researchers greater autonomy increases their productivity dramatically. Autonomy is having control over the means as well as the end of one's work (Berglund and Hellstrom, 2002). Autonomy is strategic or operational. Strategic autonomy is to set one's own agenda. Operational autonomy is the freedom to attack a problem in ways that are determined by the individual self, once it has been set by the organization. Innovative organizations retain strategic autonomy for top management. Top management defines the ultimate goals to be attained but there after provides freedom for individuals to be creative in deciding ways to achieve the goals. Giving strategic autonomy, in the sense of allowing individuals a large degree of freedom to determine their destiny, ultimately leads to less innovation. Having too little operational autonomy also has the effect of creating imbalance. Here the roadmaps become too rigidly specified, and control drives out innovative flair leading eventually to bureaucratic atmosphere. A balance between operational and strategic autonomy leads to innovation (Business Week 1990; Ahmed 1998b).

Management should be sensitive as to which method of reward and recognition inspires employees to be more creative. Motivational or intrinsic orientation brings about far greater creativity in people than extrinsic orientation governed by the reward-for-creativity strategy (Plunkett, 1990). Extrinsic rewards have to be present at a base level to ensure that individuals are at least comfortable with their salary. Beyond the base salary thresholds, innovation is primarily driven by self-esteem level rather than monetary rewards. With extrinsic rewards, people believe that every move they make is going to affect their compensation and tend to get risk averse. Such rewards can have a negative effect on creativity, especially when employees perceive the financial incentive as a means of being bribed or controlled. Research shows that employees put far more value on a work environment where creativity is supported, valued, and recognized. It is critical to match employees to projects not only on the basis of their experience but also in terms of where their interests lie. Employees are most creative when they are stretching their skills. If the challenge is far beyond their skill level, they tend to get frustrated; if it is far below their skill level, they tend to get bored. There is a need to strike the right balance (Ahmed, 1998a; Morris, 2005).

Developing new products requires teamwork. Innovative organizations strike a balance between rewarding a team as a whole and rewarding individual members for their contributions. In a new product development project, the team members are highly interdependent and therefore the reward system should be designed to encourage cooperation rather than competition. Innovative organizations clearly identify the specific situations in which team or individual rewards are warranted. However, research indicates that teams which are rewarded as a whole almost always out-perform teams in which some members are rewarded more than others (Johnson *et al.,* 1981; Mower and Wilemon, 1989; Mosey *et al.,* 2002; Mosey, 2005).

2.3.6 Reaction to Project Failures

Senior management support is very important for creativity and technological innovations. Innovative firms have appropriate systems and procedures, which emphasize that creative effort is a top priority within the company (Morgan, 1991; Anderson *et al.*, 1992; Amabile *et al.*, 1996; Jones and McFadzean, 1997; Amabile, 1998; Brennan and Dooley, 2005; Mishra and Srinivasan, 2008).

Creative effort implies personal risk, as it involves ideas or activities that are not within the normal range of work (Todd, 2004). New ideas can pose a risk because they represent disturbances in routines, relationships, power balances, and job security. The assumption that risks may be taken as long as they do not harm the organization does not encourage employees to be creative (Filipczak, 1997; Berglund and Hellstrom, 2002).

Too many management controls inhibit risk taking and consequently creativity (Judge *et al.*, 1997). There should be freedom to experiment, to do things and fail, to challenge the status quo, discussion of dumb ideas, and no punishment for mistakes Employees think creatively when they are not afraid of criticism or punishment. Allowing individual's space to fail without attributing blame promotes innovation over convention. Rigid and punishing norms promote conformity and restrict creativity. Creative employees need to be in an environment where top management takes a long-term view in order to tolerate a few mistakes (Alicia 1986; Amabile, 1988; Anderson *et al.*, 1992; Ahmed, 1998b; Brand, 1998). Mistakes can be ignored, covered up, used to punish someone or perceived as a learning opportunity (Brodtrick, 1997). In highly innovative organizations, as much as 70-90% of the projects end in a failure. These failures are not discarded. Instead they are stored for possible adoption at a later time when they may provide answers to future problems. The logic is to institutionalize an effective method for maintaining organizational memory (Ahmed, 1998b).

It is important that a balance be reached in the degree to which risk taking is allowed. This is achieved by spelling out expected results, assigning responsibility of monitoring and measuring risk taking to someone in the organization, creating a tolerant atmosphere in which mistakes are accepted as part of taking the initiative, regarding mistakes as learning experiences, and assuming that there is a fair chance of risks being successful (Martins and Terblanche, 2003). Employees should know the level of risks that can be taken safely. This helps them to define the space within which they are allowed to act in an empowered manner, and the occasions when they need to approach organizational ratification for engaging in actions. They should know the penalties if inefficiencies creep into aspects of their task. Without knowing that risk tolerance exists within the organization, employees tend not to be willing to try and innovate, or engage in activities that are a departure from tradition (Ahmed, 1998b; Blumentritt, 2004).

Innovative organizations actively celebrate success and recount stories of success throughout the organization to motivate, direct and guide actions. These stories are used to illustrate and demonstrate the potential for action and the type of behaviour that is expected of employees (Ahmed, 1998a; 1998b). Successful organizations reward success and acknowledge and celebrate failures, for example, by creating opportunities to openly discuss and learn from mistakes (Ryan, 1996). Employees are rewarded for their efforts, not just for results (Roberts, 1980; William, 1990).

2.4 Technology Infrastructure

Technology infrastructure has become critically important in a world characterized by an abundance of emerging technologies. All major technology breakthroughs require a surrounding infrastructure (Best and May, 1997). Organizational structure should be such that there are adequate funds, materials, production facilities and information support system to sustain innovation (Amabile *et al.,* 1996; Ghorbani and Bagheri, 2008).
The important issues under this key area are discussed as follows:

2.4.1 Project Resources

Project resources include an array of elements: people with necessary expertise, sufficient funds, material resources, systems and processes for work, and relevant information (Amabile and Gryskiewicz, 1989; Amabile *et al.*, 1996; Williams, 2001; Pihkala *et al.*, 2002). The physical environment or setting influences the degree to which divergent thought process is used. Divergent thinking has a broad, relaxed focus of attention that requires a sense of psychological safety and peacefulness. Appropriate space and resources enhance organizational creativity (Isaksen, 1983). Resources are important not only for functional support, but also because having an adequate level of resources for the task/ project influences workers' perceptions that the project is valuable and worthy of organizational support (Amabile *et al.,* 1996; Arad *et al.,* 1997). There is a threshold of sufficiency and when resources are added above this threshold, creativity is not enhanced. Below this threshold, a restriction of resources also limits creativity since employees are more occupied with finding additional resources and not with actually developing new products or services (Amabile, 1998).

2.4.2 Modernization and Renovation Programs

The absence of adequate infrastructure services is one of the main problems that hinder efforts to develop technology (Odette *et al.,* 2006; Ridley *et al.,* 2006). Innovative organizations have better systems and technology in place than their competitors (Laforet and Tann, 2006). Capability base of manufacturing firms is enhanced through internal learning, involving investments in formal R&D, experimentations, and making minor adaptations to products, processes and organizations, among others. Organizations, which are able to continually build new strategic assets faster and cheaper than those of their competitors, are able to create long-term competitive advantages (Ajitabh and Momaya, 2004). For better technological advances, new infrastructures (mainly telecommunication), information technology, modern production systems and new strategic thinking practices are needed (Man *et al.,* 2002; Sheel, 2002; Vargas and Rangel, 2007). Advanced equipment and resources are the most important factors to support public and private projects regarding research and development, innovation and technology modernization (Smilor *et al.,* 1988).

Technology infrastructure is like a lift. It remains unseen and unimportant when it is working properly and yet becomes hugely apparent and critical when it breaks down. However, when a lift breaks down, one can always walk. When infrastructure collapses, it takes the organization pretty much out of business (Best and May, 1997).

2.4.3 Financial Support to Research Initiatives

Developing an adequate financial program that supports training and educational activities for innovation, and building a physical infrastructure for enhancing organizational capabilities are the key success factors for highly innovative companies

(Smilor *et al.,* 1988). Manufacturing organizations in developed countries spend substantial fraction of annual turnover on technology development (Chandrashekhar, 1995). Having an innovation budget is one of the main factors that distinguish innovative firms from their less innovative counterparts. Management clearly earmarks funds for R&D activities aimed at innovations for new product and process developments (Souitaris, 2002; Huang, 2008). Higher R&D spending heightens the level of research activity within a firm and builds specialized scientific and technical expertise as a result. The tangible outcome of this is the ability to develop several significant product technologies (Charles and Burton, 1995; Parthasarthy and Hammond, 2002).

Infrastructure absolutely is a prerequisite to a global organization. Infrastructure is not a technical problem. Infrastructure is a money problem and it does not end. It could be portrayed as a negative annuity. The most important thing to remember is that infrastructure is an ongoing responsibility. It never finishes because technology is always moving (Best and May, 1997).

Capital is a necessary component for innovation but is not in itself sufficient. Not only the quantity of financial support important, it is the efficient usage of funds that is important in R&D spending. The real issue for businesses looking for competitive advantages from innovation should not be how much they spend on R&D, but how effectively they spend it. Capital simply cannot buy effective innovation. Innovation can lead to higher performance, but the process is not automatic and it does not necessarily require above average levels of investment. There is no silver bullet, and just throwing money at the problem is not the answer (Herbig and Palumbo, 1996).

A difficulty with investigating R&D spends is that organizations include different expenditures in their calculations. As a result, further data is required to compare the expenditure by the organizations. Although expenditure on R&D is important, it is likely to be more important that the expenditure is focused to produce desired outcomes (Oakey, 1995).

2.4.4 Technology Infrastructure in Small Units

Small-scale industry needs both basic and specialized infrastructure to achieve growth. The technological problem of small producers is predominantly seen to be one of lack of suitable machinery and equipment (Sethuraman, 1977; Harper, 1984). Knowledge generated in SMEs is tacit in nature due to various reasons. In the context of SMEs some elements of knowledge management are practiced but in an ‘adhoc’ fashion. Indeed any technological infrastructure that is put in place to support knowledge management must be adapted to the organization’s needs and not the other way round (Egbu *et al.,* 2005; Evangelista *et al.,* 2010).

The role of finance has been viewed as a critical element for the development of small scale manufacturing sector. For high technology SMEs and small firm innovation, generally all concerns are directly or indirectly influenced by shortages of capital (Oakey, 1997). Finance is said to be the ‘glue’ that holds together all diverse aspects involved in small business start-up and development (Green *et al.,* 2002). In many developing countries, SME development is always constrained by the limited availability of financial resources to meet a variety of operational and investment needs. A large portion of SME sector does not have access to adequate and appropriate forms of credit and equity or indeed to financial services more generally. Innovation often requires considerable front-end sunk costs, invariably beyond the scope of small firm’s internal resources. This, allied with the frequent inability of funding providers to adequately assess either the technological validity or the project viability, often mitigates against finance provision. SMEs engaged in the innovation process have different and special financing requirements that arise because of the need for seed capital and development capital. The process of research and development can take some time before the firm has a commercially viable product with which to go to market and during this period there are no returns for the investors who are required to provide ‘long-term patient money’ (Cook and Nixson, 2000; Abor and Quartey, 2010).

2.5 Regulatory Support

The business press and governments have been imploring enterprises of all kinds to embrace innovation as a matter of survival in the globalized, knowledge economy. Government can not make small organizations innovate. Businesses and the entrepreneurs that drive them must want to innovate to pursue growth and to exploit new market opportunities. However, government can create the right economic, fiscal and regulatory framework within which innovation and entrepreneurship can flourish. It can help raise the awareness of benefits of innovation, of adopting a progressive strategic management practice and provide sufficient financial resources for efficient business support services (Beaver and Prince, 2002; Hyland and Beckett, 2005).

Government assistance offered to SMEs can basically be divided into two sub-groups: financial and technical. Financial assistance includes various forms of investment incentives and soft policy loans. It includes contributions in capital accounts and interests, financing at concession rates, guarantee concessions or tax incentives (linked to economic policies that directly support SMEs). Technical assistance consists of human resource training, export promotion initiatives, and quality and technology programs (Henson *et al.,* 2009; Zeng *et al.,* 2010).

A majority of enterprises rely on their own perceived skills at the time of start-up, and continue to rely on their own resources. The perception of services offered by government to small units is evaluated as insufficient by entrepreneurs. It is reported that the diverse programs created by government largely fail to be adequate for production enterprises, as policies and actions are inconsistent. As a consequence, organizations rely heavily on informal support. Governments should remove common hurdles affecting growth-conducive environments, develop basic infrastructure, and ensure smooth functioning of its organizations (Singh *et al.,* 2008).

The important issues under this key area are discussed as follows:

2.5.1 Policy Measures to sustain Innovation

The scientific and technological development in emerging economies depends upon assistance of several government spheres, in particular from the federal one, in order to formulate policies and generate financial support mechanisms (Passos *et al.,* 2004). Policy restrictions and complex procedures greatly hinder the growth of small firms. Reforming the policies and simplifying regulations are thus preconditions for boosting the growth of small-scale sector. Policy makers need to understand much better the motivations and requirements that shape and drive an innovative firm. In short, government and the business support infrastructure it creates, must also be innovative (Beaver and Prince, 2002; Hyland and Beckett, 2005).

The job of policy makers revolves around designing, developing and managing SME support programmes. A large part of the role of SME membership bodies is concerned with lobbying government to introduce new forms of support or to improve the existing provisions. Government can act as a facilitator of technical change and leveraging, working in collaboration with other stakeholders rather than dictating policies from above (Kim, 2001; Seeman *et al.,* 2007).

Governments can encourage innovation by first, providing good data on scientific and technological trends, and networking, both nationally and internationally. Second, government policies have to reflect realities of the new innovation process. Third, government has to increase investments in universities and technical education, and put efforts on industrially-relevant research and training. Fourth, the government itself has to be innovative; its policies, regulations and laws need continually to be examined from the perspective of whether they support or constrain innovation (Kharbanda, 2000; Gupta, 2009).

Government should raise important policy issues. Firstly, there is a need for well structured mechanisms or interfaces and intermediary agents for effective and efficient interaction between small units and research institutes. Secondly, developing innovative ability in this sector requires strategic training for owners of small firms so as to increase their absorption capacity for innovation (Oluwajoba *et al.,* 2007).

Public policies focusing on improving human capital, upgrading technology availability, labor market reforms, and deregulation of financial markets are important to support growth (Acs and Szerb, 2007). Government should concentrate on quality strategy development, goal stretching, continuous improvement, and concurrent engineering programmes contributing to the creation of innovation context (Bossink, 2002). The ‘triple helix’ culture of university-industry-government link should be followed so that majority of the technologies obtained through transfer agreements can be expected to leverage local innovative efforts. In case, institutional gaps persist, technology transfer agreements stand a rare chance of success in stimulating innovation and boosting productivity growth on a sustainable basis (Etzkowitz, 2002). Government should revise its policies to remove anomalies regarding fiscal concessions also. To improve the competitiveness of small-scale sector, it seeks dialogue with various state governments, to rationalize fiscal incentives and curb unhealthy competition. Financial incentives or tax incentives used as tools to support small-scale sector are more traditional, and always turn out to be less effective if used alone. Tax incentives prove to be of a more uncertain nature, and anyway delayed, in that they are dependant on profit levels. Furthermore, the traditional tools turn out to be lacking in the ability to fulfill the growing needs of SMEs, especially in terms of direct and practical support in execution of innovative projects, availability of information, recruitment and training of specialized staff, suitability and exploitation of results of innovative activities (patents, trademarks), etc. (Siggel, 2001).

Governments should develop policies for technological innovations, both on a global and local scale, using tools, especially geared towards improving the links between firms and research. These tools involve, creation of infrastructures for assistance and technological transferal to small units, first and foremost to technological and scientific parks and innovation service centers, linked, in an optimal situation, to research and university centers. Among these tools, a key role is played by an effective network of service centers, development agencies and technological parks, suitably linked to local public or private bodies, providing a real support to the innovation needs of small units (Hansen *et al.*, 2009).

The strength of small units lies in their flexibility in production. The multiple labour laws, however, sometimes restrict this flexibility. These different laws should be revised and combined into a single legislation. It is required to effectively deal with identification of new strategic priorities and possible market/system failures blocking materialization; for design and initial implementation of new, targeted programs/policies (Avnimelech and Teubal, 2008).

Support policies are particularly vital in less-developed countries (LDCs), where problems of appropriability, coordination and information are especially severe. The financial, research and human capital base of small firms tends to be weak. Most of their technological efforts are relatively easy to copy because they are, for the most part, adaptive and incremental, not amenable to patenting. Inter-firm communication and co-operation are cumbersome because of poorly developed physical infrastructure, and risk is high in an information-poor environment (Lall and Teubal, 1998).

2.5.2 Business Support Mechanisms

Government provides a range of programmes to help businesses meet the challenges they face in starting up, running and growing their operations. Such government-funded programmes are often collectively referred to as *business support* and usually take the form of grants, subsidies, advice or other support services. These support programmes can be broadly divided into five aspects, among which are: financial and credit assistance; technical and training assistance; extension and advisory services; marketing and market research; and infrastructure support (Abdullah, 1999; Tambunan, 2008). Government can support programs to build infrastructure as well as incentives (such as tax incentives) and special start-up programs to develop private sector. Factors under infrastructure facilities are related to transport, market information, credit, power, water, telecom, technology upgradation and quality certification; non-infrastructure category includes interaction with government, taxation, and manpower availability (Thomas, 1993; Breif and Motowidlo, 1996; Sheel, 2002; Hyland and Beckett 2004).

Government aid is paramount in case of small scale organizations. Government can assist organizations in several ways such as through collaborative training programs; R&D programs among government-funded research centers and universities for specific sectors; effective reward schemes; providing laboratories for R&D work; and funding R&D projects.

Resources can be provided to support training, which is linked to organization's longevity and success. Effective deployment of resources entails organization's participation in training activities. The weak participation and lack of interest in training shown by small units is due also to a lack of time available to the heads of enterprises. They are taken up with the everyday tasks of management. Moreover, the training offered takes little account of the concerns of firms in the matter of innovation and technology, or else it is not adapted to these concerns. The absence of enterprise nurseries and centers of innovation, plus the lack of communication between universities and small-scale sector, are other factors that do nothing to facilitate access to the results of research and development (Berko, 2003).

Government can provide a supportive environment conducive for growth. Business environment is assessed by the extent of delay in obtaining government permissions and clearances. Further, in a large developing country, with infrastructure being provided largely by the regional (or state) governments, there exist considerable intra-regional variations in quality and cost of infrastructure facilities (Narayana, 2004). Problems faced by small units are numerous. They experience delays in getting credit sanctioned from banks, getting tax-and-duty benefits, obtaining temporary and permanent registration, clearances for exports, permission for expansion and diversification, power and water connections, and clearance from pollution control boards. The units have to interact with different departments of the central and state government for getting clearances, registrations and connections. These interactions are costly in terms of time, labour and money. Further, any delay in getting clearances from the administrative regulations adds to these costs. State governments have a major role in reducing burden of administrative regulations and delays for improving business environment and hence, the competitiveness of small scale sector. A congenial business environment should aim at minimizing these costs of interactions (Rolfo and Calabrese, 2003).

Government can also play an important role in enabling industry to be creative through correction of market failures, providing support where benefits of creativity and design are wider than those for the firm itself, or where there are gaps in the efficient supply of finance by the market. It can provide sector specific specialist advice within the manufacturing industry and provide more financial and tax incentives (McCole *et al.*, 2001; Johnston and Loader, 2003; Laforet and Tann, 2006; Jong and Stout, 2007). Facilitating access to credit and business development services and promoting formalization are all likely to increase firm growth (Shi *et al.*, 2008; Fajnzylber *et al.*, 2009).

Government initiatives should encourage a bottom-up approach. This is accomplished by providing resources for direct use in commercialization projects or to develop professional expertise in technology transfer in the university sector, by experimenting with new initiatives, and finally by facilitating cooperation between commercializing organizations (Rasmussen, 2008). Government can establish information centers in specific areas for assisting academic institutions and industry. Small units can approach them for assistance, especially with regards to developments in the field of technology (Kharbanda, 2001).

Small-scale units need assistance with marketing themselves and their products. Government provides this assistance indirectly by providing supporting infrastructure and opportunities for trade exchanges by setting up permanent exhibition-cum-convention centers, organizing international trade fairs, and vendor development programmes. A comprehensive development package, including technical upgrading through the provision of a common service facility for export training and support for participation in trade fairs, and investment in improvement of regional infrastructure, help the SMEs to gradually develop export markets (Sandee *et al.*, 2002).

2.5.3 Financial Support to Research Initiatives

One of the major obstacles in the development of small-scale industrial units is related with their access to financing.

Small units often face economic, institutional and legal obstacles. Such restraints include limited ability of acquiring sufficient amount of credit (including initial capital and longer term credits), inadequate infrastructure support, high transaction costs, limited managerial and technical know-how and so forth. Despite these obstacles, which are mostly interdependent, the general opinion on which supporting policies are based stems in the fact that a lack of finance makes up the principal restraint in their growth and intensification (Jaehoon, 2010; Elaine and Derek, 2007; Soderbom *et al.*, 2006).

Government support for small-scale sector is provided in the form of direct grants, subsidies or other forms of financial support. It includes free or subsidized information advice or consultancy and/or special treatment in relation to government regulations. Government support can be categorized as *direct*, and *indirect capital investment*. *Financial direct investment* refers to the capital that the state applies to the field of science and technology. This expenditure is in the nation's financial budget. The ways in which governments fund science; in the institutions that distribute funding; and in organizations that carry out research reflects far-reaching changes in the relationship between science, industry and society (Garrett-Jones *et al.*, 2005). R&D expenditure can be classified as: R&D expenditure of private sector as a percentage of *Gross Domestic Product* (GDP), government expenditure on R&D (research centers, agencies, institutes, etc. with the exception of public universities) as a percentage of GDP, higher education sector expenditure on R&D. Investment in R&D as a percentage of GDP is the main input in the knowledge production function (Osorio and Pose, 2004). Total R&D expenditure as a percentage of Gross Domestic Product (GDP) for a few selected nations (year 2006) is provided in Table 2.4 (Prathap, 2010).

Table 2.4 R&D Expenditure as a percentage of Gross Domestic Product

S. No	Nation	R&D as % of GDP
1	Sweden	3.73
2	Finland	3.45
3	Japan	*3.39*
4	South Korea	*3.23*
5	United States	*2.62*
6	Taiwan	*2.58*
7	Germany	*2.53*
8	Singapore	*2.31*
9	France	*2.11*
10	Canada	*1.94*
11	United Kingdom	*1.78*
12	China	*1.42*
13	Ireland	*1.32*
14	Spain	*1.20*
15	Italy	*1.09*
16	Russia	*1.08*
17	**India**	***0.70***

In *indirect capital investment*, the state adopts preferential policies for small scale sector, through reducing tax, to encourage them to speed up technological development and new product development. Tax policies that encourage enterprises to invest in technological innovation have played a clear role (Massa and Testa, 2008; Zhang and Dai, 2009). Government plays an important role in financial markets, particularly in helping small firms. At the aggregate level, ensuring a stable macro environment helps in keeping interest rates relatively low and stable. At the business level, government works in partnership with private sector to ensure adequate funding, for example by providing guarantees on loans or venture funding (Liyanage, 2003).

Increase in technological innovation demands that government should enhance the extent of investment on R&D and training of employees (Liyanage, 2003; Regan *et al.*, 2006).

In some developed economies, government supports investment in more formalized creative activities. R&D tax credit is available when a project seeks to achieve an evidence in overall knowledge or capability in the field of science or technology, but not a company's own state of knowledge or capability alone. Government also supports R&D through targeted expenditure and collaborative research programs (Fajnzylber *et al.*, 2009). Resources from the public sector can be targeted to support and develop technology-based businesses as an engine for long term growth. There has to be significant investment in infrastructure (development of technology parks), and also recognition of a specific need to develop skills to meet the challenges of internationalization and diversification to other industries (Storey, 1994).

2.6 Interaction with Others

Manufacturing organizations are feeling the pressure of shifting markets because of globalization and have to operate in a very competitive environment. Their need for support and information is high and they must make improvements in internal strategies to start interacting with external organizations. What is essential for these firms is that they should be provided with access to more resources than they would have if they were not a part of the network (Wani *et al.*, 2004; Santos, 2006).

Business networks are an increasingly popular form of alliance in most countries. One of the main producers of wealth and prosperity of industrialized countries is the existence of well coordinated and sustainable system that supports interaction with other organizations and formation of networks, capable of converting innovation assets into new technology (Sheel, 2002). All organizations are part of a network to some extent. Each organization develops a relationship with its suppliers, customers and with other businesses in the same industry, and this can include competitors. Networks can be described as a form of collaborative relationships that organizations enter into with others for strategic reasons (Hagedoorn and Schakenraad, 1994; Love and Thomas, 2004, De Wit and Meyer, 1998). Organizations need a culture that supports collaboration and a systematic approach for managing innovation (Roy, 2000; Hyland and Beckett, 2005). Teaming up allows to gain competitive advantage in today's fast moving markets and complex technological environment (Soh and Roberts, 2005). Through collaborations, a company can improve its exploration and exploitation capabilities and consequently improve its innovative capacity (Faems *et al.,* 2005). Furthermore, collaborations with customers and suppliers contribute most effectively to the exploitation of results while collaborations with universities rather address the explorative capabilities (Christensen and Overdorf, 2000; George *et al.,* 2002; Frishammar and Horte, 2005).

Researchers predict that technology will become increasingly complex and more expensive to develop. All R&D managers will become 'Information Managers' and all companies will be 'Information Machines'. The paradigm then is that R&D must 'either network or not work'. Therefore, many companies will choose to maintain their competencies only in selected core technologies and obtain additional capabilities through partnerships and alliances with other companies, government laboratories, universities and contract R&D organizations (Larson, 1998).

The important issues under this key component are a follows:

2.6.1 Networking as a Strategy in Small Units

The inclination and ability of SMEs to innovate is seen as being linked to the extent to which they enter into interactive learning networks with other firms, their customers and suppliers, and various other external bodies and agencies (Asheim, 1996; Morgan, 1997). Competitive advantages cannot be generated by a firm in isolation but only in collaborative relationships with other actors, namely other firms (including competitors), institutions which have been created with the purpose of knowledge generation (universities and public research laboratories), as well as vertically linked actors (as suppliers and customers). The co-operations are characterized by intensive knowledge exchange and learning processes basically by the combination of complementary assets as well as the realization of synergies (Dyer and Sing, 1998).

Networks can be a cost-effective way of improving small firm performance, particularly manufacturing firms (Love and Thomas, 2004; Xu *et al.,* 2008). Firms that use and fashion their competitive advantage around information and external networking consistently achieve better results and are more optimistic about the future (Barnir and Smith, 2002; Beaver and Prince, 2002). Innovative firms generally are well plugged into the market place and to external sources of technological expertise and advice (Rothwell, 1991). Strong ties can offer steady flow of new ideas, technological innovations, and operational support (Mitra, 2000; Terziovski, 2003; Capaldo, 2007). The cooperative and networking aspects of businesses bring many benefits in competitive advantages that small organizations can not afford on their own (Love and Thomas, 2004). Forming networks with other organizations in search for information is a mechanism, by which small firms can ameliorate the problem of extending their knowledge base and strengthening their market standing. Innovative SMEs do better when they are part of a community of like-minded firms that can participate in a supportive infrastructure that encourages their development and prosperity. Networking influences the success of small firms and it occurs naturally as part of the industry culture (Silversides, 2001). Majority of the firms judged to be innovative embrace collaboration and social networks to be extremely important for small firms because they provide additional resources as well as emotional support (Barnir and Smith, 2002). Innovative capabilities of firms can be enhanced in a business network characterized by frequent and diversified interactions, as well as collaborative interdependencies among network members (Xu *et al.,* 2008).

High technology SMEs are involved in network activity, especially with regards to research and technological development; this typically takes place over a range of spatial scales (Keeble *et al.,* 1997). SMEs' success against larger competitors may be determined by their ability to utilize external networks efficiently. In general, SMEs overcome barriers to growth due to absolute limits to resources by the astute use of alliances and development of collective efficiency (Dijk *et al.,* 1997; Schmitz, 1999). In fact, due to the nature of their operation and their size, SMEs are less R&D driven and rely more on their external environment in undertaking innovation activity (Mytelka, 1991; Waalkens *et al.,* 2004).

There are significant barriers to the initiation of networks among small manufacturers. It is argued that firms require common stimuli and traits to successfully develop a network (Lichtenstein, 1992; Pyke, 1994). But they also need an honest broker to help them develop trust among one another and identify the resources critical to a network operation (Rosenfeld, 1995). The ways in which a network navigates the initial stages of operation can have a profound consequence on its success. A second is that networks are organized for different purposes. In particular, a distinction is drawn between 'hard' networks designed for a specific business endeavor and 'soft' networks oriented towards information sharing and human resource development. The type of impact a network can produce varies according to these goals and activities. Finally the outcomes of networks are shaped by how they are organized (Malecki and Tootle, 1996).

2.6.2 Inter-firm Collaborations

In an environment of increasing turbulence and uncertainty, manufacturing enterprises must rely on developing new products and new markets to achieve growth, which requires them to establish or join networks of collaboration with various business partners. Inter-firm networks are one of the main reasons that some of the most successful regions in the world develop to be more competitive in their industry than those who have not adopted these methods (Thorelli, 1986; Fabi *et al.,* 2009).

Networks can be seen as a complex relationship between different companies. Companies usually base the relationship through meetings and other direct links with each other. These links are an investment to develop their business relationship. This can develop to be a more useful and valuable resource over time. Nurturing the relationship that companies have with each other is an important part of managing a business (Johanson and Mattson, 1987). The idea of networking has become more prominent through the theories of alliances especially connections between businesses that are situated within the same geographical area (Ferlie and Pettigrew, 1996).

Industries work together towards a common goal by sharing information and resources in order to undertake joint projects. By exchanging information and know-how, cooperation between businesses can be an inexpensive method of finding out more efficient ways of operating. Networks can help businesses to operate or receive information from outside the business in a less costly way than the other methods. Therefore, the usefulness and suitability of business networks can be seen as a means of economic development in the future (Love and Thomas, 2004).

A variety of approaches to inter-firm collaborations are being implemented today. Networks are being established following either a resource mobilization strategy or a social mobilization strategy. The resource mobilization model brings together small grants, small firms and professionals trained at facilitating networks. The goal is to create a collaborative business opportunity. The social mobilization model uses grants to trade associations and regional service organizations targeted at specific industries to stimulate collaborative activity (Indergaard, 1996). From an operational perspective, there are many forms of collaboration, ranging from one-to-one alliances through to multi-firm industrial clusters. Whilst the nature of alliances may differ, they all have to confront a number of common issues such as: *integration, organizational barriers, trust, and ongoing learning* (Hyland and Beckett, 2005). These barriers have been described in Table 2.5.

Table 2.5 Barriers to successful Inter-firm Collaborations, (Hyland and Beckett, 2005)

Issue	Description
Integration	*Unique capabilities need to be developed and embedded in the partner's organizations. A very complex mix of intra and inter-firm processes has to be aligned and implemented. Collaboration must be a strategic imperative for the firm*
Organizational Barriers	*Firms restrict access to their unique practices and maintain an independent management style. Collaboration requires sharing or changing of some established practices and acceptance of a degree of interdependency*
Trust	*Priorities given to internal work and work associated with collaboration must be equitably balanced. An above average level of trust in and respect of each others' competencies and best intentions is required*
Ongoing Learning	*Collaboration is not a natural process in a competitive environment and takes time and effort to establish and sustain. Organizations do not know instinctively how to proceed in these matters, and many require external assistance*

Collaborations and linkages with external organizations for industrial technology development and acquisition are important especially in the early growth stages of a firm (Sugasawa and Liyanage, 1999). Active collaboration between firms can enable them to achieve outcomes that they could not achieve of their own, while allowing each individual partner enterprise to realize its own strategic goals. This requires a well developed capacity to collaborate and to learn across differing organizational cultures. Also there need to be business activities present that improve the market positioning for individual partners, if an alliance is to be ongoing. Further, a range of collaborative management, learning competencies and organizational capabilities are needed. Just establishing collaboration is not enough, there must be both business and housekeeping activities carried out and clear benefits for it to endure (Marceau, 1999). Taking part in co-operative ventures, alliances and networks demands a lot of trust in alliances and also in co-operation (Thorelli, 1986).

Firms with high level of international links exhibit above average levels of local networking with respect to research collaborations and inter-industry links. The most difficult problem for innovative business is that of managing its relationship with larger firms. These may involve a variety of measures such as licensing agreements, long-term contracts, joint ventures or other arrangements to enable the emerging enterprise to develop, produce and sell its products (Keeble *et al.,* 1997).

2.6.2.1 Inter-firm Collaborations in Small Units

Relationship benefits sought by small firms collaborating with larger partners can be classified as cost, service, image and flexibility benefits and suggests that their transfer can facilitate improved small firm competitiveness by building capabilities and resources (Kelly, 2007). Partnerships between SMEs and large firm partners help the former pioneer innovation. By sharing technological resources, SMEs can further develop their core competencies and increase their opportunities to innovate. In addition, with partnerships, SMEs can gain access to new and diverse ideas and have greater opportunities to learn and increase their R&D knowledge. The assimilation of new knowledge leads to continuous innovation (Li and Qian, 2007). Collaboration with much larger organizations can provide resources, in the form fianace and expertise, as well as future sales and international opportunities (Moorman *et al.,* 1992; Rycroft and Kaash, 2002; Singh *et al.,* 2008).

In most instances small firms do not have the capital (human or otherwise) to be able to forge an inter-firm collaboration without assistance. The main catalysts for change are: small incentive grants, expert advice on modernization, expert assistance on the social and business dimensions of networking, and trust among firms (Indergaard, 1996). Further, innovatory activities are thought to be more likely in local environments in which there is a high level of interdependence between, firms, agencies and institutions. In other words, SMEs are most likely to interact with and learn from other firms and organizations within their region (Todtling, 1992).

2.6.3 Industry-Institute Bonding

University-Industry Collaborations (UIC) are especially appealing for organizations, which aim to stay up-to-date concerning the latest technological developments (Hall *et al.*, 2003; Siegel *et al.*, 2003; Hurmelinna, 2004). Although, it is recognized that manufacturing organizations need to invest in in-house research and development with the purpose to gain competitiveness, policy markers and researchers commonly agree on the necessity of establishing knowledge flow between academia and industry as one of the most promising factors to foster innovation capability (Cockburn and Henderson, 1998; Sandelin, 2003; Hofer, 2004; Hofer, 2005; Brennenraedts *et al.*, 2006). Creating and maintaining relationships between academic and industrial organizations is a highly recognized mechanism to manage the changing demands of our industrial society (Mansfield, 1991).

2.6.3.1 Need of University-Industry Collaboration

In a university environment, there is theory and abstract concepts, but without concrete experience and opportunity to experiment and test ideas. As a result full learning is difficult to achieve. On the other hand, industrial units are always under pressure to produce and use concrete experience and active testing. They have little time for abstract conceptualization or reflection on what has occurred so that their learning can be used in the innovation process. Combining theory and practice brings a balanced approach to learning (Holman *et al.*, 1997; Kolb and Kolb, 2005; Meredith and Burkle, 2008).

By collaborating with universities, firms may reduce uncertainty inherent from the innovation process, as well as expand their markets, increase access to new or complementary resources, keep up with evolution of scientific knowledge, and create new technological learning options on future technologies (Hagedoorn *et al.*, 2000). Early access to technological knowledge, risk reduction, access to unique research skills and cost reduction through delegation of selected activities, especially in the field of basic research are other factors (George *et al.*, 2002). Collaboration with a university also has a stabilizing effect, in the respect that projects with collaborations are stopped less frequently. In addition to the possibility to recruit personnel with unique skills, the collaboration on projects might also reduce the recruiting costs and increase its efficiency

(Azaroff, 1982; Hall *et al.*, 2003). University participation in research programmes is also found to have a positive impact on firm patenting (Hall *et al*, 2000; Darby *et al.,* 2003).

On university side, the motivation for collaboration is enhancement of teaching followed by funding/ financial resources and reputation enhancement. Universities' main motive for industrial-academic cooperation is the need to secure funding (Becker and Gassmann, 2006; Hanel and St-Pierre, 2006). Knowledge gain from industry researchers and the access to empirical data from industry is also documented as a strong motivation source. Further, the professors that cooperate strongly with industry have been reported to perform better concerning publications and entrepreneurial activities (Meyer-Krahmer and Schmoch, 1998; Hurmelinna, 2004; Gulbrandsen and Smeby, 2005).

Industrial-academic collaboration is an efficient way to accelerate and diversify the progression of novel technological solutions, educate new multidisciplinary professionals, and incubate new businesses. However, setting up multidisciplinary industrial-academic collaboration is a demanding task, as it involves facing challenges such as communication and the sharing of intellectual property rights, defining common targets that all participants can commit to, and funding and benefits. Universities are considered important silos of knowledge that firms acquire through hiring graduates, subcontracting training projects and R&D activities to generate new products, processes and services (Nelson and Winter, 1982; Lall, 1994; Rasiah, 1994; Katz, 2006; Nelson, 2008).

Size plays an important role in the probability of firms collaborating with universities and R&D organizations. For instance, owing to the lack of resources, and with less capability to undertake R&D, small firms may collaborate with technical institutions to innovate (Cohen *et al.,* 2002; Laursen and Salter, 2004; Mohnen and Hoareau, 2003; Arundel and Geuna, 2004).

2.6.3.2 Barriers to Industry-Institute Interaction

There are conflicts present in the mission of universities and firms on the level of goals. Universities need to produce scientific results that are thoroughly validated in order to advance their scientific reputation. Industry needs products and services which can be sold with profit in the marketplace; an extensive validation of research results is therefore not the main interest of industry, but fundamental for the achievement of goals of universities (Cyert and Goodman, 1997). The conflicting goals lead directly to the conflict concerning secrecy policy. Companies usually believe that treating R&D results as confidential is the best way to maintain their innovative competitiveness. The universities need to publish results in order to gain reputation and therefore would also like to publish the results from the collaborative research activities. Because of the different environments, cultural barriers in the form of different language and basic assumptions are present. Such assumptions are for example that in industry - reaching results fast is generally regarded as desirable. In academia, the assumptions are often opposite. Fast results are associated with research being rushed by project management and erratic and not validated enough (Rappert *et al.*, 1999).

When starting and managing a project, having a clear idea about the ideal output is one of the most important success factors. In university-industry collaboration, there usually persist different perceptions as to what the product of R&D is. For universities any advancement in knowledge is a result and would be regarded as a success. In industry, a marketable product is the least that is expected and only a product that is successful in the marketplace will be regarded as an overall successful execution of the R&D project (Bruhn, 1995).

The different nature of work consists of various aspects. Universities are usually more engaged in basic research with diffuse, abstract and complex goals while industry R&D is motivated by clear deliverables and thus generally starts with applied research or even on the development stage. In addition, companies look on short term profit, quarterly result tracking being the rule. In contrast, reporting cycles in academia are much longer and less-well defined in terms of technical results (Rosenberg and Nelson, 1994; Hurmelinna, 2004).

The fundamental difference on the operational level is that universities are still mostly public organizations and are therefore organized very differently from the manufacturing organizations that are profit driven and have well established management structures. Most firms have well defined incentive systems to align their employees' interests with the corporate strategy and interests. Universities are much more bureaucratic without explicit incentives offered to the professors and researchers. In consequence, the processes of budgeting, task definition, and task execution are very different (Siegel *et al.,* 2003).

The lack of knowledge of the partner's processes also remains a major barrier. Especially in time-critical situations, the university researchers are much more reluctant to work the extra hours to keep the deadlines, because they are not directly committed to them or profit from complying with them. In situations where results from the two partners are building on each other, coordination of the work is crucial. But frequently an insufficient project management is reported from collaborations which often lead to project delay or failure (Bonaccorsi and Piccaluga, 1994). In the moment of transfer or implementation of project results another barrier frequently stated is a lack of acceptance of the results generated by the partner (Siegel *et al.,* 2003; Hurmelinna, 2004). Trust and balanced mutual benefits are the main factors explaining successful research collaboration (Numprasertchai and Barbara, 2005).

If firms and universities are observant and are able to leverage research and development (R&D) and convert more meaningful arbitrary occurrences into opportunities, they may change an economy and the world. Firms and universities need to apply thinking strategies to their surroundings, to increase collaborations and knowledge sharing while ensuring that sufficient mutual benefits can be derived (Schwartz, 2004).

2.6.4 Alliances with Service Institutes

Service institutes and research laboratories which are engaged in the supply of scientific, technological and market knowledge can be sources of taking competitive advantage (Hippel, 1988; Dodgson and Rothwell, 1994; Coombs *et al.,* 1996). In order to produce and successfully commercialize innovation, firms must synthesize a wide variety of expertise and knowledge produced by different complementary sources. Firms learn both from internal sources of knowledge such as through R&D activity and from a wide variety of external sources (Malerba, 1992). Research partnerships are innovation based relationships that can be characterized as cooperative arrangements which consist of firms, universities, research centers and other public or private agencies in various combinations, in order to pull resources fulfilling common R&D objectives (Hagerdoorn *et al.,* 2000). Firms' innovation activity is enhanced, and sometimes depends upon, cooperation between firms and other organizations such as research institutes, government laboratories and agencies, research centers (Jaffe, 1989; Freeman, 1991; Freeman, 1994; Cohen *et al.*, 2002), suppliers and users (Lundvall, 1988; Sako, 1994; Shaw, 1994) or even competitors (Dosi, 1988; Coombs *et al.*, 1996). Firms' collaboration with external organizations allows the expansion of their range of expertise and can support the development of new products. However, in order to successfully access new knowledge through collaborations, firms must manage the capability to search, find, access, and interpret for their own use information embodied in external organizations (Forfas, 2005).

External transactions may be preferred if knowledge sources are too costly, too specialized or somehow otherwise constrained from becoming a part of the firm (Feldman, 1994). In more advanced countries, these interactions have led to the creation of a vast structure of technological services and brokerage that mainly involves three types of protagonist: the producers of innovation (universities and research centers); the collective economic organizations (chambers of commerce, industrial associations); and the autonomous institutions created specifically for dealing with technological transfer (agencies, information centers, incubators) (Justman and Teubal, 1996).

Networking is found to be positively associated with innovation (Goes and Park, 1997), but there are sector and size variations (Rogers, 2004). In addition, the position of the firm in the network is also important. Firms that occupy a central network position can produce more innovations. By sharing complementary knowledge and skills, firms can break through the bottleneck that constrains their innovation activities. Collaboration with suppliers may lead to lower costs and better quality of the new products. All this may result in higher productivity of the innovation activities (Tsai, 2001; Darby *et al.*, 2003; Hall *et al.*, 2000).

Most SMEs lack financial resources, and the best way for them is to enter into linkages and partnerships with other enterprises, academia and/or R&D institutions. In various countries numerous experimental projects have been started at local and national level to set up centers for technological transfer and foster firms in making use of the scientific and technical services offered by these centers and institutes (Kharbanda, 2001; Justman and Teubal, 1996). External linkages, both public and private, benefit SME innovation

(Hoffman *et al.,* 1998). These linkages can be important sources of knowledge that directly strengthen the technological competence of SMEs and hence their competitive advantage. Collaboration with higher education institutions, R&D agencies, and R&D laboratories allows firms to expand their range of expertise, develop specialist products, and achieve various other corporate objectives (Kitson *et al.*, 2001). Low frequency of public-private research collaboration is the result of a lack of proper mechanisms, such as, simple information channels, to ensure that firms know the benefits of collaboration, guidelines for organizing collaborative projects, public co-funding, and mechanisms for solving conflicts between public and private actors (Drejer and Jorgensen, 2005).

2.7 Development of a Conceptual Framework

Based on the examination of available literature and scope of present research, a conceptual framework has been derived to understand the complexities involved in managing technology development initiatives at firm level and their linkages with performance parameters in manufacturing industry. The conceptual framework is presented in Figure 2.1.

The detailed review of literature has brought forth *four* main *input factors* for effective implementation of technology development initiatives in the manufacturing industry. These input factors have been referred to as **'Technology Input Success Factors'** in the present work and include, '*manpower competence and management commitment*', '*technology infrastructure*', '*regulatory support*', and '*interaction with others*'. Further, it is proposed to focus on *four* main *output performance parameters* to assess the contribution of input factors towards technological improvements in the industrial sector. The output performance parameters have been referred to as '**Development Indicators**' in the present research and include, *'level of technology'*, *'strategic implementation of innovation'*, *'structure and output of research function'*, and *'response to market demands'*.

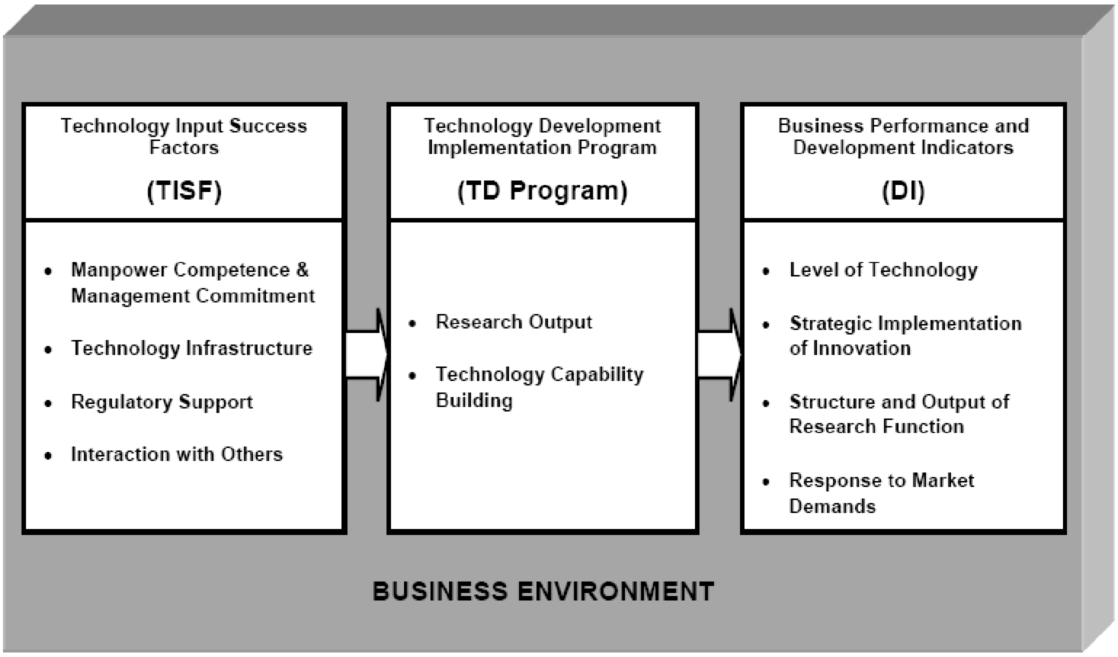

Figure 2.1 Conceptual Framework showing interlinkages between Technology Development Initiatives and Performance Improvements

In the present study, it has been hypothesized that the key input parameters *(Technology Input Success Factors)* have a significant influence on the four output performance parameters (*Business Performance and Development Indicators*). It is hypothesized that the different issues under each input factor have a positive association with each development indicator (output parameter).

The present work assesses the status of each of these factors in the selected class of industry and evaluates the contributions of various technology development initiatives towards performance improvements.

The key issues comprising the main inputs and output parameters are presented in Figure 2.2.

2.8 Limitations of Existing Approaches

An extensive review of the concepts, taxonomy and related facets of Technology Input Success Factors in the manufacturing organizations has been carried out. The review of past literature indicates sufficient gaps for the conduct of present research work.

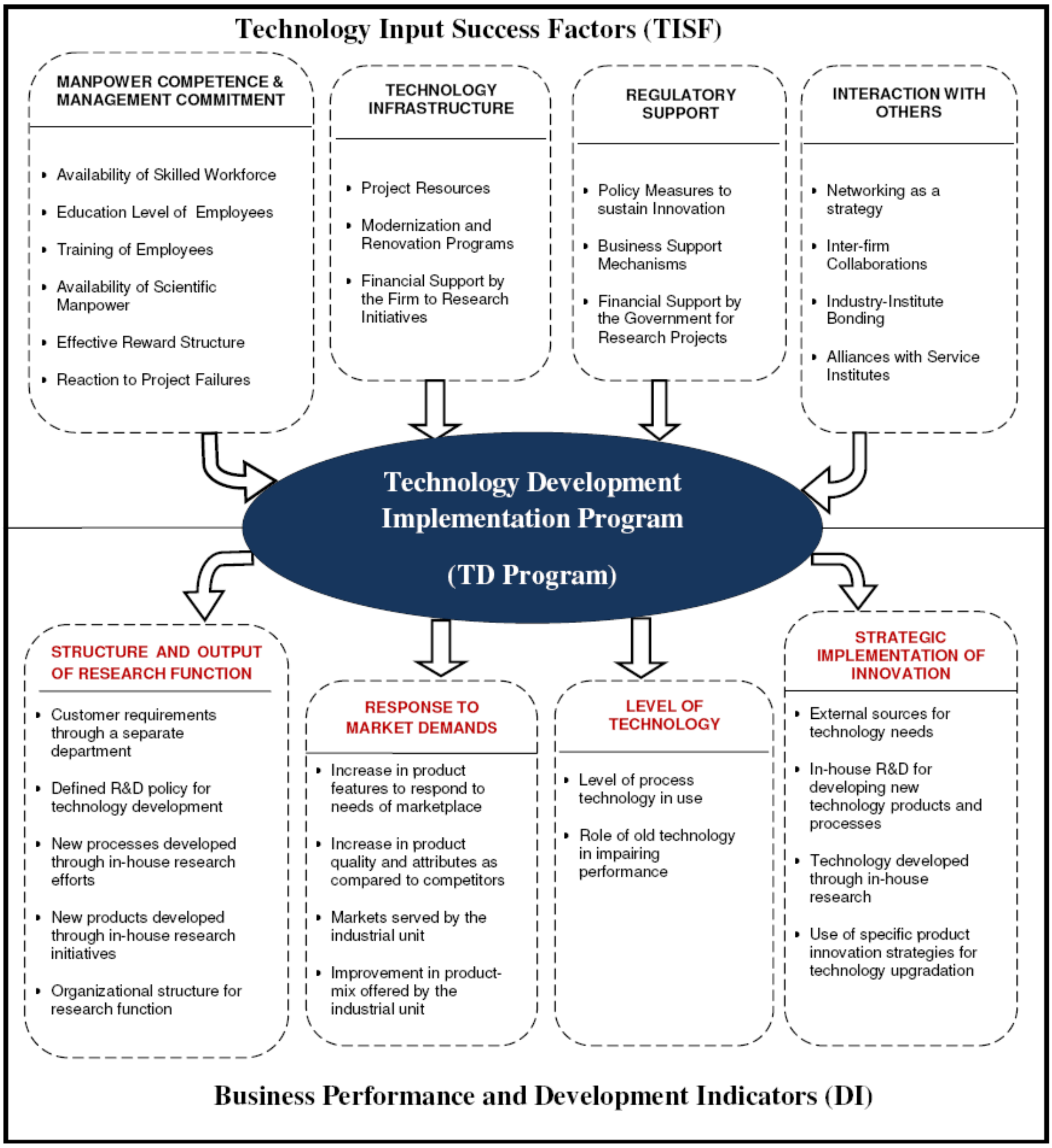

Figure 2.2 Components and Issues comprising the Technology Development Implementation Program

The main limitations in the existing approaches are as follows:

- An enormous amount of research has taken place to explain why certain organizations are more creative and innovative than others. Several researchers have worked on identifying the conditions, norms and factors which facilitate the promotion and implementation of technology upgradation and product innovations in manufacturing units. However, most of the academic writings focus only on one factor individually at a time. There is a lack of studies providing holistic perspectives on managing creativity and technological innovations comprehensively in an organizational setting.

- Further, very few empirical studies and quantitative research have been reported to support the theoretical findings. There are remote cases where the relative impact of technology development initiatives on performance improvements, especially in the small sector manufacturing sector have been reported.

The present research work intends to bridge the gaps in literature and practices by suggesting a systematic plan for evolving a technology development program for small scale manufacturing industry of the region.

2.9 Concluding Remarks

The competitive business environment is forcing organizations to perpetually seek ways of improving their products and services. Organizations increasingly aspire to become more creative to capitalize on the benefits of innovation. The past literature provides an initial explanation of the intricate exploration as to what makes certain organizations more innovative than others. The present review has synthesized the existing academic writings that address how organizations can encourage technological improvements in their working environments and identified the key factors that influence organizational creativity and innovation. A selective review of available literature in the field has brought out numerous points related to technology input success factors and business performance and development indicators in a logical manner and their interrelationships. It can be concluded that organizations should perceive the development of conditions that encourage technology upgradation and innovation in their workplace as a long-term process rather than a quick fix to their current problems. A conceptual framework has finally been developed and presented to understand the complexities involved in managing technology development initiatives at firm level and their linkages with performance parameters in manufacturing industry.

The next chapter introduces overall design of the study. It describes the various phases of research and the methodology adopted for carrying out the present work.

Chapter - III
DESIGN OF THE STUDY

3.1 Introduction

This chapter introduces overall design of the study, which includes methodology adopted for carrying out the research work as well as various phases of the study. The details of work done in each phase; the tools, techniques and models used in the work have also been covered.

3.2 Research Methodology

This study has been carried out with a purpose to analyze the technology development capabilities of Indian small scale manufacturing industry through indigenous research initiatives and developing an effective strategic technology development program for the same. Taking into view the complexity of the theme and the fact that such studies can be carried out primarily by closely analyzing the approaches adopted by various organizations and the result thereof, it has been considered appropriate to carry out the research work under the overall framework of 'flexible systems methodology'. This methodology involves use of an optimal mix of qualitative and quantitative techniques of system analysis and design (Sushil, 1993).

According to flexible systems methodology, problem situations can be handled with two possible philosophies at the extremes (i.e. isolationist, and situational). According to the isolationist philosophy, the best approach is to be developed which will be useful in all possible problem situations. On the other hand, a situational philosophy believes in developing a unique approach for each problem situation. Both these philosophies have shown some success but have some limitations too. The isolationist view is bogged down with the development of a grand paradigm which is an ideal one and difficult to achieve. Similarly, developing a unique approach for each problem situation is very time consuming and, thus, is not a practical proposition.

The philosophy, which lies in between these two extremes, is of flexibility. Getting attached to a point on the continuum cannot generate flexibility in the systemic sense. The flexibility is generated by virtue of existence of the continuum. The success lies in making a dynamic balance between the polar extremes, which is the basis of flexible systems methodology. According to this, there are multiple ways of reaching the same end and the suitability of way(s) will depend upon the nature and attributes of the problem situation at hand. It does not advocate the invention of a new approach for each problem situation, but selects an approach out of the existing ones, so as to match the requirements of a problem situation.

The flexible systems methodology tries to resolve the end of continuum paradoxes, as it is based on a spectral paradigm, treating all of the systems-based methodologies and techniques as lying on a continuum ranging from hard to soft, and all problem situations to be also on a continuum ranging from well structured to unstructured (Fig 3.1). This methodology uses the philosophy of integration of qualitative and quantitative techniques to cater to the diverse requirements of a problem situation and a management process, in a flexible manner.

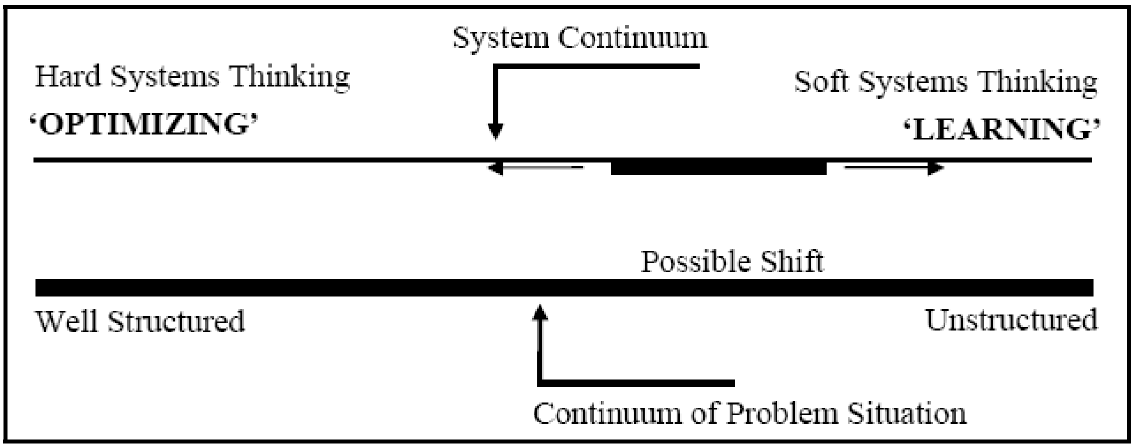

Figure 3.1 System Continuum: A Special Paradigm

3.3 Problem Conceptualization

The three basic components that define the dynamic interplay of reality in flexible systems management paradigm are situation, actor and process. They interact flexibly on multiple planes in the ambiguous reality and ultimately melt together into one at the enlightened stage as shown in Figure 3.2. The problem is conceptualized as a SAP-LAP (Situation-Actor-Process; Learnings-Action-Performance) paradigm (Sushil, 1997; 2000).

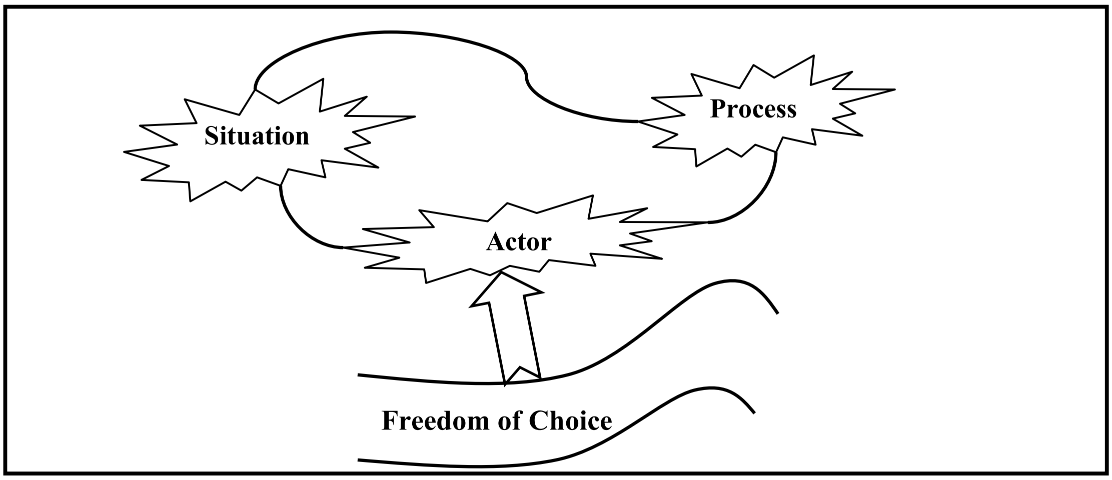

Figure 3.2 Flexible Systems Management Paradigm

The management in this paradigm can be explained from the point of view of either the situation, or actor, or process. The situation is to be managed to an organic order by an actor through a flexibly evolved self-organizing management process which recreates the situation. In the present research work, 'situation' aspect comprises of present industrial situation in the manufacturing sector, whereas the organizations constitute the 'actor' aspects. The role of in-house research initiatives in building technological capabilities constitutes the 'process'. The actor has various options to exercise, depending upon the situation and process, which form his 'freedom of choice'.

3.4 Phases of Research

The present study comprises of two major parts namely 'Analysis' and 'Design'. Analysis includes all relevant information and data regarding the status of research subject in the engineering industry, reasons thereof and corrective actions that can be profitably applied. Design deals with developing a technology development program using the information as collected and analyzed in the first part. Based on flexible systems methodology, the research work has been carried out in four phases:

Phase I : Clarifying the context

Phase II : Understanding and assessing the situation

Phase III : Assessing the actor's capability

Phase IV : Evolving a management process

Figure 3.3 depicts the relevance and importance of each phase for meeting the objective of design of a generalized '*Technology Development*' program. Details regarding the work undertaken in each phase and the tools and techniques employed for analysis are discussed.

3.5 Clarifying the Context

This phase reviews the literature on technology development capabilities of manufacturing industry with regards to investments in research function, policies, infrastructure facilities, and strategies adopted. The reasons for poor performance of Indian small scale industry in the area of indigenous technology development have been explored. Tactical issues for managing innovations and strategies for bridging the technology capability gap have been assessed. Literature review regarding economic, technical, regulatory and other related issues regarding technology upgradation has also been carried out.

3.6 Understanding and Assessing the Situation

The second phase assesses the status of technology development initiatives and resulting performance improvements in the industrial sector, through a questionnaire based survey of manufacturing units.

There are different types of survey-based research (Churchill, 1995). An overview of these is presented in Figure 3.4. Cross-sectional research is primarily used to measure the various characteristics once, whereas longitudinal research considers the measurement over time. Furthermore, cross-sectional research involves a sample of elements from the population of interest, whereas true and omnibus panels are used in longitudinal research.

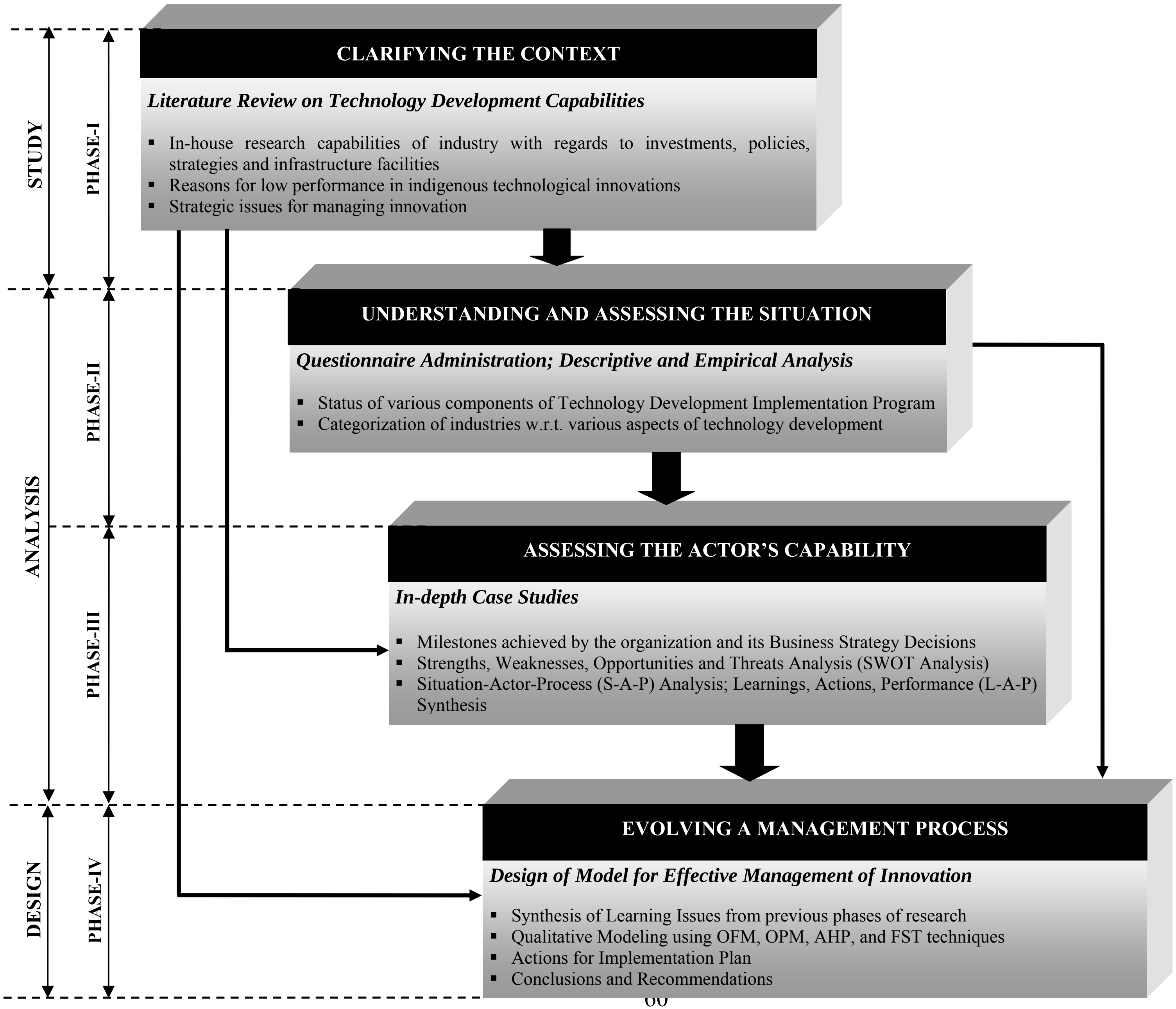

Figure 3.3 Design of the Study

Even though longitudinal research could be useful in observing technological capabilities over time, there are some critical drawbacks to this method. The main disadvantage of panels is that they are non-representative. Furthermore, the agreement to participate involves a far-reaching commitment of the respondent, which is very difficult to achieve. Instead, the use of cross-sectional research is far more useful in this study. Besides, it is also considered the most important type of survey-based research in terms of the number of times it is used as compared to other methods. First of all, cross-sectional research provides a snapshot of the variables of interest at a single point in time. Second, the sample of elements selected is considered to be representative of some known universe.

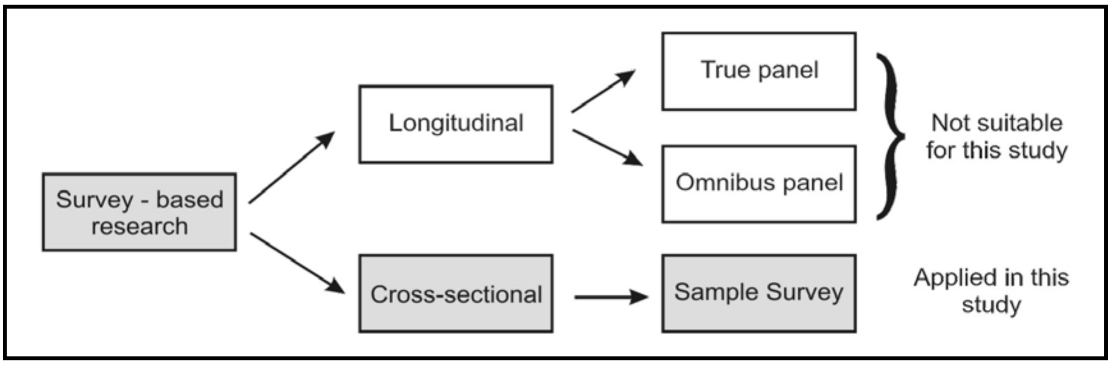

Figure 3.4 Types of Survey Based Research

3.6.1 Methodology of Survey

The study has been carried out in small scale manufacturing organizations that have successfully implemented or are in the process of implementing proactive technology innovation initiatives. In the present research work, a reasonably large number of manufacturing organizations have been extensively surveyed. The approach has been directed towards justification of strategic technology development implementation program for its support to competitive manufacturing in the Indian industry. The questionnaire survey technique has been employed.

Questionnaire Development: For effectively conducting the survey, the first task was to design a questionnaire. A relevant and detailed questionnaire containing objective type questions with multiple choice answers pertaining to the desired conceptual framework was designed. Information on various aspects related to this research work in the Indian small scale manufacturing industry was sought in it. Scale items have been used in the analysis, since the research interest is to examine the effects of independent variables on dependent variables. This approach is consistent with previous research studies, which employ single scale items for various variables (Ettlie and Hahn, 1994; Suarez *et al.,* 1996; Gupta and Somers, 1996).

Questionnaire Validation and Pre-testing: The 'TD Questionnaire' has been prepared through an extensive literature review and validated through peer review from academicians, consultants, technology innovation councilors, and practitioners from the industry. To ensure the relevance and effectiveness of the questions to the manufacturing industry, the questionnaire was pre-tested on a representative sample of industry chosen on statistical basis covering every region and type of industry under the scope of present research work. The suggestions received from peers, academic experts, and senior executives from industries were incorporated to make the questionnaire more relevant to the purpose so that it may bring out key outcomes. The objective was to confirm that responses were based on correct interpretation of the questions. A high degree of consistency was found in the responses of manufacturing and engineering executives to the questionnaire items. The qualitative feedback provided was very helpful in the preliminary efforts to assess the reliability of the scales. Further, Cronbach's Alpha coefficient was assessed for each scale item as well as the item-to-total correlation for empirical analysis.

Before finalizing the questionnaire, a methodical review of all the items and instructions was undertaken.

Sampling and Data Collection: The survey instrument (along with a postpaid reply envelope) was mailed to all the 227 manufacturing organizations in the sample frame (organizations to be surveyed were chosen at random from among the member industries of various 'District Industrial Centers' of different districts in the state of Punjab). Each questionnaire was sent personally to the respondent after a short enquiry in which the person was asked to participate. This technique additionally offered the opportunity to verify the respondent's data. A reminder with an additional copy of the questionnaire was sent to all the non-respondents to the initial study. A total of 91 responses were received and elimination of incomplete or unusable responses resulted in 83 cases. This constituted a response rate of 37% which compares well with the response rates for studies in operations management and other empirical research (Hyer and Wemmerlov, 1989; Handfield, 1994; Suarez *et al.,* 1996; Malhotra and Grover, 1998).

The survey has primarily been conducted through mail but personal visits have also been undertaken to the extent possible. The methodology employed for the survey has been illustrated in Figure 3.5.

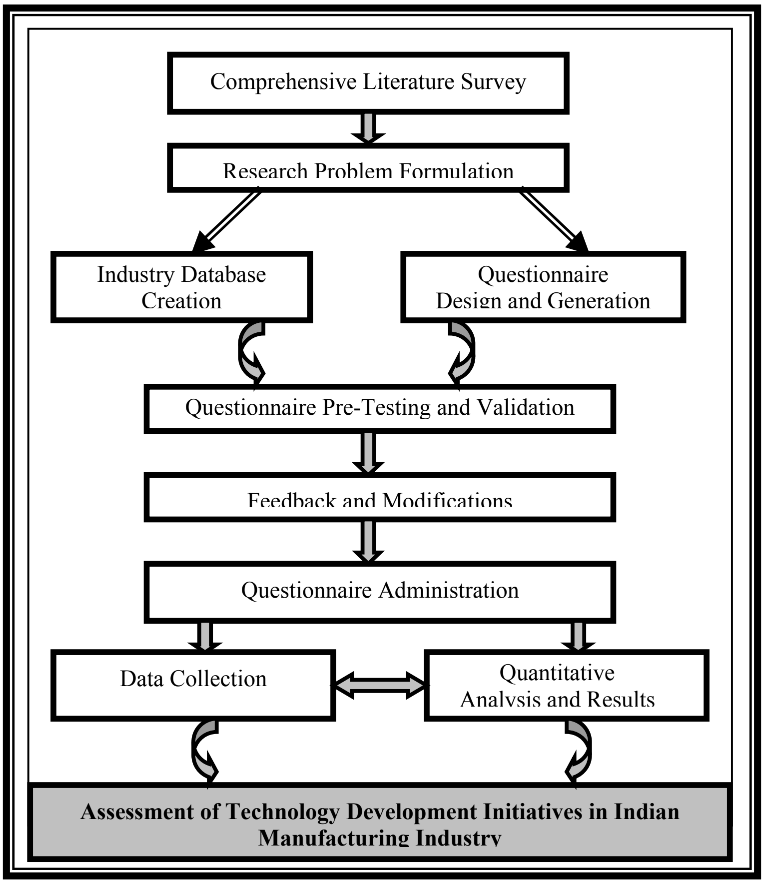

Figure 3.5 Methodology for the Sample Survey

3.6.2 Analysis of Response

The analysis of response of the survey has been carried out from the following view points:

- To determine the status of industry with regards to existence of certain departments, facilities and programs for technology development through indigenous research.
- To assess the status of main factors and problems impairing the performance of small scale manufacturing industry.
- To review the status of each component (aspect) of Technology Development Implementation Program (TD Program) in the industry.
- To assess the overall standing of each manufacturing organization in different components of TD, leading to classification of organizations into various categories ranging from very good to very poor.
- To evaluate contributions of technology development initiatives (Technology Input Success Factors) towards achieving manufacturing performance improvements (Development Indicators).

Descriptive Analysis: The descriptive analysis for various research parameters has been carried out to assess their status in the manufacturing organizations. Present level of technology capability has been determined by using a self assessment technological capability audit tool.

In the present research work, *Technology Development Implementation Program* (TD Program) is considered to comprise of five main components (or aspects):

1. *Manpower Competence and Management Commitment* for creative input
2. *Technology Infrastructure* facilities for in-house research initiatives
3. *Regulatory Support* to the development efforts of industry
4. *Interaction with Other Agencies* and
5. *Research Output* as a result of innovation initiatives

The status of each component of '*Technology Development Implementation Program*' has been evaluated and discussed for the manufacturing sector. Further, the overall standing of different organizations in various TD components has been reviewed and presented.

Empirical Analysis: The empirical analysis has been carried out to evaluate the contributions of technology development initiatives (Technology Input Success Factors) towards achieving manufacturing performance improvements (Development Indicators).

Relationships between input success factors and output performance parameters have been explored in the study. For this, independent and dependent constructs (variables) have been formulated based on literature review and the objectives of this research. Constructs related to 'Development Indicators' have been categorized as dependent variables whereas those related to 'Technology Input Success Factors' as independent variables.

The four distinct input constructs (Technology Input Success Factors) that are likely to influence the technological capability objectives include:

- *Manpower Competence and Management Commitment*
- *Technology Infrastructure*
- *Regulatory Support* and
- *Interaction with Others*

The output performance parameter based constructs comprise of the following parameters:

- *Level of Technology*
- *Strategic Implementation of Innovation*
- *Organization and Output of Research Function* and
- *Response to Market Needs*

3.6.3 Statistical Tools

The various statistical tools used in the analysis of data are discussed in this section.

The convergent and discriminant validities of the constructs and their measures have been carried out. Various statistical tools and techniques have been employed using SPSS software (SPSS 14.0) to predict the results.

Cronbach's Alpha Coefficient: This parameter has been used for convergent validity. Convergent validity assesses the degree to which measures of the same concept (construct) are correlated. It is assessed by the correlation among items which make up the scale or instrument measuring the construct (internal consistency validity). The internal reliability of items (inter-item analysis) under each output parameter has been assessed by using Cronbach's alpha coefficient, as recommended for empirical research in operations management. Cronbach's alpha is an index of reliability associated with the variation accounted for by the true score of the ‘underlying construct’. Construct is the hypothetical variable that is being measured. Alpha coefficient ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from dichotomous (that is, questions with two possible answers) and/or multi-point formatted questions or scales. The higher the score, the more reliable the generated scale is (Best and Kahn, 1986; Flynn *et al.,* 1990; Radhakrishna, 2007). Cronbach's alpha coefficient (α) is defined as per the following equations.

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N}\sigma^2_{Y_i}}{\sigma^2_X}\right)$$ ---------------- Equation 3.1

Here, N is the number of components (items or testlets), σ^2_X is the variance of the observed total test scores, and σ^2_Y is the variance of component *i*.

Alternatively, the standardized Cronbach's alpha can be defined as

$$\alpha = \frac{N \cdot \bar{c}}{(\bar{v} + (N-1)\cdot \bar{c})}$$ ---------------- Equation 3.2

Here, **N** is the number of components (items or testlets), $\bar{v}$ equals the average variance and $\bar{c}$ is the average of all covariances between the components.

t-Test Analysis: To find the relationship between key inputs and key outputs, Pearson’s correlation coefficient values (r values) between various issues of inputs and the Development Indicators (output parameters) have been calculated. The correlation values obtained have been further validated using t-test. Pearson’s correlation values and t-values (obtained from t-test) have been worked out to ascertain significant issues and factors contributing to the success of TD implementation program in industry. The t-values obtained (from t-test) can also be worked out through empirical expression indicated in Equation 3.3.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \geq t_{n-2} \text{ (from't' Tables)} \qquad \text{---------------- Equation 3.3}$$

Here, '***n*-2**' represents degrees of freedom (df) for a particular test, '**r**' represents Pearson's correlation coefficient between a particular input issue and an output parameter, 't_{n-2}' is the $t_{critical}$ value from statistical't' tables for (**n–2**) degrees of freedom.

Canonical Factor Loading Analysis: The significant correlations obtained as a result of t-test have been validated through 'Canonical Factor Loading' analysis. This analysis describes the combined effect of multiple inputs on individual output variables. Canonical loadings measure the correlation between an original observed variable in the dependent or independent set and the set's canonical variate. The canonical loading reflects the variance that the observed variable shares with the canonical variate and can be interpreted like a factor loading in assessing the relative contribution of each variable to each canonical function. The larger the coefficient, the more important it is in deriving the canonical variate.

Multiple Regression Analysis: Further, multiple linear regression analysis has been performed taking into account a set of all independent variables and each dependent variable individually. This technique has been used to identify a set of variables which conjointly contribute significantly towards the criterion variable. The notations employed in this test include: β= Regression Coefficient (Beta Coefficient), R= Multiple Correlation Coefficient.

3.7 Assessing the Actor's Capability

The survey has been followed by case studies in two different manufacturing units that are 'actors' in the present context. The purpose of case studies has been to analyze those aspects of management of technology development program which have been reflected as potential areas requiring further investigation. The case studies have focused upon the step-by-step implementation procedure adopted by organizations towards achieving global competitiveness through management of innovation in research initiatives. The case studies have been analyzed to determine the practices and techniques adopted by manufacturing units towards effective technology development and the results accrued through such programs. The obstacles faced by organizations towards effective implementation of such programs have also been reviewed.

The overall methodology adopted in this phase of work is depicted in Figure 3.6.

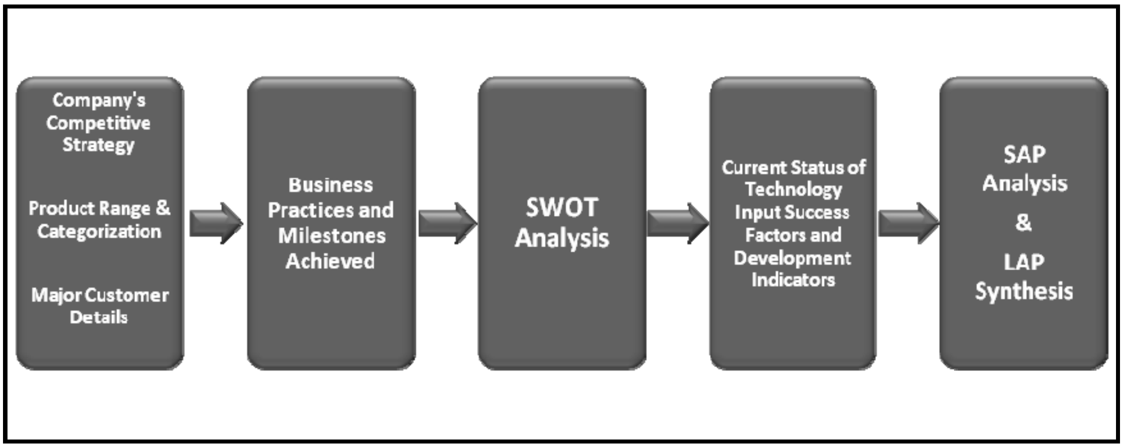

Figure 3.6 Methodology for Case Studies

The main tools used for data analysis in case studies have been SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, SAP analysis (Situation-Actor-Process) and LAP (Learnings- Actions-Performance) synthesis. SAP-LAP types are categorized according to various facets. The following may be noted for the SAP-LAP interplay used in the present work:

- Since technology development is a generic area for application and study, the context of all sectors of manufacturing industry, the SAP-LAP analysis is also generic.
- The analysis is atomic or naive as it does not take into consideration, the interaction and interdependence of the six basic components of SAP-LAP.
- Though in case studies, the historical context, business strategy decisions, and milestones achieved by the manufacturing organizations have been briefly discussed over a time span, yet a snap shot of various practices and processes followed for technology development has been taken, therefore, the SAP-LAP analysis is static.
- Since only one systematic framework representing the approaches for technology development has been developed, the SAP-LAP analysis on which this framework is partly based – is singular.

The details of steps followed for developing the case studies; the techniques used and their justification is presented in Table 3.1.

Table 3.1 Analysis and Justification of Case Study Methodology

S.No	Steps of Analysis	Techniques Used	Justification of Techniques
Step 1.	Collection of data and information from organizations regarding performance and various measures undertaken from time to time.	▪ Personal interactions and observations. ▪ Scanning of published annual reports and other printed material.	This information is necessary for such studies and all the techniques utilized are proven effective methods.
Step 2.	Status and analysis of practices followed by the organization for technology upgradation.	▪ Consolidating the role of technology development implementation process and assessing the strategies adopted by the organization.	To study and analyze the impact of various practices followed by organization regarding the research problem.
Step 3.	Learning issues from case studies.	▪ SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats). ▪ SAP Analysis (Situation-Actor- Process) ▪ LAP Synthesis (Learning-Action-Performance)	SWOT analysis puts forth the strategies adopted by organizations for technology development in the light of their strengths, weaknesses, opportunities and threats. SAP analysis consolidates the processes adopted by the actors under various situations. LAP synthesis brings out learning's from the approaches, actions and performance.

3.8 Evolving a Management Process

This phase of work presents a synthesis of learnings and outcomes of survey and case studies for their utilization through a qualitative model to evolve a technology development program for small scale industry of the region.

Qualitative modeling used in this study involved deriving expert opinion and using this along with findings of previous phases (survey and case studies) in a structured manner. For this purpose, experts were invited to participate in the exercise. The panel of experts was drawn from the participating industry and academic institutes. The detailed findings of previous phases were shared with the experts. Four main techniques for modeling of the research problem have been used in the present work. These include Options Field Methodology (OFM) and Options Profile Methodology (OPM) developed by Warfield (1979, 1982, 1990), Analytic Hierarchy Process (AHP) developed by Saaty (1980, 1986, 1990) and Fuzzy Set Theory (FST) methodology developed by Zadeh (1965).
A brief overview of the different techniques used for qualitative modeling of the research problem is presented as follows:

Options Field Methodology: Options Field Methodology (OPM) and Options Profile Methodology (OFM) provide a means for thorough development of the design situation and the design target description. The main steps in OFM are:

- *Construction of a Polystructure*: Generate a list of options as a solution to the present research problem using modified idea writing.
- *Initial Structuring*: Place the options into a set of categories.
- *Naming of Categories*: Develop a suitable name for each category.
- *Identification of Design Dimensions*: Identify the dimensions of the target.
- *Determining Clusters of dependent Dimensions*: Put various dimensions together into different clusters based on their proximity and affinity to each other.
- *Sequencing of Clusters*: Structure the clusters on the basis of sequence in which choices of options should be made.
- *Sequencing of Dimensions within Clusters*: Define the initial decision making sequence among dimensions of each cluster.
- *Displaying the completed Options Field*: Organize the Options Field displaying the clusters, dimensions and options in an orderly manner.

Options Profile Methodology: The next technique used in qualitative modeling was Options Profile Methodology (OPM). Here, various courses of actions (Profiles) of the design are developed. These profiles can be employed to achieve overall objective of the research problem. The main steps in OPM are:

- Developing various courses of actions (Profiles) as a solution to the problem.
- Allocating various options to these alternate profiles.

The completed options profiles represent alternative approaches and courses of action to be adopted in each approach.

Analytic Hierarchy Process: The next step in modeling was use of Analytic Hierarchy Process (AHP) which involves the following steps:

- Deciding various sub-objectives (under the main objective) of the research problem. These are also referred to as 'features of design'.
- Deciding the relative weightage of these sub-objectives using paired comparison by experts.

Fuzzy Set Theory: Finally, Fuzzy Set Theory (FST) technique was employed. This approach quantifies (from the qualitative feedback provided by experts) the contribution of each profile towards each objective. The main steps in this approach are:

- Developing 'Position Matrices' to quantify the contribution of each profile to each objective.
- Making 'Weighted Position Matrices' to ascertain the effectiveness of each profile for the fulfillment of goals.
- Making 'Dominance Matrices' to find out the best course of action (profile) under optimistic, pessimistic and realistic scenario.

Finally, a conceptual framework has been developed which represents the linkage between essential components of 'Technology Development Implementation Program' and elaborates on their relative contribution in meeting the overall research objective. The framework is based on outcomes of various phases of work including literature review, sample based survey, case studies and qualitative modeling.

3.9 Concluding Remarks

The methodology adopted for the study along with the step-by-step approach employed for the research has been elaborated in this chapter. Flexible Systems Methodology has been used as a tool to help evolve the problem in a Situation, Actor and Process (S-A-P) interplay. Empirical studies have been used to yield rich data for statistical analysis that can be used for drawing relevant inferences. Case study methodology has been used to provide deep insight into the problem by giving real picture of the industrial situation. The critical learning issues from the survey and case studies have been synthesized to develop a systematic plan and evolve a management process. In view of the insights gained from this synthesis and the literature available, actions for implementation in the manufacturing industry have been recommended.

CHAPTER - IV
SURVEY BASED RESEARCH RESULTS

4.1 Introduction

This chapter presents the results of a detailed survey conducted in small scale manufacturing sector in North India covering almost all major industrial cities in the state of Punjab. The objective of survey is to review the status of technology development initiatives of industry through indigenous research. The survey explores the present status of research capabilities of industry with regard to R&D policies, infrastructural facilities, investments in development projects, organizational structure of research function, support from government, academic institutions and the like. The reasons for poor performance of Indian industry in the area of technological innovations have also been investigated. Further, the analysis of survey establishes the relationship of various technology development implementation dimensions with manufacturing performance indicators. The analysis of preliminary data serves as a useful input for case studies and for formulation of an indigenous technology development implementation program (TD Program) for the manufacturing industry.

4.2 Methodology

For survey, the first task has been to design a questionnaire which seeks information on the status of technology development and its various components in the engineering industry. A simple, relevant and comprehensive questionnaire covering various aspects of the research problem has been specially designed. For effectively conducting the survey, the 'TD Questionnaire' has been designed through an extensive literature review (Choi, 1989; Ahmed, 1998a; Ahmed 1998b; Kim, 2001; Sheel, 2002; Martins and Terblanche, 2003; Shaw and Craig, 2003; Swann and Birke, 2005), and validated through peer review from academicians, consultants, technology innovation councilors, and practitioners from industry. To ensure the relevance and effectiveness of questions to the manufacturing industry, the questionnaire has been pre-tested on a representative sample of industry. The feedback received has been incorporated to make the questionnaire more relevant for the purpose. The design methodology for framing the 'TD Questionnaire' is elaborated in Chapter - III and detailed description of it is presented in Appendix - A.

The questionnaire is divided into two sections. Section 1 seeks information on general aspects of the manufacturing organizations (product range, annual turnover, year of inception etc). Section 2 seeks information on the status of technological innovations, in general, and specific information on various factors and issues related to technology development in manufacturing organizations. Section 2 is devoted to multiple choice questions with a scale of 4 provided for each response. The key items and issues contained in the questionnaire are summarized in Table 4.1.

While designing the questionnaire, time constraints for people in the industry and the actual form in which information is available with the industry has been taken into consideration.

4.2.1 Manufacturing Organizations Covered

Small scale manufacturing organizations in the state of Punjab (northern region of India) covering the cities of Barnala, Chandigarh, Hoshiarpur, Jalandhar, Ludhiana, Mohali and Patiala have been included in the survey. The present research has been limited to three types of small scale industry viz. cutting tool, machine tool and auto-component units. The main products of cutting tool industry are metal slitting saws, slotting cutters, side and face cutters, milling cutters, reamers, gear hobs, broaches, harvester blades, jack plane blades etc. Machine tool industry mainly deals with parts and subassemblies for lathes, power presses, shearing machines and other special purpose machines. Hand tool industry products have also been considered. The main products of auto-component industry are various types of gears, pistons, piston rings, cylinder liners, clutch plates, motor shafts, seat parts, handle parts etc.

A total of 227 units were selected, and in the first place, the questionnaire was mailed to all of them along with a covering letter stating the objective of the study and its usefulness to the industry. A request to respond at the earliest was made and subsequent reminders were also sent. Information from some of the organizations has been received in this way.

Most of the information, however, has been collected by making personal visits to the industrial units and through discussions with proprietors and/or senior executives.

Table 4.1 Key Items in the Questionnaire

Major Area	Issues	Number of Items
FACTORS AFFECTING PERFORMANCE OF INDUSTRY	▪ Physical Infrastructure ▪ Capacity Utilization ▪ Modernization Programs ▪ Marketing Strategies ▪ Availability and Cost of Materials and Power ▪ Geographical Location ▪ Technological Obsolescence ▪ Manufacturing Competency	**17**
MANAGEMENT SUPPORT ISSUES	▪ Multi- skilled Workforce ▪ Employee Education Level ▪ Employee Training ▪ R&D Personnel Strength ▪ Reward Mechanism	**09**
INFRASTRUCTURE FACILITIES	▪ Production Facilities ▪ Research Infrastructure ▪ Renovation Programs ▪ Financial Support to Research Function	**08**
POLICY ENVIRONMENT	▪ Pricing Policies ▪ Support Infrastructure Facilities ▪ Subsidies and Incentives ▪ Financial Support to Development Initiatives ▪ Business Support Mechanisms	**12**
COLLABORATIONS AND NETWORKS	▪ Industry-Institute Interactions ▪ Industry-Industry Tie-ups ▪ Interaction with Research Institutes ▪ Interaction with Service Institutes	**14**
TECHNOLOGY DEVELOPMENT OUTPUTS	▪ Technological Innovations through indigenous Research Initiatives ▪ Structure and Output of Research Function ▪ Response to Market Needs ▪ Strategic Implementation of Innovation	**17**

4.2.2 Response to the Survey

Out of 227 units to which the questionnaire was sent, 58 belonged to cutting tool, 67 to machine & hand tool and the remaining 102 to auto-component sector.

A total of 91 responses were received, and elimination of incomplete or unusable responses resulted in 83 cases (out of 227). Out of these, 26 were from cutting tool, 25 from machine/hand tool, and 32 from auto-component industry. The response of industry is presented in Table 4.2.

Table 4.2 Response of the Industry

S. No.	**Classification**	**Questionnaire sent to**	**Response**	
		No. of Industries	Number	Percentage
1	All Units	227	83	37
2	Cutting Tool	58	26	45
3	Machine Tool	67	25	37
4	Auto Component	102	32	31

The salient details of industrial units which participated in the survey are presented in Appendix - B. The sector wise response as a percentage of total response is given in Figure 4.1.

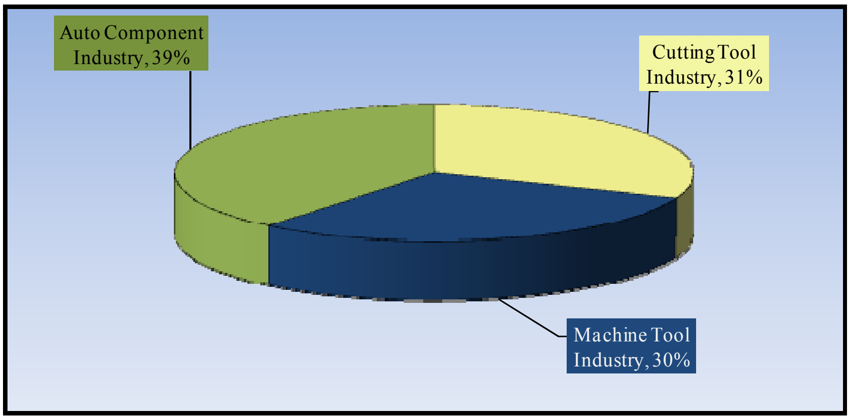

Figure 4.1 Sector-wise Response to Survey

4.3 Analysis of the Response

The analysis of questionnaire has been carried out from the following view points:

1. To determine the status of manufacturing industry with regards to existence of department, facilities and programs for technology development through indigenous research efforts.

2. To assess the main factors and reasons impairing the performance of small scale manufacturing industry.
3. To assess the status of each component (aspect) of technology development implementation program (TD Program) in the industry.
4. To assess the overall standing of each manufacturing organization in different components of TD, leading to classification of organizations into various categories.
5. To evaluate contribution of TD initiatives (Technology Input Success Factors) towards achieving manufacturing performance improvements (Development Indicators).

4.4 Existence of Facilities for Technology Development

Section 2 of the questionnaire contained several keys/ statements to assess the status of manufacturing organizations with regard to existence of departments, policies, facilities and programs for technology development through in-house research efforts. The results have been complied and shown in Table 4.3 and Figure 4.2.

Table 4.3 Existence of Departments, Facilities, Programs

S. No.	Departments, Facilities and Programs	Type of the Industry (in percentage)			Total Percentage
		Cutting Tool	Machine Tool	Auto Components	
1	R&D Department	19	43	56	41
2	R&D Policy	23	24	11	18
3	Marketing Department	19	48	50	40
4	Infrastructural Facilities	12	10	9	10
5	Employee Training	23	29	44	34

A department entrusted with the task of research and development (R&D) activities exists in less than half of the manufacturing organizations. Well defined R&D policy for technology development is practiced in only about one fifth of the industrial units. Only 40 percent organizations collect information on customer requirements in a structured manner. State of the art infrastructure facilities for R&D are available in only one tenth of the manufacturing units. Only about one third of the organizations provide training to employees to enhance creativity and innovation skills.

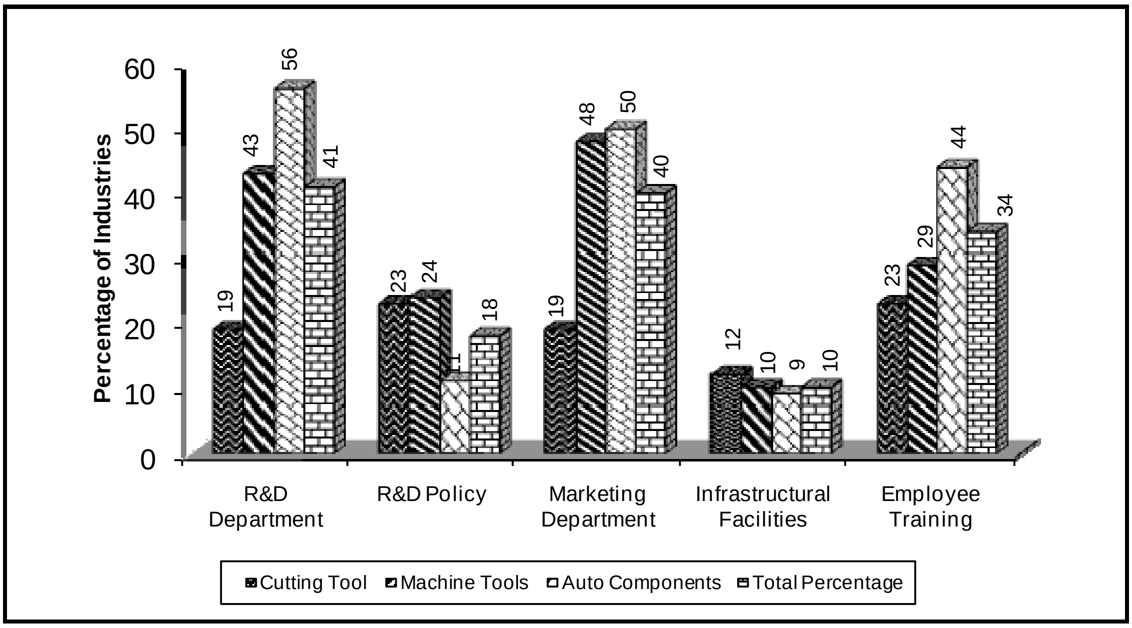

Figure 4.2 Existence of Departments, Facilities and Programs

4.5 Factors Impairing Performance of Industry

A section of the questionnaire (Q.No 16) seeks information on factors which are responsible for impairing the performance of small scale manufacturing industry (SSMI), in this part of India. The information on these factors has been tabulated and presented in Table 4.4. Table 4.4 shows the scores of different factors, signifying their relative impact in impairing the performance of manufacturing organizations. The scores are expressed in terms of, *Percent Point Score* (PPS). It is defined as the ratio of score obtained in an aspect to the maximum score possible in that aspect, expressed as a percentage.

Out of the seventeen factors considered in the survey, four factors have obtained a very high rating (PPS>70) and thus are considered to be most significant in deteriorating the performance of industry. These factors include lack of government support, use of old technology, absence of large scale manufacturing industry and shortage of electric power.

Table 4.4 Factors Impairing SSMI Performance

S. No.	Factor	No. of Companies	No. of Companies Scoring Points 4 (A)	3 (B)	2 (C)	1 (D)	Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$
1	Shortage of Raw Material	79	20	16	16	27	187	59.18
2	High Prices of Raw Material	79	20	27	20	12	213	67.41
3	Shortage and Cost of Power	79	26	25	17	11	224	70.89
4	Non Availability of Multiskilled Labour	79	4	24	24	27	163	51.58
5	Old Process Technology	79	31	20	19	9	231	73.10
6	Shortage of Finance	79	15	26	19	19	195	61.71
7	Poor Education Level of Workers	79	11	15	25	28	167	52.85
8	Under Utilization of Capacity	79	11	24	19	25	179	56.65
9	Absence of Modernization Programs	78	17	31	17	13	208	66.67
10	Absence of Large Scale Industry	79	32	17	19	11	228	72.15
11	Competition from Other Countries	79	16	24	17	22	192	60.76
12	Poor Transportation Infrastructure	79	8	5	17	49	130	41.14
13	Geographical Location	79	0	8	15	56	110	34.81
14	Poor Marketing Management	79	7	7	26	39	140	44.30
15	Lack of Government Support	78	34	20	15	9	235	75.32
16	Unorganized Sector	78	20	22	21	15	203	65.06
17	Inability to Reduce Cost of Manufacturing	78	23	21	21	13	210	67.31

 # (Total Points Scored "TPS" = 4 x A + 3 x B + 2 x C + 1 x D)

Inadequate government support to industrial sector for technology development initiatives, and use of old technology (lack of technology dynamism) to manufacture products are the prime reasons decreasing the competitiveness of small scale sector. This outcome also justifies the need of carrying out the present research work. Further, the absence of large scale manufacturing organizations in the state of Punjab, shortage and cost of electric power are also major reasons impairing the performance.

Another four factors have secured a reasonably high rating (PPS~ 65-70). These include high price of raw materials, inability to reduce cost of manufacturing to improve profit margins, absence of modernization/ renovation programs, and unorganized structure of small scale industrial sector. These factors are placed in the next range of scores and also need to be addressed seriously.

Lack of financial support to research initiatives, competition from other countries, shortage of raw material, and underutilization of capacity are other important issues (PPS~ 55-65) needing attention.

However, the remaining five issues have obtained relatively low scores (PPS<55) and are not considered significant in lowering the performance. The industry is doing fairly well in these issues. These include availability of workforce with multiple skill-base to perform varied tasks, education level and technical know-how of employees, geographical location of the state of Punjab, transportation infrastructure in the region, and effectiveness of marketing management strategies used in the industry.

Figure 4.4 shows various factors in order of their relative impact in impairing the performance of industry.

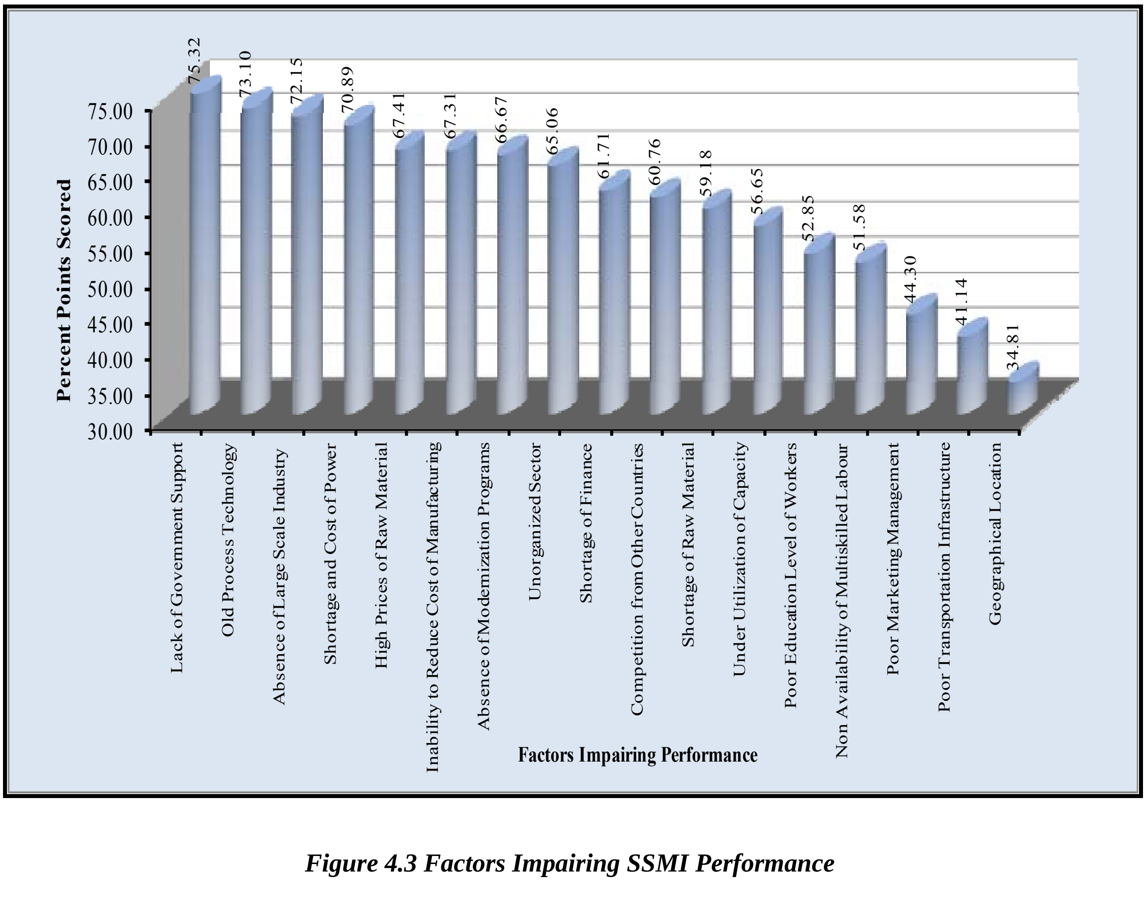

Figure 4.3 Factors Impairing SSMI Performance

4.6 Status of Technology Development (TD) Components

The present work considers five key areas (components) for overall assessment of technology development implementation program in the small scale sector. These include

- *Manpower Competence and Management Commitment* for creative input
- *Technology Infrastructure* facilities for research function
- *Regulatory Support* to the development efforts of manufacturing sector
- *Interaction with Others* for technological developments
- *Research Output* as a result of innovation initiatives

This section presents the status of each of these components (or aspects) in the manufacturing sector.

Table 4.5 presents the status of, 'Manpower Competence and Management Commitment' component. A set of questions which reflect different issues under this component are presented in Table 4.5. For each item, the measures of central tendency (C.T) and percent points scored (P.P.S) have been calculated. These measures reflect as to how well the area (issue) represented by a question is being looked after in the industry. Finally, the overall average for each component is calculated (considering all issues under the component), which represents the status of the entire component.

Similarly, Table 4.6, Table 4.7, Table 4.8 and Table 4.9 represent the status of 'Technology Infrastructure', 'Regulatory Support', 'Interaction with Others' and 'Research Output' components of technology development (TD) respectively.

4.6.1 Status of Manpower Competence and Management Commitment

The keys and statements on this component contained in section 2 of the questionnaire aim at collecting information on the following:

i) Competence of employees to contribute in technology development efforts. Here information is collected regarding availability of workforce with multiple skill base, education level of employees, availability of scientific personnel, awareness amongst employees regarding significance of technology upgradation, formal training to employees to enhance creativity and innovation skills.

ii) Commitment of management to utilize the human resource efficiently and effectively. Here information is collected regarding encouragement provided to undertake research initiatives and obtain patents, reward schemes for innovative efforts, reaction to project failures.

The response to various issues of this component is presented in Table 4.5.

Table 4.5 Evaluation of Manpower Competence and Management Commitment Issues

S. No.	Q. No.	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring 1 (A)	2 (B)	3 (C)	4 (D)	Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$	Central Tendency (CT) TPS/N
1	16 d	Availability of multi-skilled workforce	79	4	24	24	27	232	73.42	2.94
2	16 g	Education level of employees	79	11	15	25	28	228	72.15	2.89
3	28	Formal training of employees to enhance innovation skills	83	55	0	24	4	143	43.07	1.72
4	35	Awareness with regards to significance of technology	83	22	19	22	20	206	62.05	2.48
5	36	Adequate scientific and technical personnel	83	34	27	15	7	161	48.49	1.94
6	37	Encouragement to undertake R&D work	83	48	12	22	1	142	42.77	1.71
7	38	Patents obtained	83	83	0	0	0	83	25.00	1.00
8	39	Reward schemes for innovative efforts	83	1	2	76	4	249	75.00	3.00
9	40	Reactions to R&D project failures	83	6	0	62	15	252	75.90	3.04
		Overall Average								2.30

 # (Total Points Scored "TPS" = 1 x A + 2 x B + 3 x C + 4 x D)

Small scale sector in the region is doing fairly well (PPS= 73.42) with regard to availability of multi-skilled workforce for performing wide-ranging tasks. About two thirds of the organizations have this workforce in adequate strength. However, the remaining organizations consider unavailability of multi-skilled labor force to be significant in impairing performance.

Education level of employees is helpful in enhancing the creative potential. About one third of the organizations consider education level of their workforce at a very good level. In nearly half the units, education level is between fair to good. The remaining (about 14 percent) organizations consider poor education level of employees to be a serious concern.

Literature reveals that innovative organizations rely heavily on proper training of employees to enhance creativity and innovation skills. The manufacturing industry in the region has overlooked this fact. Organizations have shown an unreasonably low rating, in terms of percent points scored in this issue (PPS= 43.07 only). About two thirds of the organizations do not provide any formal training to employees. A little less than one third provide training, either during orientation period through senior executives or on-the-job training where employees learn through experience. Only a very few (5 percent) organizations provide formal training to employees just after induction into the organization. Surprisingly, none of the organizations make use of standard creativity tests to improve innovation level of employees. Also, there is very low encouragement to participate in conferences, workshops, seminars etc.

The industrial sector secures a reasonable rating (PPS= 62.05 only) as far as awareness among employees regarding significance of technology development through in-house research efforts is concerned.

Inadequacy of technical and scientific manpower (R&D personnel) is a serious concern (PPS= 48.49) for the Indian small scale sector. Majority of the organizations do not have R&D personnel to undertake development projects. Only less than one tenth of the organizations have technical staff in sufficient strength.

Innovative corporations worldwide, use patents as a strategic tool for technological innovations. Small scale sector in the country does not value this fact The level of encouragement to employees by senior management for undertaking R&D work and obtaining patents is very low (PPS= 42.77 only). Generally, there is little pressure on employees to put efforts for technology development. In the last fifteen years, none of the cutting tool, machine tool or auto-component units in the region has obtained a patent.

One of the key strategies to stimulate interest of employees in research initiatives is to suitably reward their innovative efforts. Results reveal that contribution of employees is adequately recognized (PPS= 75.00) in case profits are made because of innovative endeavors. Majority of the organizations either give a fixed monetary reward, or an increment in salary or a share in profits made on account of the creative outcome. A few organizations (5 percent) go to the extent of providing promotion in designation for contributions in the area of technology development. In another few (about 3 percent), recognition is in the form of an appreciation letter.

In case of research project failures, management's role has been observed to be supportive in majority of the organizations. A large fraction of units counsel their employees to learn from current failures to improve for future and encourage them to continue with technology innovation efforts. About one fifth conduct a thorough analysis to find root causes of failures and plan a future action by consensus. Only a few organizations (7 percent) take strict action against members of the project team when a failure occurs. However, none of the small scale units discourage employees from undertaking development initiatives despite failures.

The average score of this aspect is 2.30 (out of 4.00) as shown in Figure 4.4. The analysis of this component reveals that formal training of employees, availability of scientific personnel, encouragement by top management to undertake R&D work and obtain patents are critical areas needing improvement.

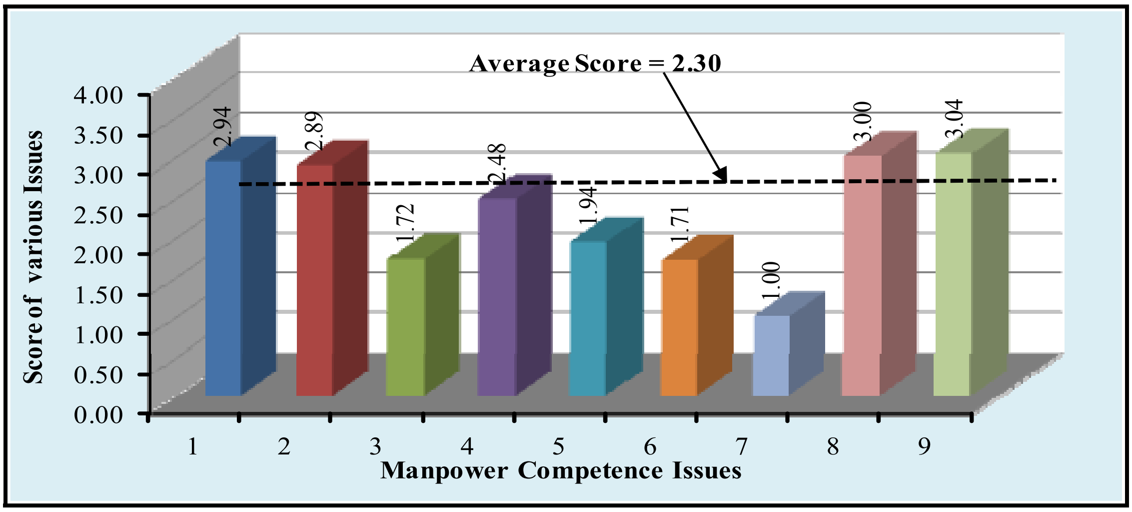

Figure 4.4 Issue-wise Performance regarding Manpower Competence Issues

4.6.2 Status of Technology Infrastructure

The keys and statements on this component contained in the questionnaire aim at collecting information on the following:

i) Availability of financial support for developmental work, specific earmarking of funds for research activities, sources of funds, investments in research function as a proportion of annual turnover.
ii) Availability of infrastructural facilities to carry out technology development work and the role of modernization and renovation programs.

The response to various issues of this component is presented in Table 4.6.

Financial support to research function is critical for the success of technology development initiatives. About one fifth of the organizations have been facing acute shortage of funds for developmental work and consider this factor as most significant in impairing the performance of industry. Majority of the organizations have only little to reasonable support for their projects. However, about one fourth of the industrial units do not consider shortage of finance as a reason for poor performance.

Absence of modernization and renovation programs is an important aspect preventing development in majority of the organizations. About one fifth of the organizations consider this factor as most significant in causing sickness in small scale industry. Only a few organizations (16 percent) regularly implement modernization and renovation measures.

For technological innovations, dedicated laboratories with facilities for experimentation and subsequent analysis are essential. Industry has shown an extremely poor rating (PPS= 33.33) in this issue. A large fraction (79 percent) of the units does not have these amenities. Another, one tenth have these only to a small extent. Only a very few industrial units have proper R&D infrastructure for experimentation, testing etc, which is discouraging.

State of the art production equipment, machining centers, robots etc. are not available in nearly three fourth of the industrial units and thus a very low (PPS= 34.15) rating in this issue has been shown. Only about one tenth of the organizations have these facilities at an acceptable level. Moreover, the organizations do not have latest softwares for drafting, designing, modeling etc. and thus a very poor rating (PPS= 46.04) is shown. Nearly half of the organizations do not have requisite softwares. Another one third is using only to a small extent. It is only less than one tenth of the organizations which possess completely, the state of the art software packages for R&D work. The absence of these basic infrastructural facilities has proved to be a major retardant in the technology development efforts of industry.

Table 4.6 Evaluation of Technology Infrastructure Issues

S. No.	Q. No.	Topics in the Aspect	No. of Responses (N)	No. of Industries Scoring 1 (A)	2 (B)	3 (C)	4 (D)	Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$	Central Tendency (CT) TPS/N
1	16 f	Funds for R&D activities	79	15	26	19	19	200	63.29	2.53
2	16 i	Modrenization and renovation programs	78	17	31	17	13	182	58.33	2.33
3	27 a	Dedicated labs for experimentation and analysis	81	64	9	6	2	108	33.33	1.33
4	27 b	State of the art production facilities	82	61	12	9	0	112	34.15	1.37
5	27 c	Latest softwares for modeling and analysis	82	38	25	13	6	151	46.04	1.84
6	29	Earmarking funds for R&D activities	83	65	5	8	5	119	35.84	1.43
7	30	Investments in R&D as a fraction of annual turnover	80	53	18	6	3	119	37.19	1.49
8	31	Organization as main source of funds for R&D	83	7	7	13	56	284	85.54	3.42
		Overall Average								1.97

 # (Total Points Scored "TPS" = 1 x A + 2 x B + 3 x C + 4 x D)

The state of affairs in the industry is disappointing (PPS= 35.84) as far as earmarking of funds specifically for research activities is concerned. More than three fourth of the organizations do not clearly allocate funds for research and development initiatives. About one tenth of the organizations, club these funds with other developmental activities. There are only a very few organizations (6 percent) where management clearly assigns funds for research projects aimed at innovations for new product and process developments. This strategic initiative needs to be strengthened for reaping the potential benefits from TD programs.

Manufacturing units in developed economies spend on an average upto 18 percent of annual turnover on technology development projects. Indian industry with an extremely low rating (PPS= 37.19) in this issue fails to notice this fact. Two thirds of the organizations do not spend even 0.5 percent of annual turnover on R&D. Another one fourth spends between 0.5-2.5 percent on development initiatives. The number of units whose spending compares global standards is less than 4 percent which is discouraging.

The investments in R&D are very low but all the blame does not lie with the industry. Small scale sector is not financially self-contained and largely depends upon support from government and other agencies for research and development activities. Despite this fact, in majority of the organizations (83 percent), the major source of funds for technology development efforts is the organization itself and not the government or any other agency.

The average score of this aspect is 1.97 (out of 4.00) as shown in Figure 4.5. The survival of industry is not feasible in the absence of research and development initiatives and for that infrastructure and financial support are needed. The critical analysis of various issues related to 'Technology Infrastructure' component reveals that most of the issues and concerns of this component have shown very low rating. Substantial improvements need to be affected for ensuring effectiveness of this component.

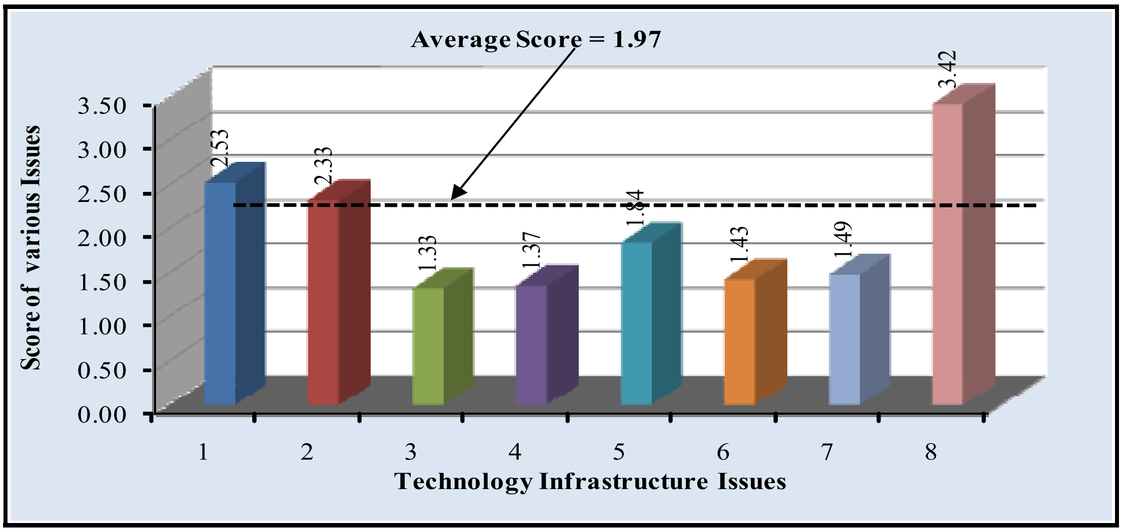

Figure 4.5 Issue-wise Performance regarding Technology Infrastructure Issues

4.6.3 Status of Regulatory Support

This section discusses the role of government in supporting the small scale industry in its technology development efforts. The keys and statements on government support aim at collecting information on the following:

i) Status of raw material prices, availability and cost of electric power, condition of transportation infrastructure, government policies regarding subsidies.
ii) Status of government funding for research initiatives, reward schemes, programs for technology awareness, availability of government laboratories for research projects, assistance in acquiring latest technologies, sponsoring employee development programs.
iii) Awareness of industrial units regarding government subsidiaries set-up to support the small scale sector, assistance from these government organizations.

The response to various issues on this component is presented in Table 4.7.

The analysis of data reveals that some improvements need to be affected in government policies for ensuring availability of raw materials at appropriate prices (PPS= 57.59 only). A little more than one fourth of the organizations consider raw material prices to be exceptionally high and regard this factor as most significant in impairing technological innovation performance of the industry. Another one third considers prices to be very high. There are only a very few organizations (15 percent) which are satisfied with government policies on pricing of raw materials.

Availability and cost of electric power in the region also show a relatively low rating (PPS= 58.33) and are amongst the most significant factors impairing performance of industry. One third of the organizations consider this factor as most significant. Another one third considers it as a major hurdle in their progress.

Good transportation infrastructure plays a vital role in increasing competitiveness of any manufacturing industry. Government is performing fairly well (PPS= 83.86) as far as rail and road infrastructure in the region is concerned. Only a very few organizations (15 percent) consider the condition of transportation infrastructure to be below standards and thus significant in impairing performance.

Table 4.7 Evaluation of Regulatory Support Issues

S. No.	Q. No.	Topics in the Aspect	No. of Responses (N)	No. of Industries Scoring 1 (A)	2 (B)	3 (C)	4 (D)	Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$	Central Tendency (CT) TPS/N
1	16 b	Raw material prices	79	20	27	20	12	182	57.59	2.30
2	16 c	Shortage and cost of power	79	26	25	17	11	171	58.33	2.16
3	16 l	Transportation infrastructure	79	8	5	17	49	265	83.86	3.35
4	16 o	Policies regarding subsidies	78	34	20	15	9	155	49.68	1.99
5	31 a	Funding for research initiatives	83	66	11	2	4	110	33.13	1.33
6	41 a	Funding related to R&D performance	83	16	13	14	40	244	73.49	2.94
7	41 b	Funding related to annual turnover	82	20	9	11	42	239	72.87	2.91
8	41 c	Reward schemes for research initiatives	83	16	8	20	39	248	74.7	2.99
9	41 d	Organizing seminars for technology awareness	83	12	10	21	40	255	76.81	3.07
10	41 e	Providing labs for research projects	82	17	10	11	44	246	75	3.00
11	41 f	Assistance in acquiring imported technologies	83	16	10	15	42	249	75	3.00
12	41 g	Sponsoring employee training programmes	83	18	10	14	41	244	73.49	2.94
		Overall Average								2.67

 # (Total Points Scored "TPS" = 1 x A + 2 x B + 3 x C + 4 x D)

Small scale industrial sector needs active support from government with regard to sponsoring funds for development activities, loans at low interest rates, assistance in import of technologies, favorable excise duties etc. However, majority of the organizations consider lack for government support to be the most significant factor in lowering the performance. Government has failed miserably (PPS= 33.13) in providing funds to the industry for innovation initiatives. Majority of the units (80 percent) do not receive any financial grant from government which is dispiriting.

Nearly half of the organizations are of the view that government can allocate funds for research and development initiatives to different organizations based on their performance of previous years in utilizing the allocated resources. However, about one fifth disagrees with this viewpoint and suggests allocation to be independent of previous performance.

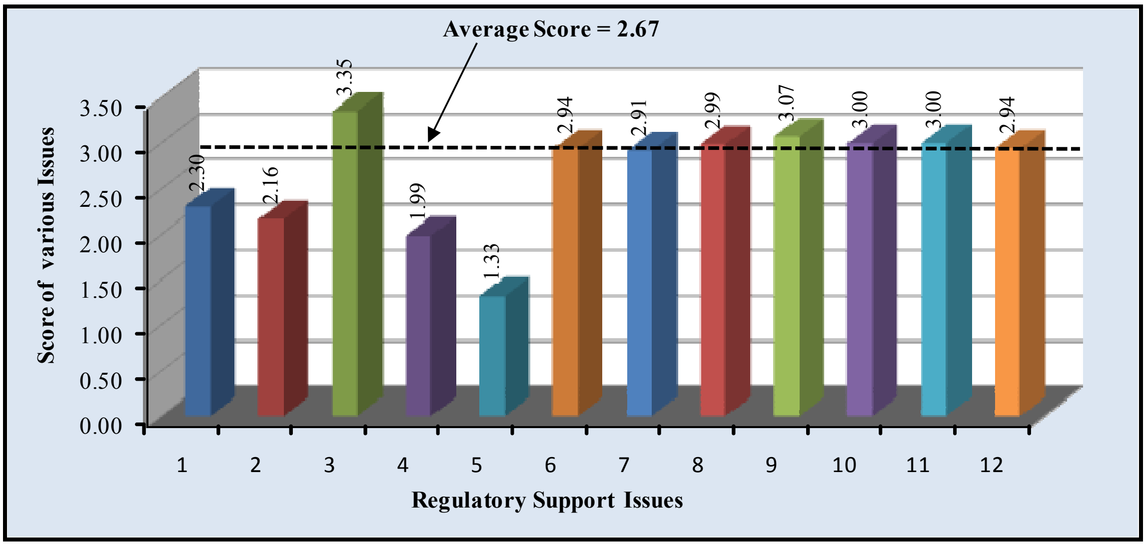

Figure 4.6 Issue-wise Performance regarding Regulatory Support Issues

Majority of the organizations are of the opinion that government can suitably reward entrepreneurs for contributions in the field of technological innovations. Further, the government can support industry by organizing seminars to increase awareness about new and upcoming technologies. It can also lend assistance to the industry in acquisition of imported technologies. About three fourth of the industrial units consider this government support to be really helpful.

Nearly half of the organizations are of the view that government can regularly sponsor employee training programs on skill development, new production techniques etc. Another, about one fifth (17 percent) propose that this type of support, if provided, even occasionally can benefit the industry.

The average score of this aspect is 2.67 (out of 4.00) as shown in Figure 4.6. Lack of government support to development initiatives is among the most significant factors impairing the competitiveness of small scale sector. The analysis of data reveals that major improvements need to be made regarding effective deployment of various government support mechanisms in the Indian manufacturing industry.

4.6.4 Status of Interaction

This section presents the status of interaction and networking of manufacturing organizations with external agencies like other industries, universities, R&D institutes etc. for technology development. The keys and statements on interaction aim at collecting information on the following:

i) Extent of technology acquired from abroad, from within the country, developed in collaboration with other industries.
ii) Industry–Institute collaborations on research and development for solving technology related problems.
iii) Collaborations with research institutes, service institutes and other agencies for technology development.

The response to various issues on this component is presented in Table 4.8.

Small scale manufacturing sector, it may be anywhere, greatly depends on external help for its process technology needs. The situation is no different for small scale industry in the region. The dependency has remained mainly on large scale Indian organizations rather than foreign firms. More than three fourths of the organizations have acquired almost all process technology from large Indian firms. Majority of the units have not acquired any technology from abroad. About one tenth of the units depend partially on industry outside the country. There are only a very few (5 percent) organizations which depend largely or completely on foreign industry for their process technology needs.

Manufacturing organizations are not interacting much with external research institutes and agencies for technology development projects. Organizations have shown an unreasonably low rating, in terms of percent points scored in this issue (PPS= 30.72 only). Most of the units have never worked in collaboration with external agencies. There are only a few manufacturing units (6 percent) where all or most of the product and process technologies have been developed through collaborations.

Creating and maintaining relationships between academic and industrial organizations is a highly recognized mechanism to manage the changing demands of industrial society. Indian entrepreneurs have a mixed response on this issue. Nearly half of the units consider that interaction with regional academic institutes can solve technology related problems of industry to a large extent. However, the remaining organizations do not consider such collaborations to be of considerable use. This opinion is corroborated by an extremely poor rating (PPS= 31.33) shown by industrial units in obtaining positive results through industry-institute interactions. Most of the organizations (85 percent) have not experienced positive results through industry-institute interface programmes, which is discouraging. Only less than one tenth of the organizations have successfully collaborated with regional technical institutions for technology development.

Table 4.8 Evaluation of Interaction Issues

S. No.	Q. No.	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring				Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$	Central Tendency (CT) TPS/N
				1 (A)	2 (B)	3 (C)	4 (D)			
1	21 a	Technology acquired from abroad	83	68	11	3	1	103	31.02	1.24
2	21 b	Technology from within the country	83	11	3	10	59	283	85.24	3.41
3	21 c	Technology developed in collaboration	83	72	6	2	3	102	30.72	1.23
4	42	Awareness of Industry-Institute interaction	83	23	17	20	23	209	62.95	2.52
5	43	Industry-Institue ties on research initiatives	83	70	6	6	1	104	31.33	1.25
6	44 a	Academia for preparing the road maps	83	17	26	9	31	220	66.27	2.65
7	44 b	Expert lectures by academicians	83	12	17	17	37	245	73.8	2.95
8	44 c	Training through short term courses	89	14	25	22	28	242	67.98	2.72
9	44 d	Combined teams for projects	82	12	18	22	30	234	71.34	2.85
10	44 e	Institute laboratories for analysis	83	13	22	22	26	227	68.37	2.73
11	44 f	Combined supervision of dissertations	83	16	34	10	23	206	62.05	2.48
12	48	Assistance from service institutes	83	54	0	0	29	170	51.2	2.05
13	49	Awarenes regarding government subsidiaries	83	18	14	19	32	231	69.58	2.78
14	51	Assistance from government organizations	81	56	11	12	2	122	37.65	1.51
		Overall Average								2.31

 # (Total Points Scored "TPS" = 1 x A + 2 x B + 3 x C + 4 x D)

More than half of the organizations suggest that experts from academic institutes can prepare roadmaps for industry to make research function an integral part of firm's working which to a large extent can be helpful in technological innovations. The remaining organizations do not consider this activity to be of much use.

Technical institutions can help the manufacturing industry in product innovation efforts through expert lectures on upcoming key technologies. This seems to be the most preferred interaction mode (PPS= 73.8) by the industry. Majority of the organizations consider this option to be useful to a large extent. A few organizations (21 percent) consider it to be helpful but only to a small extent.

Formal training of employees in specialized skills through short-term courses and apprenticeship programs is another feature of industry-institute acquaintance. More than half of the organizations consider this activity to be helpful to a large extent.

Another attribute of such collaborations can be formation of combined project teams comprising members both from industry and technical institutions. The teams can work on research projects of mutual benefits by sharing specialized knowledge. Majority of the organizations regard this option to be largely helpful (PPS= 71.34) in increasing technological capability of the industry.

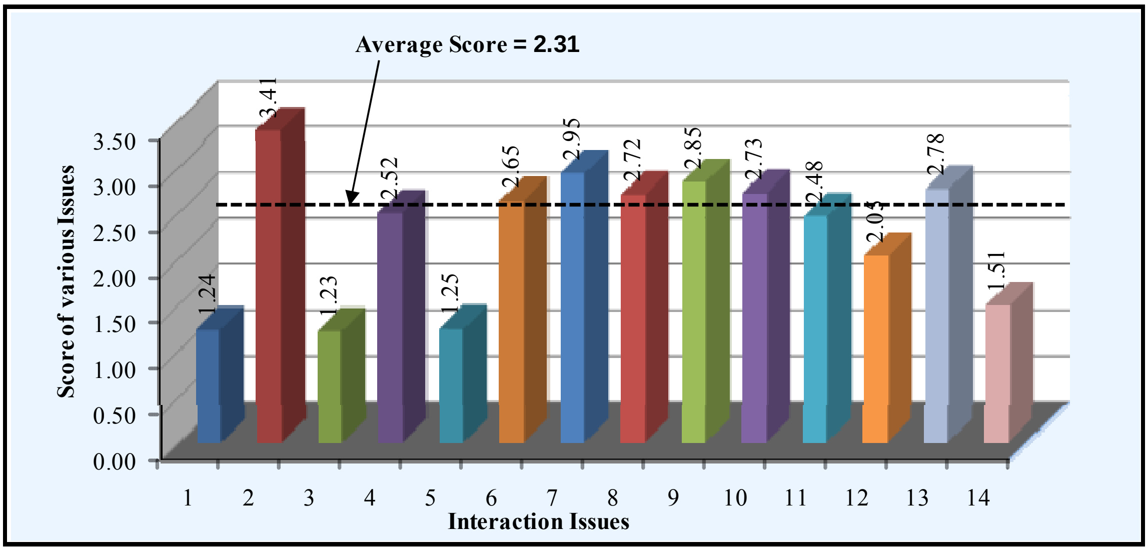

Figure 4.7 Issue-wise Performance regarding Interaction Issues

Small scale manufacturing organizations are generally not financially self-sufficient to create state of the art infrastructure facilities for research and development. Most of the industrial units in the region do not possess state-of-the-art production facilities and laboratories for experimentation, testing and analysis. In the light of this fact, industry can utilize facilities at regional technical institutions. More than half of the units consider this alternative to be helpful to a large extent. Nearly one fourth believe that institutes can be of help only to a small extent. The remaining (16 percent) units do not consider this alternative to be of use.

Several institutions (here, referred as Service Institutes) have been set up by the government with the objective of providing support to small scale sector for technology innovation programs. These include Small Industries Service Institutes (SISI), District Industrial Centers (DIC), and National Small Industries Corporation (NSIC) etc. Majority of the industrial units (two thirds) are not seeking any support from these service institutes. It is only about the remaining one third that seeks support from these government subsidiaries. An extremely poor rating (PPS= 37.65) reflects that this form of collaboration has remained largely ineffective.

The overall score of this aspect is 2.31 (out of 4.00) as depicted in Figure 4.7. Majority of the industries have acquired technology from large Indian industries rather than developing technology through interaction mode. The performance of industry in developing technology through collaborations with academic institutes or research institutes is also below desired levels.

4.6.5 Status of Research Output

The keys and statements pertaining to research output issues aim at collecting information on the following:

i) Response of manufacturing sector to the increased competition situation through increase in product mix, improvement in product features, collecting data on specific customer requirements.

ii) Awareness regarding significance of technology development through indigenous research efforts.

iii) Level of technology employed in the industry, extent of technology developed through indigenous research, role of research function in developing new processes, new products, solving maintenance related problems and improving product quality.

iv) Structure and organization of research function, strategic implementation of innovation, utilization of R&D policy etc.

The response to various issues on this aspect is presented in Table 4.9.

The initiatives undertaken for technology development through in-house research can be deemed as successful if they enable the manufacturing organizations to respond to market demands by increasing their product mix and adding features to the current product range. The performance of industry has not been very encouraging in these areas. Organizations have shown low ratings, in terms of percent points scored in these issues (PPS= 54.52 and PPS= 54.82 respectively). Only one tenth of the organizations have increased their product mix or product features considerably in the last few years. Another one fourth has increased the product mix marginally. However, in majority of the organizations (about 62 percent), the number of variants and type of products offered to respond to the changing customer needs has not increased significantly in the last few years.

Most of the organizations value the fact (PPS= 94.58) that technology is the most important resource and the main driver of survival and growth.

For improving the level of technology in use, manufacturing firms can avail one of the two options. The first option is of '*Technology Acquisition*' (purchasing technology) from an outside source. This alternative does not demand huge investments in R&D or technology infrastructure but makes the organization largely dependent on others for its technology needs. The second option for technology upgradation is indigenous '*Technology Development*' through in-house research efforts. This alternative requires extensive investment of time and capital in research infrastructure and project work. More than half of the manufacturing units agree that their over dependence on external sources has rendered their available technologies and skills incompetent and archaic.

Due to globalization and liberalization, the foreign firms which used to sell their state of the art technology to the borrowing Indian firms, have now become their competitors. In the light of this fact, most of the industrial units (82 percent) consider that technology development through indigenous efforts is the only option to face global competition. The

Indian industry appreciates the importance of technology as a resource for building competitiveness, but a lot needs to be done on the practical front. At present, not even one tenth of the industries are employing latest technology to produce products. The cause of concern is that more than one third of the manufacturing organizations are producing products based on old technology.

The actual performance of industry in developing indigenous technology through in-house R&D is not very encouraging with a very low rating (PPS= 46.99).

Table 4.9 Evaluation of Research Output Issues

S. No.	Q. No.	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring 1 (A)	2 (B)	3 (C)	4 (D)	Total Points Scored (TPS) #	Percent Points Scored (PPS) $\frac{TPS}{4*N}100$	Central Tendency (CT) TPS/N
1	8	Increase in product mix	83	26	25	23	9	181	54.52	2.18
2	14	Changes in product features	83	25	27	21	10	182	54.82	2.19
3	17	Significance of technology upgradation	83	0	2	14	67	314	94.58	3.78
4	18	Limitations of technology acquisition	82	9	23	36	14	219	66.77	2.67
5	19	Need of in - house R&D	83	1	14	24	44	277	83.43	3.34
6	20	Type of technology employed	79	27	24	21	7	166	52.53	2.10
7	21 d	Technology development through in-house R&D	83	37	26	13	7	156	46.99	1.88
8	22	Option for technology upgradation	81	8	15	6	52	264	81.48	3.26
9	23	Collecting data for customer requirements	83	30	20	10	23	192	57.83	2.31
10	25	Use of R&D policy	83	47	21	3	12	146	43.98	1.76
11	26 a	R&D for developing new processes	82	20	17	11	34	223	67.99	2.72
12	26 b	R&D for developing new products	82	19	16	15	32	224	68.29	2.73
13	26 c	R&D for maintenance related problems	81	7	17	20	37	249	76.85	3.07
14	26 d	R&D to improve product quality	81	9	12	19	41	254	78.4	3.14
15	32	Organization of R&D function	83	38	5	6	34	202	60.84	2.43
16	33	Risky research strategy	83	19	16	8	40	235	70.78	2.83
17	34	Imitation for creation strategy	89	37	33	5	14	174	48.88	1.96
		Overall Score								2.61

 # (Total Points Scored "TPS" = 1 x A + 2 x B + 3 x C + 4 x D)

Nearly half of the industrial units have never developed any process or product technology in-house through indigenous research. Another one third (31 percent) has partially developed some technology. There are only less than one tenth of the organizations (8 percent) which completely meet their technology needs independently through indigenous technology development programs.

To respond to the changing market demands, data collection on customer requirements is very important. About 40 percent of the organizations perform this job in a structured manner. Out of these, most of the organizations (28 percent) have a separate marketing department to perform this function and in the remaining, a team of senior executives performs this job. In nearly one fourth of the units, information is collected in an informal manner from the existing customers. The remaining, nearly one third of the units do not make any special efforts to collect information on customer needs.

There appears to be a strong correlation between the extent of technology developed by organizations through in-house research and the use of well defined R&D policy for technological innovations. A little more than half of the organizations do not work with a well defined R&D policy and majority of these have never developed any technology in-house. One fourth of the organizations have just started formulating their research policy. There are only a few organizations in which a well defined R&D policy is followed. These organizations have largely developed their product technologies on their own. This fact establishes the importance of having a clearly defined policy for the research function.

R&D function is used for various errands in the industry. These include development of new products, improvement in production processes, solution to maintenance related problems, improvement in product quality etc. Almost every small scale unit is utilizing its research function for all these activities. A little less than half of the organizations (42 percent) tend to develop all new processes through in-house research efforts. About 39 percent organizations tend to use research function to develop new products. Majority of the Indian organizations (70 percent) use research initiatives to solve maintenance related problems also. However, the industrial sector needs to comprehend that research function should be used for technology development initiatives and not for fire fighting of production problems.

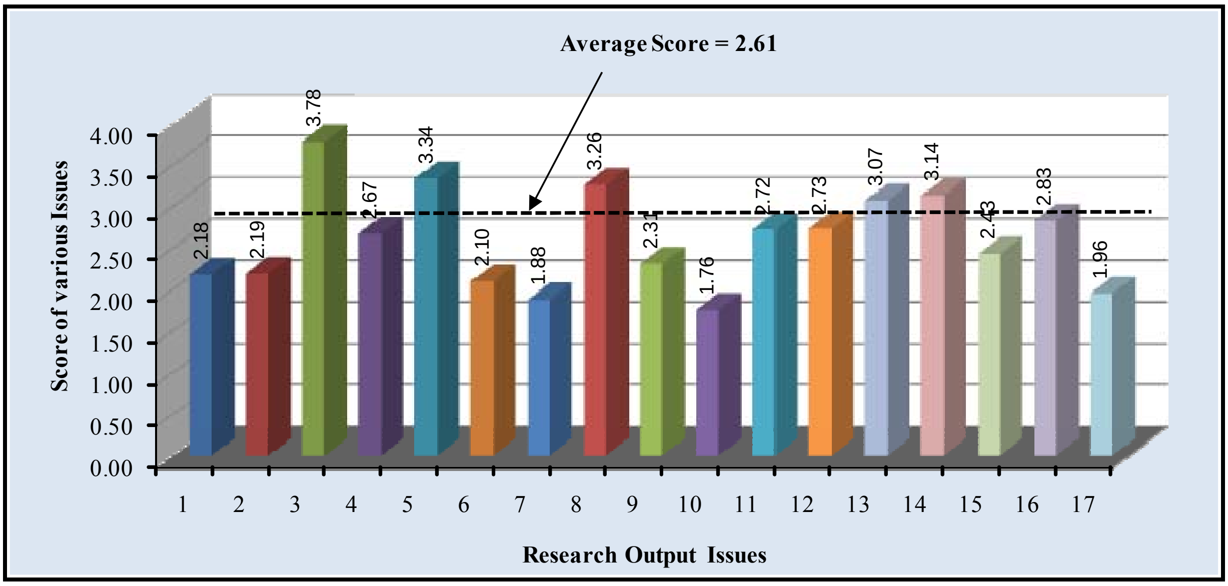

Figure 4.8 Issue-wise Performance regarding Research Output Issues

Literature reveals that manufacturing firms with separate research facilities are more innovative than their counterparts without these facilities. 41 percent of the organizations have R&D function as a separate department. In nearly one tenth (7 percent) of the organizations, teams are formed by top management for specific research projects and in another few (6 percent), design department is responsible for product innovations. In the remaining, about half of the organizations, the structure of R&D function is not clearly defined, which is discouraging.

In order to have long term gains, innovative organizations in developed economies work with specific product innovation strategies. One of the successful strategic approaches followed by Japanese manufacturing firms is '*Risky Research*'. The response of Indian industry to this strategy is mixed. A little less than half of the organizations use this strategy completely as they believe there is no survival otherwise. Another one tenth uses it to a large extent. The remaining units (42 percent) do not use this strategy much.

Another R&D strategy behind the success of Japanese firms is '*Imitation for Creation*'. In this, the firms purchase raw technologies developed by other nations. These raw technologies are developed into innovative products through indigenous research programs. Thus imported technology is used as a complimentary means of technology development. A relatively low rating in terms of percent points scored (PPS= 48.88) shows that Indian manufacturing sector is not influenced much by this thriving Japanese strategy. Most of the organizations (42 percent) have either not used this strategy or have used it only occasionally (37 percent). It is only about one fifth of the units that use this strategy more than often for technology development.

The overall score of this aspect is 2.61 (out of 4.00) as depicted in Figure 4.8. The analysis reveals that some issues have shown very low ratings (PPS). There is an urgent need to use research function for technology upgradation rather than using it for solving production or maintenance problems. Further, adopting well defined R&D policy and effective implementation of strategic approaches for innovation can greatly improve the efficacy of research and development function.

4.7 Classification of Manufacturing Organizations

The purpose of this section is to evaluate the performance of manufacturing units in different components of technology development implementation program and thus to classify them into different categories. The overall standing of various units in different components has been assessed. The score (PPS) of each organization in individual components of '*Manpower Competence and Management Commitment', 'Technology Infrastructure', 'Regulatory Support', 'Interaction with Others', and 'Research Output'* has been calculated from the raw score of issues under each component.

Table 4.10 Criteria for Classification of Industries

Category	Range of Percent Score	Inference	Grading
1	25 - 35	Industry at the lowest stage. Nearly all responses to the lowest choice box on an average.	***Very Poor***
2	36 - 55	Industry at a poor stage. Nearly all responses to the third or fourth choice on an average.	***Poor***
3	56 - 75	Nearly all responses to the second or third choice on an average.	***Fair***
4	76 - 90	Industry at a good stage. Nearly all responses to the first and second choice on an average.	***Good***
5	91 - 100	Industry at the highest stage. Nearly all responses to the highest choice box on an average.	***Very Good***

While deciding upon the choice carrying highest marks in each issue, the levels achievable by small scale manufacturing industry in India have been taken into consideration. Requirements for highest score are definitely less than those for best in the world. Thus, a score close to 100% (PPS≈100) obtained by an organization has been graded as *Very Good* only and not *Excellent*. Further, the organizations score just 25% marks (PPS= 25) in a component if all responses to various issues of that component fall at the lowest choice and score 100% marks if all responses correspond to the best choice. The criterion used to classify the industries into different categories is presented in Table 4.10. Table 4.11 presents the performance rating of organizations in various components of technology development implementation program (TD Program).

Table 4.11 Percent Point Score of Organizations in various TD Components

Range of % Score (PPS)	Number of Manufacturing Organizations				
	Manpower Competence	Technology Infrastructure	Regulatory Support	Interaction with Others	Research Output
25 - 30			4	2	
31 - 35		2	3	4	
36 - 40		10	3	4	
41 - 45	6	27	2	11	
46 - 50	10	15	6	8	10
51 - 55	13	5	5	5	4
56 - 60	22	10	8	6	20
61 - 65	19	5	3	9	8
66 - 70	12	2	6	16	11
71 - 75		4	9	14	11
76 - 80		1	11	4	13
81 - 85		1	12		4
86 - 90	1	1	8		2
91 - 95			3		
96-100					
Average	**57%**	**50%**	**67%**	**58%**	**65%**

The performance rating of organizations in various TD components according to the given criteria is presented in Table 4.12.

Table 4.12 Status of Organizations in various TD Components

S. No.	Range of Percent Points Scored (PPS Range)	Category	Number of Manufacturing Organizations				
			Manpower Competence	Technology Infrastructure	Regulatory Support	Interaction with Others	Research Output
1	25 - 35	Very Poor		2	7	6	
2	36 - 55	Poor	29	57	16	28	14
3	56 - 75	Fair	53	21	26	45	50
4	76 - 90	Good	1	3	31	4	19
5	91 - 100	Very Good			3		

The classification of organizations into different categories is presented in Table 4.13.

Table 4.13 Classification of Manufacturing Organizations

S. No.	Components of TD	Percentage of Organizations under the Category				
		Very Good	Good	Fair	Poor	Very Poor
1	Manpower Competence	-	1	64	35	-
2	Technology Infrastructure	-	4	25	69	2
3	Regulatory Support	4	37	31	20	8
4	Interaction with Others	-	5	54	34	7
5	Research Output	-	23	60	17	-

From the performance of organizations in various TD components, the following points have emerged:

a) The performance of organizations in '*Manpower Competence and Management Commitment*' component is not very encouraging with an average score of 57.37 % only. The industry wise performance in this component is shown in Figure 4.9. The classification of organizations in this component is depicted in Figure 4.10. More than one third of the organizations fall in *Poor* category in this component. Only 1 percent of the units are in *Good* category.

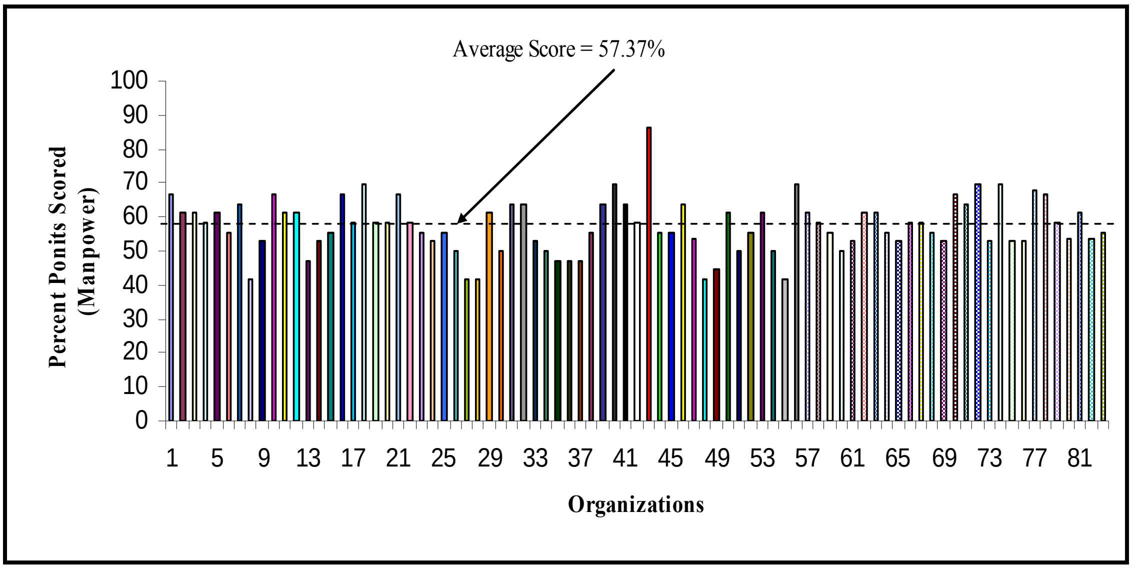

Figure 4.9 Performance of Organizations in Manpower Competence Component

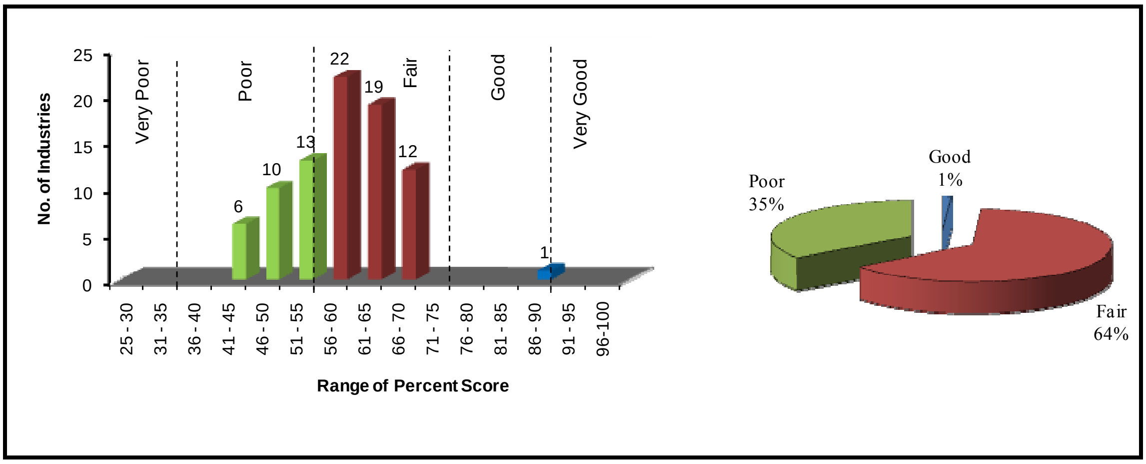

Figure 4.10 Status and Classification of Industries in Manpower Competence Component

b) The performance of organizations is worst in '*Technology Infrastructure'* component with an average score of only 49.68%. The industry wise performance in this component is shown in Figure 4.11. The classification of organizations in this component is depicted in Figure 4.12. More than two thirds of the organizations are at a *Poor* level in this component which is disappointing. One fourth of the units are doing *Fairly Well* and only 4 percent are at *Good* level.

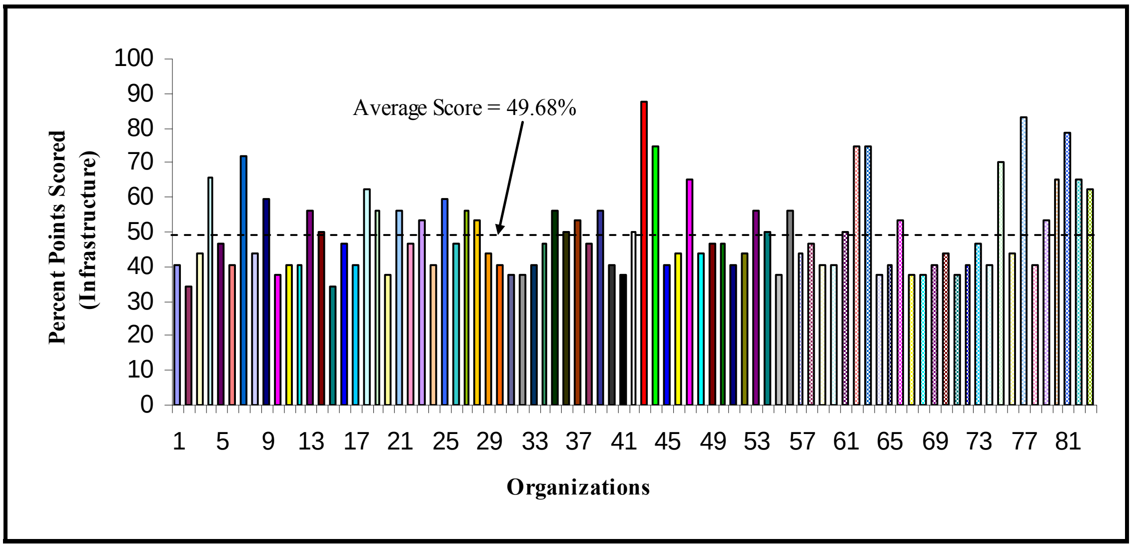

Figure 4.11 Performance of Organizations in Technology Infrastructure Component

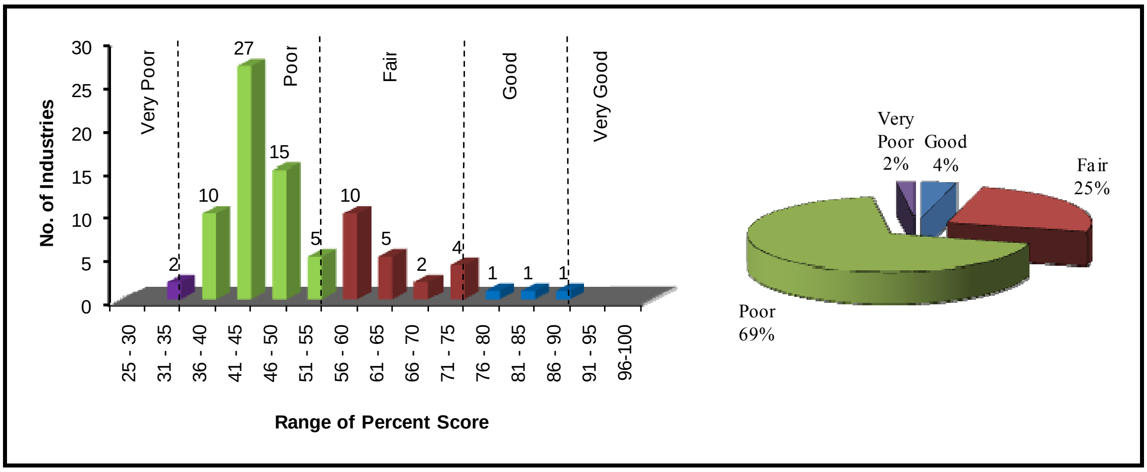

Figure 4.12 Status and Classification of Organizations in Technology Infrastructure Component

c) The average score of organizations in the component, '*Regulatory Support'* is 66.87%. The industry wise performance in this component is shown in Figure 4.13 and the classification of units is depicted in Figure 4.14. About one tenth of the units are at a *Very Poor* level and one fifth in the *Poor* category as far as seeking government support for development activities is concerned. About one third of the units are doing *Fairly Well* and another one third (37 percent) fall in *Good* category. A few organizations (4 percent) are even in *Very Good* class.

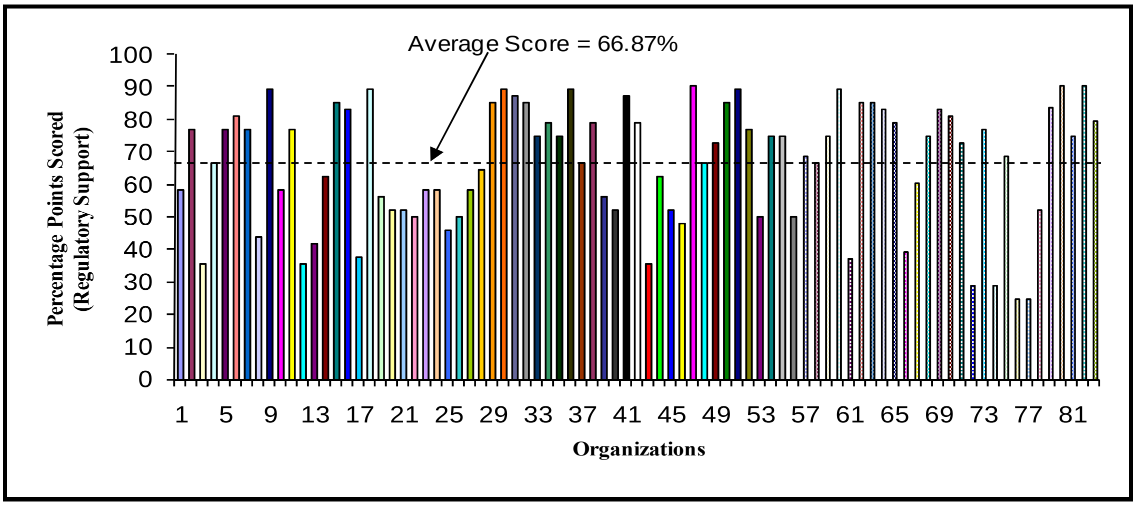

Figure 4.13 Performance of Organizations in Regulatory Support Component

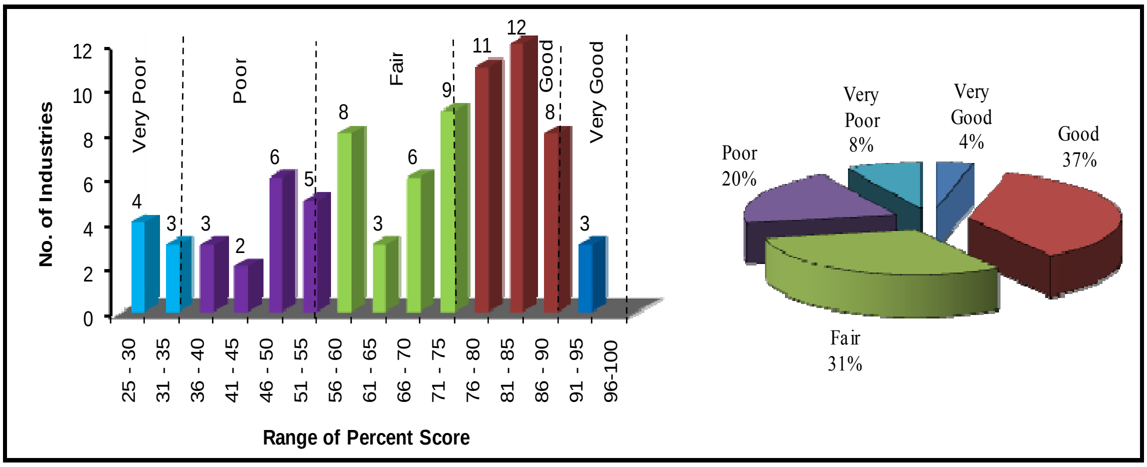

Figure 4.14 Status and Classification of Organizations in Regulatory Support Component

d) The average score of organizations in *Interaction* component is 57.89% only. The industry wise performance in this component is shown in Figure 4.15. The classification of organizations in this component is depicted in Figure 4.16. The results show that not even one tenth of the organizations are at a *Good* level as far as this component is concerned. More than one third of the units are in the *Poor* class in collaborating with external agencies for product innovations which is discouraging.

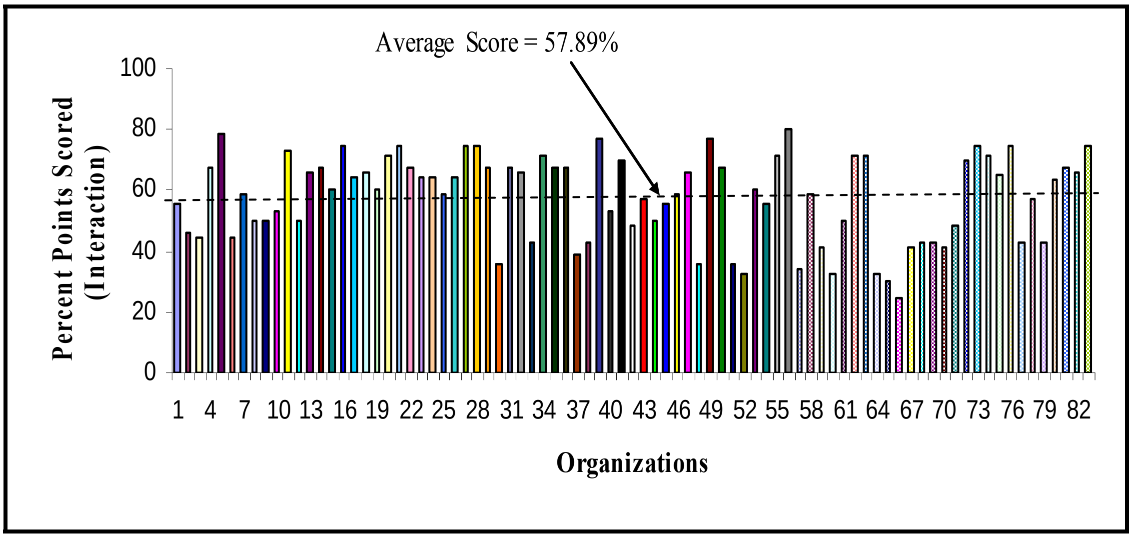

Figure 4.15 Performance of Organizations in Interaction Component

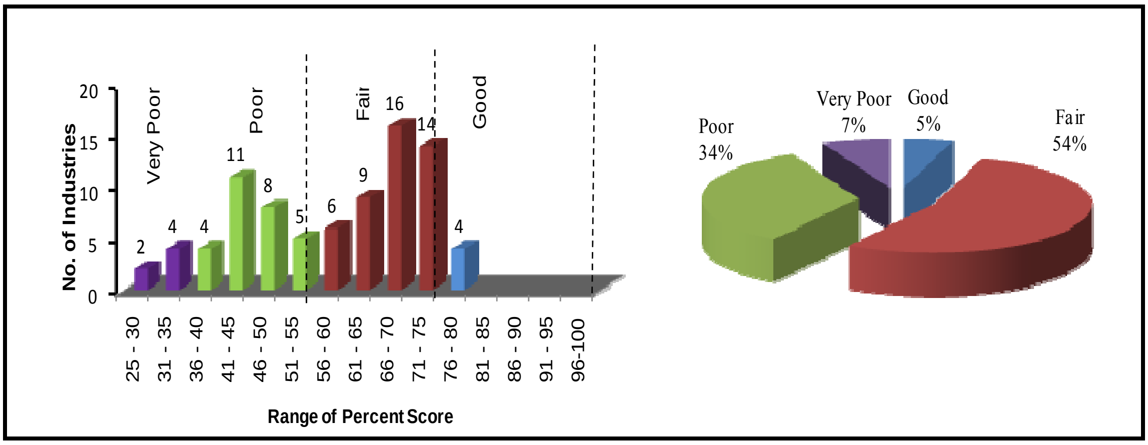

Figure 4.16 Status and Classification of Organizations in Interaction Component

e) The average score of organizations in *Research Output* is 65.22%. The industry wise performance in this component is shown in Figure 4.17. The classification of organizations in this component is depicted in Figure 4.18. About one fifth of the organizations are performing *poorly* as far as managing their research function is concerned. A little more than half are in *Fair* category and the remaining about one fourth is at a *Good* level.

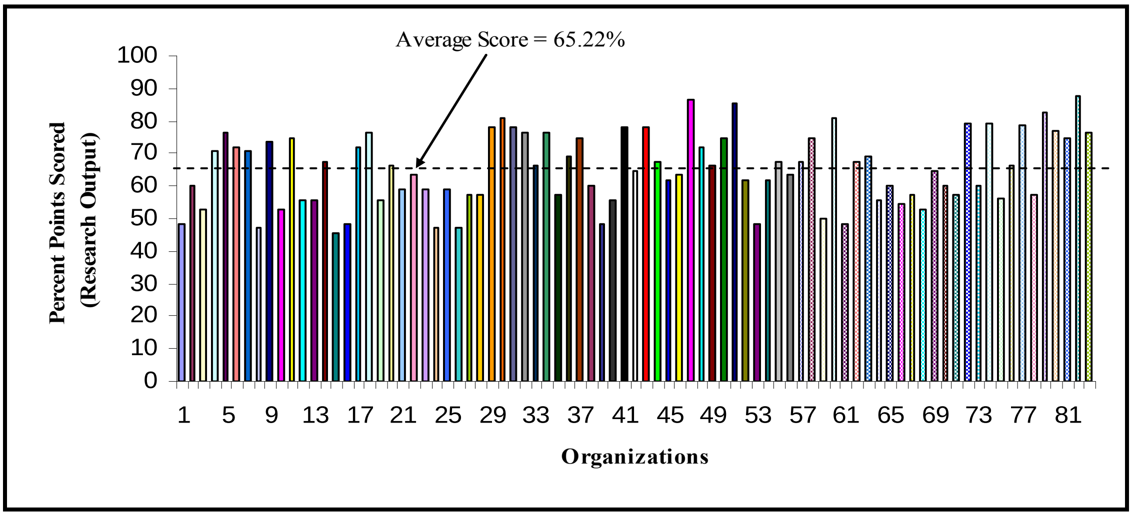

Figure 4.17 Performance of Organizations in Research Output Component

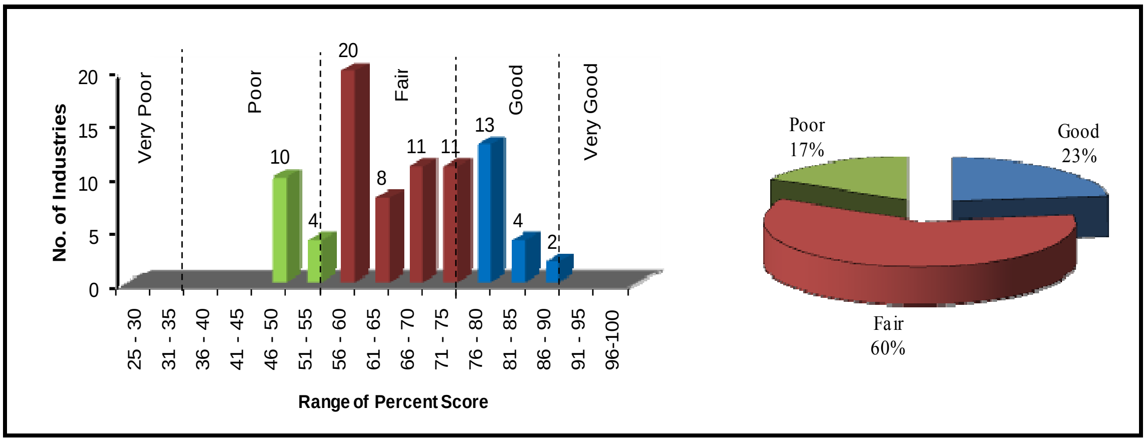

Figure 4.18 Status and Classification of Organizations in Research Output Component

The performance of industrial units in various components of technology development implementation program (TD Program) has not been impressive. The percentage of industrial units which are at a *Good/ Very Good* level in different components is too low. The overall status of manufacturing sector in different components is depicted in Figure 4.19.

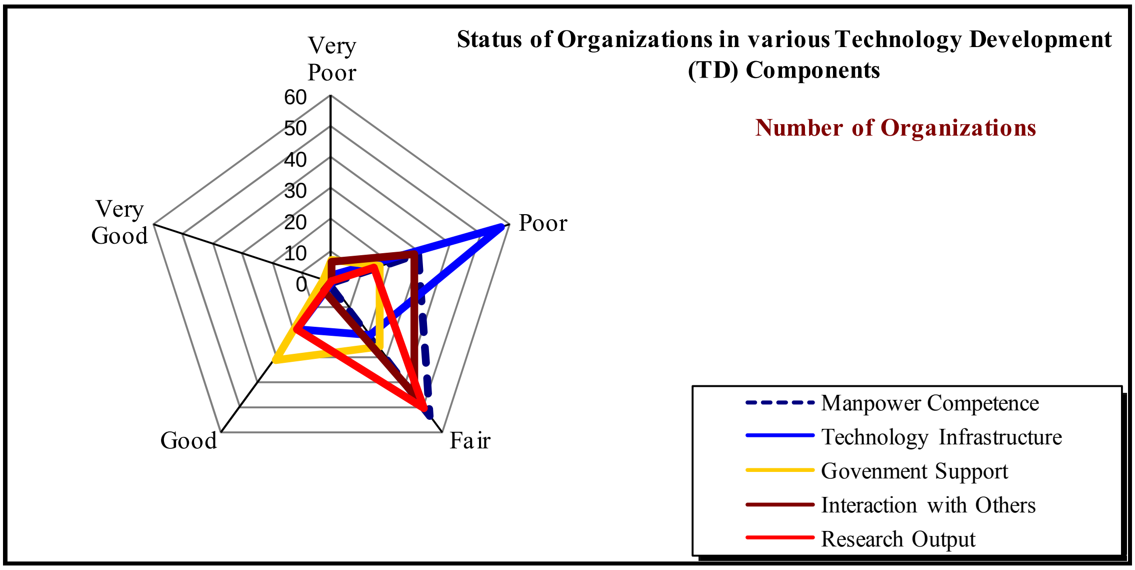

Figure 4.19 Classification of Industries in various Technology Development Components

'Technology Infrastructure' has been the most critical component with the lowest average score. Without state-of-the-art infrastructural facilities and adequate financial support to the research function, the objective of technology development through indigenous research will remain a distant dream.

'*Manpower Competence and Management Commitment'* has been the next critical area. The industrial sector needs to improve its performance in this area as the entire creative input and top management support for development projects comes from this component. Also, the manufacturing organizations are doing little to derive advantage of *interacting* with external agencies like academic institutes, research institutions etc.

Further, maximum variation in the performance of industrial units has been observed in the component of, '*Regulatory Support*'. The results reflect considerable differences among the industrial units in deriving government support for technology development initiatives. As a result, *'Regulatory Support'* is the only component in which manufacturing units are dispersed in all the categories ranging from *very good* to *very poor*.

4.8 Contributions of Technology Development Initiatives in achieving Performance Improvements

Managing the strategic implementation of a technology development program from a current state to a desired future condition is a complex process. Technology development goals and objectives must be fully understood and integrated into the strategic and business plans of the organization. In the present work, a structured approach has been employed to manage the *'Technology Development Implementation Process'* (TD Program) effectively to enhance the probability of success through such initiatives. This underlines the significance of identifying specific metrics to track the progress of such a program in organizations. The performance evaluation has been based on multiple inputs and multiple outputs. Since evaluation involves multiple inputs and multiple outputs, it can be thought of as a multi-criteria decision problem.

Literature reveals that very limited information is available regarding contributions of technology development initiatives towards harnessing core competencies in small scale sector in the country. Thus the present study assumes high significance as it brings forward the contributions of TD initiatives in Indian industry for accruing core competencies for meeting the challenges posed by global competition.

In order to ascertain the benefits realized by an effective TD approach, it becomes imperative that various input factors and output performance parameters for such a program be scrutinized carefully. In the present work, four input factors called '*Technology Input Success Factors*' (A1, A2, A3, A4) and four output performance parameters called '*Development Indicators*' (Y1, Y2, Y3, Y4) have been identified. These input and output factors are presented in Table 4.14. A brief overview of various issues (statements/ items) under input and output factors is presented in Table 4.15.

Table 4.14 Inputs and Outputs for tracking the success of TD Program

Technology Input Success Factors (INPUTS)	Development Indicators (OUTPUTS)
A1. Manpower Competence and Management Commitment	**Y1.** Level of Technology
A2. Technology Infrastructure	**Y2.** Strategic Implementation of Innovation
A3. Regulatory Support	**Y3.** Structure and Output of R&D Function
A4. Interaction with Others	**Y4.** Response to Market Demands

Table 4.15 Issues regarding Input and Output Performance Parameters

Technology Input Success Factors – KEY INPUTS
A1. MANPOWER COMPETENCE AND MANAGEMENT COMMITMENT
M1. Extent of multi-skilled workforce for executing innovation work M2. Education level and technical know-how of employees M3. Formal training of employees to enhance creativity skills M4. Adequacy of scientific and technical staff for R&D work M5. Reward mechanism to facilitate innovative efforts of employees M6. Reaction of top management in situations of project failures
A2. TECHNOLOGY INFRASTRUCTURE
T1. Modernization and renovation initiatives for technology development T2. Dedicated laboratories with state-of-the-art equipment for experimentation and analysis T3. Earmarking funds for research initiatives aimed at innovations for new product developments T4. Investments in R&D as a function of annual turnover
A3. REGULATORY SUPPORT
G1. Pricing policies regarding raw materials as compared to other states G2. Availability and cost of electric power in the region G3. Subsidies to support small scale industrial sector G4. Government funding for research initiatives and development projects G5. Business Support Mechanisms for technology development
A4. INTERACTION WITH OTHERS
I1. Collaborations with other industrial units and external agencies for technology development I2. Industry-institute tie-ups for process and product innovations I3. Networking with R&D institutions for technology development I4. Interaction with service institutes for small scale sector
Development Indicators — KEY OUTPUTS
Y1. LEVEL OF TECHNOLOGY IN USE
1. Performance impairment because of old technology 2. Level of process technology in use
Y2. STRATEGIC IMPLEMENTATION OF INNOVATION
1. Dependence on external sources for technology needs 2. In-house R&D for developing new technology products and processes 3. Extent of technology developed through indigenous efforts to generate innovations 4. *Risky Research*, as a strategy for technology development 5. *Imitation for Creation*, as a strategy for new technology
Y3. STRUCTURE AND OUTPUT OF RESEARCH FUNCTION
1. Use of well defined R&D policy for technology development 2. Information on customer requirements through a separate marketing department 3. Development of new processes through in-house research initiatives 4. Development of new products through indigenous research efforts 5. Defined structure for R&D function
Y4. RESPONSE TO MARKET DEMANDS
1. Improvement in product features in response to market demands 2. Enhancement in product quality and attributes of products 3. New market creation through novel products 4. Increase in product-mix offered by the manufacturing organization

Table 4.16 Four Point Likert Scale

Technology Input Success Factors	Development Indicators
1 – No emphasis at all	**1 –** Nominal gain
2 – Very little emphasis	**2 –** Reasonable gain
3 – Reasonable emphasis	**3 –** High gain
4 – Extensive emphasis	**4 –** Extremely high gain

On the basis of responses received from the industry, an assessment of association of various input parameters with key development indicators (output parameters) has been presented in the study. Each of the input factors (A1, A2, A3 and A4) and output parameters (Y1, Y2, Y3 and Y4) consist of several issues (statements/ items). Each item of various input factors has been separately correlated with each of the four output performance parameters.

The score of each output parameter has been calculated by averaging the raw scores of items comprising it. For example, the output parameter, *'Strategic Implementation of Innovation'* (Y2) consists of five items. The score of this output parameter has been obtained by averaging the raw scores of its five items as shown in Equation 4.1.

$$S_{Y2} = \sum_{i=1}^{n} rs_i \qquad \text{---------------- Equation 4.1}$$

where, 'S_{Y2}' represents the calculated total score of output parameter (Y2), 'rs' represents the raw score of individual items and 'n' is the total number of items in a particular output parameter.

The total score of other output parameters has been calculated in the same manner from their respective items. The score for *Overall Output* (Overall TD) has been computed by averaging the scores of all four output parameters. The raw scores of various input keys are presented in Appendices C to F.

The internal reliability of items under each output parameter (inter-item analysis) has been assessed by using Cronbach's Alpha co-efficient, as recommended for empirical research in operations management (Best and Kahn, 1986; Flynn *et al.,* 1990). Cronbach's Alpha coefficient measures the extent to which a set of variables are consistent in what they are intended to measure (internal cohesiveness of items of a construct). Cronbach's Alpha values calculated for various categories are greater than 0.5, which is considered adequate for exploratory work (Nunally, 1978; Hair *et al.,* 1998). This also indicates high reliability of data collected through the 'TD Questionnaire'. Cronbach's Alpha values calculated for various output parameters are presented in Table 4.17.

Table 4.17 Cronbach's Alpha values for Development Indicators

Development Indicator Items		Cronbach's Alpha Value
Level of Technology	Y1	0.968
Strategic Implementation of Innovation	Y2	0.954
Structure and Output of R&D Function	Y3	0.562
Response to Market Demands	Y4	0.622

4.8.1 Correlation of Manpower Competence and Management Commitment with Development Indicators

The present work considers '*Manpower Competence and Management Commitment*' (A1) as the first key input parameter for planned implementation of TD program in manufacturing organizations. The contributions of this parameter in achieving performance improvements in the Indian industry have been discussed. For this, Pearson's correlation coefficient values (r values) between various issues of this input and the 'Development Indicators' (output parameters) have been calculated. The correlation values obtained have been further validated and authenticated using other statistical tools like t-Test, Canonical Factor Loading analysis and Multiple Regression analysis.

Pearson's correlation values and t-values (obtained from t-test) have been worked out to ascertain significant issues contributing to the success of TD implementation program in the industry. Table 4.18 depicts the Pearson's correlations, t-values and significance levels (p-values) for pairs of interrelationships of various 'Manpower Competence and Management Commitment' issues with 'Development Indicators'. The t-values obtained (from t-test) can also be worked out through the empirical expression indicated in Equation – 4.2.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \geq t_{n-2} \text{ (from't' Tables)} \quad \text{----------------} \quad \text{Equation 4.2}$$

where, 'n-2' represents degrees of freedom (df) for a particular test, 'r' represents Pearson's correlation coefficient between a particular input issue and an output parameter, 't_{n-2}' is the $t_{critical}$ value from statistical 't' tables for (n – 2) degrees of freedom.

The results presented in Table 4.18 have been used to identify the 'Manpower Competence and Management Commitment' (A1) issues which have a significant contribution towards realization of performance improvements in organizations. The '$t_{critical}$' value for confidence limits corresponding to 'n-2' (= 81) degrees of freedom and significance level of 0.05 percent works out to be 1.99 from the statistical t-tables. So, pairs with t-value greater than or equal to this critical value (t = 1.99; r = 0.21) are considered as having a significant association.

Table 4.18 Pearson's Correlation and t-Test Analysis between 'Manpower Competence and Management Commitment' and 'Development Indicators'

			DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)				
			Level Y1	**Strategy Y2**	**Organization Y3**	**Response Y4**	**Overall TD**
Multi-skill base of workforce	**M1**	r	0.26	-0.14	-0.10	0.29	0.16
		t(p)	2.39(0.01)**	-1.23(0.22)	-0.89(0.39)	2.72(0.01)**	1.44(0.16)
Education level of employees	**M2**	r	0.21	0.11	-0.18	0.22	0.15
		t(p)	1.92(0.05)*	0.96(0.34)	-1.63(0.12)	2.02(0.05)*	1.35(0.21)
Formal training to enhance creativity	**M3**	r	0.08	0.31	0.30	0.07	0.32
		t(p)	0.65(0.51)	2.91(0.01)**	2.80(0.01)**	0.58(0.56)	3.00(0.01)**
Adequacy of R&D personnel	**M4**	r	0.25	0.10	0.39	0.21	0.39
		t(p)	2.31(0.05)*	0.89(0.39)	3.77(0.01)**	1.92(0.05)*	3.77(0.01)**
Reward schemes for innovative efforts	**M5**	r	-0.27	0.29	0.21	-0.23	-0.11
		t(p)	-2.49(0.01)**	2.72(0.01)**	1.92(0.05)*	-2.10(0.05)*	-0.96(0.34)
Reaction to project failures	**M6**	r	0.25	-0.32	-0.18	0.21	0.01
		t(p)	2.31(0.05)*	-3.0(0.01)**	-1.63(0.12)	1.92(0.05)*	0.06(0.95)

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

To further investigate the contributions of 'Manpower Competence and Management Commitment' issues, the significant correlations obtained as a result of t-test are validated through Canonical Factor Loading analysis (using SPSS 14.0). This analysis describes the combined effect of multiple inputs (all issues under input factor 'A1' considered simultaneously) on individual output variables and helps in extracting significant contributors for achievement of various 'Development Indicators' (output parameters). Table 4.19 depicts the results of Canonical Factor Loading analysis.

Table 4.19 Extracting Significant Factors using Canonical Factor Loading Analysis

		DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)			
		Level Y1	**Strategy Y2**	**Organization Y3**	**Response Y4**
Multi-skill base of workforce	**M1**	0.565*	-0.286	-0.181	0.544*
Education level of employees	**M2**	0.428	0.225	-0.332	0.476
Formal training to enhance creativity	**M3**	0.179	0.617*	0.510*	0.155
Adequacy of R&D personnel	**M4**	0.479	0.084	0.687*	0.441
Reward schemes for innovative efforts	**M5**	-0.578*	0.554	0.397*	-0.507*
Reaction to project failures	**M6**	0.474	-0.652*	-0.332	0.443

The inter-relationships between significant input issues and output factors obtained through Canonical Factor Loading analysis have been further validated through multiple regression analysis as depicted in Table 4.20. The notations employed in this test include: β= Regression Coefficient (Beta Coefficient), R= Multiple Correlation Coefficient.

4.8.1.1 Result Discussion

The critical examination of Pearson's correlation values and t-test results explicitly depict that adaptation of strategic '*Manpower Competence and Management Commitment*' initiatives (A1) by organizations have a significant impact on realization of overall performance improvements. The results highlight that this input parameter (A1) strategically contributes towards realization of '*Development Indicators*' by adequately affecting organizational cultural transformations, thereby institutionalizing a favourable environment towards managing innovations in organizations.

Table 4.20 Multiple Regression Analysis between 'Manpower Competence and Management Commitment' and 'Development Indicators'

Development Indicator	Significance Factors	Beta Value (β)	t Value	Significance Value (p)	R Value	F Value
Y1	M1	0.284	2.473	0.016	0.376	16.254
	M5	-0.750	-2.258	0.014		
Y2	M3	0.199	3.102	0.002	0.432	19.184
	M6	-0.236	-2.436	0.017		
Y3	M3	0.211	2.743	0.008	0.495	18.107
	M4	0.295	3.512	0.001		
	M5	0.149	1.971	0.052		
Y4	M1	0.249	2.242	0.028	0.332	14.703
	M5	-0.600	-2.092	0.039		

It is observed that several '*Manpower Competence and Management Commitment*' issues are significantly associated with the *level of technology* (Y1) in small scale organizations. The results are discussed as follows:

Availability of *workforce with multiple-skill base* (M1) to run manufacturing operations has facilitated organizations (r = 0.26) to harness significant improvements in the *level of technology* (Y1). Innovative organizations have adequate strength of multi-skilled workforce. Strategies range from identification of areas of skills in which shortfalls either occur or can occur and efforts are made to generate those skills. Small units which lack in availability of such labour force have to increasingly rely on external knowledge sources to build up technological competence.

Higher *education levels* and better *technical know-how of employees* (M2) help in upgrading (r = 0.21) *technology levels* (Y1) thereby allowing organizations to compete effectively in dynamic environments. As market trends evolve and core business activities shift into new territories, there is a need for organizations to facilitate a corresponding change in the education level of employees. Better educated workers provide the flexibility needed to switch production between sectors and branches, and to restore external balance through innovation, retraining and relocation. This adaptability is essential for keeping labor and capital employed and maintaining technological capability.

Literature reveals that innovative organizations extensively use formal training as a means to augment creativity skills of employees. Maintaining competitiveness relies not only on job-specific training or on-the-job training, but also on a greater degree of formal training. The advantage of formal training is the gain of accredited experience and knowledge from other sources. Small scale sector in the region has overlooked the importance of this fact as two thirds of the units do not provide any formal training to employees. As a result, there exists no significant association between *training of employees* (M3) and *technological improvements* (Y1).

Adequacy of *R&D personnel* (M4) for undertaking research initiatives has been influential (r = 0.25) in the realization of *improved technology* (Y1). Innovative organizations make strategic choices with regard to their human resources. When the human resources are competitive, they can push the boundaries of technical competence into the area of the unknown or the new. Small firms lack in R&D initiatives because requisite personnel are not available in required numbers.

Reward schemes for innovative efforts (M5) and *level of technology* (Y1) have shown a significant negative relationship (r = -0.27). Technology levels in small firms have remained below desirable standards despite employees being rewarded for development initiatives. Reward schemes have failed to bring positive results because these have been largely based on extrinsic benefits (like pay hikes, increments, bonus etc.) and not on intrinsic means. Intrinsic rewards are based on internal feelings of accomplishment by the recipient and include increased autonomy and improved opportunities for personal and professional growth. Small units have not relied on personalized intrinsic rewards and tend to place almost exclusive emphasis on extrinsic awards. With extrinsic rewards, employees believe that every move they make is going to affect their compensation and tend to get risk averse. They tend to channelize their energies in trying to get the reward rather than unleashing their creative potential. Such rewards have a negative effect on creativity.

Technology levels (Y1) are affected (r = 0.25) by the manner in which *top management reacts in situations of project failures* (M6). Innovative efforts represent disturbances in routines, relationships, power balances, and job security. The assumption that risks may be taken as long as they do not harm the organization does not encourage employees to be creative. It is important that a balance be reached in the degree to which risk taking is allowed. This is achieved by spelling out expected results, creating a tolerant atmosphere, regarding mistakes as learning experiences, and assuming that there is a fair chance of risks being successful. However, in small organizations, employees do not know the level of risks that they can take safely. They are not able to define the space within which they are allowed to act in an empowered manner and do not know the penalties if inefficiencies creep into aspects of their task. As a result, technological levels have remained low.

'Manpower Competence and Management Commitment' (A1) as an input to technology development initiatives of an organization contributes significantly in improving the level of technology being used (Y1). Availability of workforce with multiple-skill base (M1) and presence of an appropriate reward mechanism (M5) are important issues.

The role of '*Manpower Competence and Management Commitment*' (A1) in *implementation of strategic approaches for technology development* (Y2) is discussed as follows:

Availability of *multi-skilled workforce* (M1), *education level of employees* (M2) and *adequacy of scientific manpower* (M4) have not exhibited a significant correlation with *strategic implementation of innovation* (Y2). This means, the success of technology strategy adopted by organizations depends on broader issues like extent of training, type of reward structure, management reaction to project failures etc.

The role of *formal training* (M3) has been statistically significant (r = 0.31) in proper *implementation of technology strategies* (Y2). Specific strategies adopted by organizations for process and product innovations are put to practice by the employees. It is through proper orientation and training of employees that strategies can be implemented effectively. Innovative organizations operate training programs to make their employees aware of organization's competition, and to identify strategies to face the competition. These organizations ensure that each employee spends at least some fraction of his payroll on training. Apart from blue-collar workers who receive on-the-job training; supervisors, middle and senior managers receive outside and in-house training.

Reward schemes for innovative efforts (M5) and *strategic implementation of innovation* (Y2) are also significantly associated (r = 0.29). This reveals the importance of having an effective in-house reward system to motivate employees for achieving goals of innovation, productivity and profitability. Recognizing individual and team accomplishments in implementing strategies for technology development encourages innovation and its very existence galvanizes employee contributions. However, management should be sensitive as to which method of recognition inspires employees to be more creative. Motivational or intrinsic orientation brings about far greater creativity than the extrinsic orientation governed by reward-for-creativity strategy. Extrinsic rewards have to be present at a base level to ensure that individuals are at least comfortable with their salary. Beyond these base salary thresholds, innovation is primarily driven by self esteem level rather than monetary rewards.

Reaction to project failures (M6) has a significant negative correlation (r = -0.32) with *strategic implementation of innovation* (Y2). In majority of the small units, no suitable action is taken (against project team members) by the top management when a research task fails. This sector is financially not self sufficient and top management has to be more critical in situations of failures. Further, the project failures are generally discarded. Instead, they should be stored for possible adoption at a later time.

'Manpower Competence and Management Commitment' (A1) contributes toward effective implementation of strategic approaches for technology development (Y2) if employees are properly trained in creative problem solving (M3) and top management reacts aptly in case of project failures (M6).

The contributions of '*Manpower Competence and Management Commitment*' (A1) input factor in improving the *structure and output of research function* (Y3) have been discussed as follows:

Proper *training of employees* (M3) facilitates the organizations (r = 0.30) to harness significant developments through improved *structure of the research function* (Y3). When trained aptly, employees work with a well defined policy and utilize the research initiatives to improve/ develop new processes and products.

Availability of *R&D staff in adequate strength* (M4) contributes effectively (r = 0.39) in improving the *structure and output of research function* (Y3). R&D activities can be organized well and can produce results when necessary intellectual capital resource is available to execute its functions.

The reward structure adopted by organizations to *recognize innovation efforts of employees* (M5) also improves (r = 0.21) the *output of research function* (Y3). In organizations where innovation is the driving force, an effective reward system motivates employees to take risks, generate new product ideas, experiment and develop new products. If creative behavior is rewarded, it becomes the general, dominant way of behaving with employees.

'Manpower Competence and Management Commitment' (A1) as an input parameter has a significant impact on the structure and output of R&D function (Y3). Formal training of employees (M3), adequacy of R&D staff (M4) and appropriate reward and recognition mechanism (M5) are the significant issues.

The role of '*Manpower Competence and Management Commitment*' (A1) factor in meeting the *needs of marketplace* (Y4) is discussed as follows:

The presence of *multi-skilled workforce* (M1) significantly improves (r = 0.29) the firm's *response to market demands* (Y4). Basic and strategic management skills are crucial for the success of manufacturing organizations. Manufacturing enterprises can continuously increase their product range to cater to needs of international markets when workforce can perform varied tasks requiring multiple skills. Also, better *education levels and technical knowledge of employees* (M2) helps the organizations (r = 0.22) to *compete effectively in the global market place* (Y4). A highly skilled and educated workforce is the key to increased competitiveness and sustainable growth.

Successful innovative organizations world wide, provide formal training to employees to enhance their creativity and innovation skills. This helps in introducing rapid changes in product features and improving product quality. Small scale sector has been overlooking this fact as majority of the organizations do not provide proper training to employees. As a result a significant association between *formal training* (M3) and *response* (Y4) has not existed.

Availability of *R&D personnel* (M4) facilitates organizations (r = 0.21) in responding to the *market needs* (Y4). Sufficiency of R&D staff places the organization in a more pragmatic mode to implement technology development initiatives effectively for meeting changing customer demands.

The *reward schemes for employees* (M5) have exhibited a significant negative correlation (r = -0.23) with *response of organizations to market demands* (Y4). Majority of the Indian units have reward schemes based on extrinsic incentives. Such rewards have a negative effect on creativity as employees perceive the financial incentive as a means of being controlled. Small scale industrial units need to restructure their reward systems.

'Manpower Competence and Management Commitment' (A1) input factor has exhibited a significant linkage with response to market demands (Y4). Availability of multiple-skilled workforce (M1) and an appropriate reward structure (M5) are critical issues to meet the ever changing needs of customers.

4.8.2 Correlation between Technology Infrastructure and Development Indicators

'*Technology Infrastructure*' (A2) is the second key input parameter for tactical implementation of TD program in manufacturing organizations. The contributions of this input parameter in achieving performance improvements in the Indian industry have been discussed in this section.

Table 4.21 Pearson's Correlation and t-Test Analysis between 'Technology Infrastructure' and 'Development Indicators'

			DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)				
			Level Y1	**Strategy Y2**	**Organization Y3**	**Response Y4**	**Overall TD**
Modernization programs	**T1**	r	0.52	-0.30	-0.01	0.53	0.41
		t(p)	5.41(0.01)**	-2.80(0.01)**	0.06(0.95)	5.56(0.01)**	4.00(0.01)**
Dedicated labs with state-of-the art equipment	**T2**	r	0.25	-0.13	0.30	0.23	0.01
		t(p)	2.31(0.05)*	-1.17(0.25)	2.80(0.01)**	2.10(0.05)*	.06(0.95)
Earmarking funds for research initiatives	**T3**	r	-0.10	-0.15	0.21	-0.12	-0.05
		t(p)	-0.89(0.39)	-1.35(0.21)	1.92(0.05)*	-1.07(0.29)	-0.45(0.64)
Investments in R&D as a fraction of turnover	**T4**	r	0.32	-0.23	0.08	0.28	0.25
		t(p)	3.0(0.01)**	-2.10(0.05)*	0.65(0.51)	2.59(0.01)**	2.31 (0.05)*

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

On the basis of responses received from the industry, an assessment of association of various issues of this input factor with the output parameters has been made. Table 4.21

depicts the Pearson's correlations, t-values and significance level (p) values for pairs of inter-relationships between various '*Technology Infrastructure*' issues and '*Development Indicators*'.

To identify the significant contributors under the combined effect of various input issues, the Canonical Factor Loading analysis has been performed. Table 4.22 depicts the results of this analysis.

Table 4.22 Extracting Significant Factors using Canonical Factor Loading Analysis

		DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)			
		Level Y1	Strategy Y2	Organization Y3	Response Y4
Modernization programs	**T1**	0.871*	-0.821*	-0.053	0.885*
Dedicated labs with state-of-the art equipment	**T2**	0.362	-0.231	0.965*	0.326
Earmarking funds for research initiatives	**T3**	-0.203	-0.236	0.719	-0.236
Investments in R&D as a fraction of turnover	**T4**	0.436*	-0.644*	0.319	0.378*

The results of Canonical Factor Loading analysis have been validated through Multiple Regression analysis as depicted in Table 4.23.

Table 4.23 Multiple Regression Analysis between 'Technology Infrastructure' and 'Development Indicators'

Development Indicator	Significance Factor(s)	Beta Value (β)	t Value	Significance Value (p)	R Value	F Value
Y1	T1	0.483	5.092	2.56 E-06	0.572	28.268
	T4	0.288	2.421	0.018		
Y2	T1	-0.184	-2.676	0.009	0.293	17.161
Y3	T2	0.324	2.779	0.007	0.298	17.725
Y4	T1	0.469	5.098	2.56 E-06	0.559	27.006
	T4	0.230	2.001	0.049		

4.8.2.1 Result Discussion

The results highlight that the input factor '*Technology Infrastructure*' (A2) contributes significantly towards improvement of '*Development Indicators*'.

Modernization and renovation programs for technology development (T1) effectively improve (r = 0.52) the *level of technology* employed in organizations (Y1). Advanced equipment and resources are critical factors to support public and private projects regarding research and development, innovation and technology modernization. For better technological advances, information technology, modern production systems and new strategic thinking practices are needed. The absence of adequate modernization initiatives is one of the main problems that hinder efforts to develop technology in small firms.

Availability of *dedicated laboratories* (T2) facilitate organizations (r = 0.25) to harness major *technology improvements* (Y1) through experimentation and subsequent analysis. Building a physical infrastructure for enhancing organizational capabilities that support experimentation and educational activities for innovation are the key success factors for highly innovative companies. The physical environment or setting influences the degree to which divergent thought process is used. Appropriate space and resources enhance organizational creativity and hence technological levels.

The *investments made by organizations in their R&D function* (T4) makes a significant impact (r = 0.32) on the realization of *improved technology* (Y1). Innovative organizations spend substantial fraction of their annual turnover on technology development. However, for manufacturing units in this part of the country, investments in R&D have been very low. Access to finance and presence of equity gaps are commonly cited as major barriers to innovation throughout the small business literature. Innovation often requires considerable front-end sunk costs, invariably beyond the scope of small firm's internal resources. This, allied with the frequent inability of funding providers to adequately assess either the technological validity or the project validity, often mitigates against finance provision.

'Technology Infrastructure' (A2) as an input factor facilitates organizations to upgrade technology levels (Y1) if proper modernization initiatives are undertaken (T1) and adequate financial support to the research function (T4) is provided. These measures facilitate realization of technological improvements in production systems to garner enhanced manufacturing capabilities.

Modernization programs (T1) and *strategic implementation of innovation* (Y2) exhibit a significant negative correlation (r = -0.30). This reflects that manufacturing organizations which are regularly undertaking modernization initiatives (exposure to new concepts, machines, tooling etc) are largely dependent on other firms and do not undertake strategic measures for technology development through indigenous research.

The *investments made in research and development initiatives* as a fraction of annual turnover (T4) also show a significant negative correlation (r = -0.23) with *strategic approaches for technology development* (Y2). This shows that organizations are aware of the benefits of strategic measures of innovation (i.e. benefits of in-house R&D, limitations of technology acquisition, different strategies for technology development) but implementation has remained poor because of a lack of adequate financial support.

The presence of *dedicated research infrastructure* (T2) significantly contributes (r = 0.30) towards improved *structure and output of research function* (Y3). Infrastructure becomes critically important in a world characterized by an abundance of emerging technologies. All major technology breakthroughs (development of new products and processes) require a surrounding infrastructure. Technology infrastructure and resources are important not only for functional support but also because having an adequate level of resources for the task/ research project influences workers perception that the project is valuable and worthy of organizational support.

Earmarking specific funds for development initiatives (T3) also improves (r = 0.21) the *research output* (Y3). The different activities of R&D function can be organized and utilized effectively if an explicit financial plan is apportioned for each.

'Technology Infrastructure' (A2) significantly improves the structure and output of research function (Y3) if dedicated labs with state of the production equipment and facilities for experimentation and analysis (T2) are available.

Modernization programs (T1) help organizations (r = 0.53) in building core competencies and facilitate them in providing *enhanced service to the customers* (Y4), thereby improving overall market image of the organizations. It is because of shortage of such initiatives that small scale sector has lacked in meeting changing customer demands.

Availability of *dedicated research infrastructure* (T2) also facilitates (r = 0.23) organizations in enhancing their product range and improving product features to *respond to the market demands* (Y4).

Adequate *financial support to the development initiatives* (T4) is also influential (r = 0.28) in improving organization's *response to market needs* (Y4). Higher R&D spending heightens the level of research activity within a firm and builds specialized scientific and technical expertise as a result. The tangible outcome of this is the ability to develop several significant product technologies. Restriction of resources limits creativity since employees are more occupied with finding additional resources and not with actually developing new products or services.

'Technology Infrastructure' (A2) helps the organizations to respond to changing requirements of the marketplace (Y4) through modernization initiatives (T1) and adequate financial support to research initiatives (T4).

4.8.3 Correlation between Regulatory Support and Development Indicators

'*Regulatory Support*' (A3) is the third key input parameter for planned implementation of TD program in manufacturing organizations. The contributions of this input parameter in achieving performance improvements in the Indian industry have been discussed in this section.

The correlations between '*Regulatory Support*' issues and '*Development Indicators*' have been worked out to ascertain the significant issues contributing to success of TD program in manufacturing organizations. The Pearson's correlations thus calculated have been depicted in Table 4.24.

The relationships between various 'Regulatory Support' issues and 'Development Indicators', obtained by Pearson's coefficient values have been further validated using other statistical tools like t-test, Canonical Factor Loading analysis, and Multiple Regression analysis. The results of t-test have been depicted in Table 4.24. The results reveal that several 'Regulatory Support' issues and 'Development Indicators' are closely associated since the significance factor 'p' works out to be less than 0.05 in those cases.

Table 4.24 Pearson's Correlation and t-Test Analysis between 'Regulatory Support' and 'Development Indicators'

			DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)				
			Level Y1	**Strategy Y2**	**Organization Y3**	**Response Y4**	**Overall TD**
Pricing policies for raw materials	**G1**	r	0.22	0.01	0.12	0.23	0.29
		t(p)	2.02 (0.05)*	0.06 (0.95)	1.07 (0.29)	2.10 (0.05)*	2.72 (0.01)**
Availability & cost of power	**G2**	r	0.03	0.13	0.18	-0.02	0.15
		t(p)	0.27 (0.80)	1.17 (0.25)	1.63 (0.12)	-0.16 (0.87)	1.35 (0.21)
Policies for subsidy to industry	**G3**	r	0.31	-0.08	0.10	0.27	0.29
		t(p)	2.91 (0.01)**	-0.65 (0.51)	0.89 (0.39)	2.49 (0.01)**	2.72 (0.01)**
Support mechanisms for research initiatives	**G4**	r	0.34	0.61	0.12	0.29	0.38
		t(p)	3.21 (0.01)**	6.57 (0.01)**	1.07 (0.29)	2.72 (0.01)**	3.62(0.01)**

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

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

To further investigate the contributions of 'Regulatory Support' issues, the significant correlations obtained as a result of t-test are validated through Canonical Factor Loading analysis. This analysis describes the combined effect of multiple inputs (all issues under input factor 'A3' considered simultaneously) on individual output variables and helps in extracting significant contributors for achievement of various 'Development Indicators'. Table 4.25 depicts the results of Canonical Factor Loading analysis.

Table 4.25 Extracting Significant Factors using Canonical Factor Loading Analysis

		DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)			
		Level Y1	**Strategy Y2**	**Organization Y3**	**Response Y4**
Pricing policies for raw materials	**G1**	0.536*	0.011	0.414	0.479
Availability & cost of power	**G2**	0.055	0.204	0.524*	-0.040
Policies for subsidy to industry	**G3**	0.595*	-0.120	0.333	0.584*
Support mechanisms for research initiatives	**G4**	0.663*	0.962*	0.414	0.610*

The inter-relationships between significant input issues and output factors obtained through Canonical Factor Loading analysis have been further validated through multiple regression analysis as depicted in Table 4.26.

Table 4.26 Multiple Regression Analysis between 'Regulatory Support' and 'Development Indicators'

Development Indicator	Significance Factor	Beta Value (β)	t Value	Significance Value (p)	R Value	F Value
Y1	G1	0.217	2.156	0.034	0.513	18.805
	G3	0.257	2.627	0.010		
	G4	0.325	3.479	0.001		
Y2	G4	0.363	6.847	1.33 E-09	0.605	56.877
Y3	G2	0.194	2.341	0.022	0.258	15.482
Y4	G3	0.246	2.557	0.073	0.403	17.290
	G4	0.271	2.879	0.005		

4.8.3.1 Result Discussion

Materials limit the level of technology of any age, and thus a significant correlation (r = 0.22) between availability of *materials at appropriate prices* (G1) and *level of technology* (Y1) is obvious. The results show that high price of raw materials has been a major impediment in technology improvement efforts of small scale sector in the region. Government has to ensure that raw materials are readily available and reasonably priced.

Availability of *electric power and its cost* (G2) have not shown a significant effect on realization of technological improvements (Y1). Though, shortage and high cost of electricity is an important concern but this issue does not affect the level of technology being used. Technological levels are governed by other components of government support viz. material availability at suitable prices, financial support to research projects, effective reward schemes for entrepreneurs to promote excellence in the area of technological innovations etc.

The *subsidies provided by government* to the industrial units (G3) strategically contribute (r = 0.31) towards realization of *improved process and product technologies* (Y1). Government support is provided in the form of direct grants, subsidies or other forms of financial support. It includes free or subsidized information advice or consultancy and/or special treatment in relation to government regulations. The state can adopt preferential policies for small scale sector, through reducing tax, to encourage them to speed up new product developments.

The role of government *support mechanisms* (G4) has been statistically significant (r = 0.34) towards *improvement of technology* (Y1). Government support includes initiatives like funding R&D projects, establishing effective reward schemes, providing laboratories for R&D work, providing collaborative training programs, R&D programs among government-funded research centers etc.

Thus, 'Regulatory Support' (A3) as an input factor contributes significantly in improving the level of technology (Y1) through effective policies for material pricing (G1), subsidies to organizations (G3) and an adequate support structure (G4).

The results show that *pricing policies for raw materials* (G1), *power situation in the region* (G2), and *policies regarding subsidies* (G3) do not exhibit a significant linkage with implementation of *strategies for technology development* (Y2). Strategic implementation of innovation depends on broader issues like culture and climate for innovation, management philosophy, and the effectiveness of government support structure. The role of *support mechanisms* (G4) has been very influential (r = 0.61) in effective implementation of *strategic approaches for technology development* (Y2). Government plays an important role in supporting firm's ability to use and foster innovation.

The results reveal that *raw material prices* (G1) significantly affect (r = 0.23) the *response of small scale sector to market demands* (Y4). Material cost is a major fraction of product cost. If government facilitates material availability at reasonable prices, the savings achieved can be invested in development projects to improve product features and attributes.

Favourable regulatory environment regarding *subsidies* (G3) helps (r = 0.27) organizations to respond effectively to the *needs of market place* (Y4). Also, the various *support mechanisms* (G4) facilitate (r = 0.29) organizations in *responding to the stiff competition* (Y4). Government can create the right economic, fiscal and regulatory framework within which innovation flourishes. There has been a lack of active government support because of which small sector in the region is just serving local markets and finding it difficult to compete with global counterparts.

'Government Support' (A3) as an input to the technology development initiatives helps organizations to respond (Y4) to the cut throat competition by providing subsidies (G3) and business support mechanisms (G4). Government can provide sector specific specialist advice with the manufacturing industry and provide more financial and tax incentives.

4.8.4 Correlation between Interaction and Development Indicators

'*Interaction with Others*' (A4) is the fourth key input parameter for effective implementation of TD program in manufacturing organizations. The contributions of this input parameter in achieving performance improvements in the Indian industry have been discussed in this section.

Table 4.27 depicts the Pearson's correlations, t-values and significance levels (p-values) for pairs of interrelationships of various '*Interaction with Others*' issues with '*Development Indicators*'.

Table 4.27 Pearson's Correlation and t-Test Analysis between 'Interaction with Others' and 'Development Indicators'

			DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)				
			Level (Y1)	**Strategy (Y2)**	**Organization (Y3)**	**Response (Y4)**	**Overall TD**
Collaboration with other industries	**I1**	**r**	-0.27	0.08	0.30	-0.21	-0.06
		t(p)	-2.49(0.01)**	0.65(0.51)	2.80(0.01)**	-1.92(0.05)*	-0.53(0.60)
Collaboration with technical institutions	**I2**	**r**	0.14	-0.16	0.12	0.16	0.11
		t(p)	1.23(0.22)	-1.44(0.16)	1.07(0.29)	1.44(0.16)	.96(0.34)
Collaboration with R&D establishments	**I3**	**r**	-0.16	0.39	0.32	-0.13	0.21
		t(p)	-1.44(0.16)	3.77(0.01)**	3.00(0.01)**	-1.17(0.25)	1.92(0.05)*
Collaboration with service institutes	**I4**	**r**	-0.15	-0.21	0.18	-0.19	-0.17
		t(p)	-1.35(0.21)	-1.92(0.05)*	1.63(0.12)	-1.72(0.09)	1.53(0.14)

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

To identify the significant contributors under the combined effect of various input issues, the Canonical Factor Loading analysis has been performed. Table 4.28 depicts the results of this analysis.

Table 4.28 Extracting Significant Factors using Canonical Factor Loading Analysis

		DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)			
		Level (Y1)	**Strategy (Y2)**	**Organization (Y3)**	**Response (Y4)**
Collaboration with other industries	**I1**	-0.727*	0.358	0.574*	-0.592*
Collaboration with technical institutions	**I2**	0.370	-0.366	0.304	0.452
Collaboration with R&D establishments	**I3**	-0.435	0.755*	0.654*	-0.365
Collaboration with service institutes	**I4**	-0.390	-0.409*	0.476	-0.538

The results of Canonical Factor Loading analysis have been validated through Multiple Regression analysis as depicted in Table 4.29.

Table 4.29 Multiple Regression Analysis between 'Interaction with Others' and 'Development Indicators'

Development Indicator	Significance Factor(s)	Beta Value (β)	t Value	Significance Value (p)	R Value	F Value
Y1	I1	-0.420	-2.509	0.014	0.275	16.293
Y2	I3	0.234	4.024	0.000	0.445	19.886
	I4	-0.097	-2.132	0.036		
Y3	I1	0.358	3.040	0.003	0.445	19.858
	I3	0.229	3.284	0.002		
Y4	I1	-0.308	-1.905	0.061	0.212	13.628

4.8.4.1 Result Discussion

Organizations and individuals dedicated to the industrial development agree that one of the main producers of wealth and prosperity of industrialized countries is the existence of well coordinated and sustainable system that supports interaction with other organizations and formation of networks, capable of converting innovation assets into new technology. However, taking part in cooperative ventures, alliances and networks demands a lot of trust in alliances and also in cooperation. The results show that *collaborations between manufacturing organizations* for technological innovations (I1) exhibit a significant negative correlation (r = -0.27) with *level of technology* (Y1). Industrial collaborations have been successful in many developed economies, especially in the large scale manufacturing sector but have not yielded positive results in the Indian small scale industry. The results indicate lack of mutual trust among manufacturing units to discuss common problems and share specialized knowledge to improve technology.

Industry-institute partnerships for research work (I2) have not contributed towards *technological improvements* in firms (Y1). There are very few manufacturing organizations (less than one tenth only) which collaborate for technology development initiatives with technical institutions and universities in the region. Small scale industrial sector and academic institutions have lived and grown apart, developing diverse views and wide communication gaps. Paradigm shift is warranted to mitigate this dismal situation.

Collaborations between industry and R&D institutes (I3) have not played a significant role in enhancing the *level of technology* (Y1). This is because manufacturing units have been working together with R&D establishments for solutions to production and maintenance problems and not for product innovations.

Government has set up several institutions (here, referred as Service Institutes) with the objective of providing support to the small scale sector. These include, Small Industry Service Institutes (SISI), District Industrial Centers (DIC), Indian Institute of Machine Tool Technology (IIMT), National Small Industries Corporation (NSIC), and Technology Bureau for Small Enterprises (TBSE) to name a few. *Collaborations with service institutes* (I4) have not facilitated *technology improvements* in the small scale units (Y1). These institutions need to reformulate their policies regarding technology support and improve their functioning to meet the objectives for which they have been set up. Also government needs to regularly monitor their performance.

Thus, ‘Interaction with Others’ (A4) can improve technology levels (Y1) through effective industrial collaborations (I1). However, knowledge exchange between participating industries requires each partner to allow others ‘to look into their kitchen’. In addition, priorities given to internal work and work associated with collaboration must be equitably balanced. For this, an above average level of trust and respect for each others’ competencies and best intentions is required.

The results show that *collaborations between manufacturing organizations* (I1), *industrial tie-ups with technical institutions* (I2) have not contributed towards *implementation of strategic approaches for technology development* (Y2). However, *collaboration between manufacturing units and R&D institutions* (I3) has exhibited a significant association (r = 0.39) with *strategic implementation of innovation* (Y2). R&D establishments work with a project based approach and utilize specific strategies for creative outcome. Networking with these institutions leads to greater success in implementing strategic approaches for product innovations.

Collaborations between manufacturing organizations (I1) have been statistically significant (r = 0.30) towards improvement of *structure and output of research initiatives* (Y3). Research function is said to be well organized when it exists as a separate department, follows a well defined R&D policy, collects specific information on customer requirements and utilizes research effectively to develop new processes and products. *Collaborations with R&D institutes* (I3) have contributed (r = 0.32) effectively towards more *organized R&D function* (Y3) as these institutions are the best source of information on how to manage the research activities.
'Interaction with Others' (A4) has exhibited a significant linkage with accruing improved structure and better organized R&D function (Y3) through industrial collaborations with other manufacturing organizations (I1) and interaction with research establishments (I3).

The results show that a negative correlation (r = -0.21) exists for *collaborations between industries* (I1) and *response to needs of the marketplace* (Y4). In an environment of increasing turbulence and uncertainty, manufacturing enterprises must rely on developing new markets to achieve growth, which requires them to establish or join networks of collaboration with various business partners. Through this mechanism, small firms can ameliorate the problem of extending their knowledge base and to strengthen their market standing. The results however show that at present, industrial collaborations are creating more problems than benefits. Small units in the region are having difficulty in building credibility with a potential partner. Such credibility typically arises with the perception that the firm seeking a partner may have some valuable knowledge to offer in return. Further, collaborations require sharing or changing of some established practices and acceptance of a degree of interdependency on other firms, as well as development of a common language.

Industry-institute partnerships (I2) have not been effective in facilitating industrial units to *respond to the changing demands of market* (Y4). Technical institutions have lagged behind in clearly understanding the current and potential future needs of industry. Institutions have shown neither interest nor inclination to market their resources, and industry is mostly unaware of what institutes can deliver and how they can be helpful to it. *Industrial collaborations with R&D institutes* (I3), *service institutes* (I4) have also not been effective in facilitating industry to *respond to the market demands* (Y4). This is because such partnerships have focused more on production/ maintenance issues and less on technological innovations.

'Interaction with Others' (A4) as an input factor can influence response of manufacturing sector to the increased competition (Y4) if collaboration between manufacturing units is effective (I1). The results reveal that Indian small scale sector is yet to learn the art of working in mutual cooperation with external agencies. This sector is financially not self-contained to acquire state of the art technologies or to develop them indigenously. In the light of this, partnerships and alliances is a viable solution to meet the ever changing needs of marketplace.

4.8.5 Contributions of 'Technology Input Success Factors' in achieving 'Development Indicators'

The overall inter-relationships between various '*Technology Input Success Factors*' and '*Development Indicators*' has been shown in Table 4.30 to develop an understanding of inter-play between different input factors and output performance parameters.

'*Manpower Competence and Management Commitment*' initiatives (A1) have a significant association (r = 0.21) with '*Technology Infrastructure*' (A2). Organizational structure should be such that there are adequate funds, materials, production facilities and information support system to sustain innovation Top management support to technology development initiatives is important to ensure availability of requisite support infrastructure and resources for innovation.

Table 4.30 Interrelationships of Technology Input Success Factors with Development Indicators

	A1	A2	A3	A4	Y1	Y2	Y3	Y4
A1	**1**	**0.21***	0.09	-0.18	**0.31****	0.14	**0.31****	**0.33****
A2	**0.21***	**1**	-0.05	0.04	**0.31****	**-0.35****	**0.21***	**0.28****
A3	0.09	-0.05	**1**	-0.02	**0.27****	**0.36****	**0.23***	**0.21****
A4	-0.18	0.04	-0.02	**1**	**-0.22***	0.05	**0.44****	**-0.21***
Y1	**0.31****	**0.31****	**0.27****	**-0.22***	**1**	**-0.28****	-0.01	**0.64****
Y2	0.14	**-0.35****	**0.36****	0.05	**-0.28****	**1**	0.19	**-0.31****
Y3	**0.31****	**0.21***	**0.23***	**0.44****	-0.01	0.19	**1**	0.01
Y4	**0.33****	**0.28****	**0.21***	**-0.21***	**0.64****	**-0.31****	0	**1**

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

'*Manpower Competence and Management Commitment*' factor (A1) significantly contributes in improving (r = 0.31) the *level of technology* (Y1) in firms and also in *responding* (r = 0.33) *to market needs* (Y4) through availability of workforce with multiple-skill base and presence of an appropriate reward structure in the organization. Further, this *input factor* (A1) has a significant impact (r = 0.31) on *structure and output of research function* (Y3) through proper formal training of employees, adequacy of R&D staff and an apposite recognition mechanism.

'*Technology Infrastructure*' (A2) as an input factor facilitates organizations to upgrade (r = 0.31) *technology levels* (Y1) and to effectively meet (r = 0.28) the *changing needs of customers* (Y4) if proper modernization initiatives and adequate financial support to the R&D function are provided.

'*Technology Infrastructure*' (A2) and *strategic implementation of innovation* (Y2) have exhibited a negative correlation (r = -0.35). This shows that small units are aware of the benefits of strategic measures for innovation but implementation has remained poor because of inadequate financial and infrastructural support.

This *input factor* (A2) improves (r = 0.21) the *structure and output of research function* (Y3) if dedicated laboratories with state of the art production equipment and facilities for testing and analysis are available.

'Regulatory Support' (A3) as an input factor contributes significantly in improving (r = 0.27) the *level of technology* (Y1) and in responding (r = 0.21) to *cut throat competition* (Y4).
This *factor* (A3) facilitates (r = 0.36) organizations in *strategic implementation of innovation* (Y2) if effective support mechanisms are present.

'*Interaction with Others*' (A4) can improve (r = -0.22) *technology levels* (Y1) and organization's *response* (r = -0.21) *to customer demands* (Y4) through effective collaborations between industries. Industrial collaborations are effective if an environment of mutual trust prevails and organizations are willing to share common problems, specialized knowledge and solutions. Negative correlation indicates that industrial partnerships in small scale sector are creating more problems than benefits.
'*Interaction with Others*' (A4) exhibits a significant linkage (r = 0.44) with accruing improved *structure and output of research function* (Y3) through industrial collaborations with other manufacturing units and with research establishments.

Level of technology (Y1) used in firms and their *response to market demands* (Y4) show a very strong association (r = 0.64). This reflects that technology is the most important resource to manufacturing organizations which helps them to compete effectively in the global marketplace and become market leaders in appropriate business domains.

4.9 Chapter Summary

The outcomes of survey have been studied to explore the present status of technology development capabilities of industry. For this, both descriptive and empirical analyses have been utilized. The descriptive analysis has assessed the present status of various research parameters in the manufacturing units. The reasons for poor performance of Indian industry in the area of technological innovations have been identified. The empirical analysis has established the relationship of various technology development implementation dimensions with manufacturing performance indicators. The learning issues from the survey have been summarized for further use in qualitative modeling.

CHAPTER - V

CASE STUDIES

5.1 Introduction

This chapter describes the detailed case studies carried out in manufacturing organizations, which are actors in the present context. The objective of case studies has been to look into and critically analyze various facets of the working of organizations including the need for technology development, the role of technology input success factors and resulting developments accrued as a result thereof.

In each case study, the techniques and approaches adopted by organizations for technological improvements, success achieved and modifications made in the future plans have been complied and analyzed in detail. The preliminary information provided by the survey has been validated through these case studies and synthesis of the two (survey based results and case studies) helps in designing the technology development program for manufacturing industry.

To carry out the case studies, the basis for selection of organizations has been:

- The organization has to be a representative of the manufacturing industry. This means most of the operations and processes are prevalent in that organization.
- The organization has requisite activity going on pertaining to technology development initiatives through indigenous research efforts to maintain competitiveness.
- The organization is forthcoming and cooperative for conducting the case studies.

Accordingly, case studies have been conducted at the following organizations:

i) Super Hobs and Broaches Private Limited, Patiala.

ii) Pye Hand Tools Private Limited, Ludhiana.

5.2 Super Hobs and Broaches Private Limited (Case - I)

Super Hobs and Broaches Private Limited (STC, formerly Super Tools Corporation) is a cutting tool manufacturing organization. The manufacturing facility is located at industrial area (B-22, Focal Point), Patiala in the state of Punjab in North India.

STC is a fast growing organization and over the years has expanded its product range to suit a large spectrum of customers in and outside the country. The company presently has a wide product range with several variants of high speed cutting tools. The products are manufactured to standards as well as to customer drawings and specifications.

The major products of this manufacturing enterprise include Gear Hob Cutters, Gear Shaper Cutters, Gear Shaving Cutters and Broaches. Table 5.1 presents the categorization of products offered by the organization.

Table 5.1 Product Range of STC

S. NO	PRODUCT CATEGORY	VARIANTS
1.	HOB CUTTERS	Gear Hobs, Spline Hobs, Chain Sprocket Hobs, Timing Pulley Hobs
2.	GEAR SHAVING CUTTERS	Conventional, Diagonal, Underpass and Plunge-cut
3.	GEAR SHAPING CUTTERS	Spur Shaper Cutters, Helical Shaper Cutters (Disc, Hub and Shank Type)
4.	METAL SLITTING SAWS	Coarse Teeth Saws and Fine Teeth Saws
5.	SIDE AND FACE CUTTERS	Straight Teeth and Staggered Teeth
6.	PUSH & PULL TYPE BROACHES	Splines, Internal Hole and Keyway

STC was born as a family joint venture on February 2, 1999 with the necessary setup to manufacture high speed steel cutting tools (HSS tools). This small scale unit was started with a resolve to bring about expansion and technology modernization to the cutting tool sector in the region. To achieve these objectives, one of the foremost tasks before STC was to determine the most suitable product mix. The range of products manufactured at the time of inception of the manufacturing facility included hob cutters, milling cutters, thread rolling dies, reamers, and end mill cutter slitting saws. There were only two main customers in the year of inception. These included Pepsu Roadways Transport Corporation (PRTC), Patiala and Diesel Component Works (DCW), Patiala. Apart from these, the products served the open local market.

There were several problems faced initially when the unit was started. These included unavailability of qualified workforce, lack of high-quality heat treatment facilities in the region, inadequacy of market network and lack of technological know-how for process and product developments. Presently, the promoters of this organization have sufficient experience and technically trained personnel. A group of highly dedicated and experienced employees form a dynamic team to take up normal as well as challenging jobs.

The company has two manufacturing facilities (Plant I and Plant II) in India, both located at Focal Point, Patiala. The main manufacturing plant (Plant I) was started with an initial capacity of 24,000 units per annum and its present annual capacity is 240,000 units. To further expand the business and to meet the needs of trade market, the company started its new facility (Plant II) in the year 2007 to manufacture all types of broaches. The present capacity of Plant II is 20,000 units per annum. STC plans to scale up to an annual capacity of 360,000 units in the near future.

The plant has several inbuilt systems and mechanisms to ensure that products manufactured are of good quality. Each cutting tool is accompanied by a process data sheet and each process is followed by stage inspection. Tools manufactured are heat treated by the unique salt bath process which ensures uniform and deep heating, better structure and tool life. The standards followed are BIS, BS, DIN, ASA, JIS and GOST. The detail of major customers of the organization is presented Table 5.2.

Table 5.2 Major Customers of STC

S. No	Details of Customer	Products Supplied to the Customer	Fraction of Total Sales
1.	Diesel Component Works (DCW), Patiala, India	Gear Hobs, Gear Shaving Cutters, Side and Face Milling Cutters	10%
2.	Musashi Auto-Hero Honda, Gurgaon, India	Gear Shaper Cutters, Chamfer Cutters, Side and Face Milling Cutters, Flat and Circular Thread Rolling Dies, Spline and Chain Sprocket Hobs	25%
3.	HK Tools, Romania	Gear Hobs, Profile Relieved Milling Cutters, Bore and Shank type Milling Cutters	20%
4.	Dynamic-Tightwell Limited (DT), Rohtak, India	Gear Hobs, Master Gears, Spline and Worm Hobs, Reamers and Slitting Saws	30%
5.	Sona Koyo Systems Steering Limited (SKSSL), Gurgaon, India	Push and Pull type Broaches, Master Gears	15%

The management has clearly earmarked specific future targets for the organization. In terms of capacity, the company plans 150% enhancement by the end of year 2010. It plans to further increase the product range, improve product quality and improve the marketing network. STC is also exploring the feasibility of switching over to plastic gear manufacturing. A snapshot of the achieved milestones and business strategy decisions are delineated and presented in Table 5.3.

Table 5.3 Milestones of Super Hobs and Broaches Private Limited

YEAR	MILESTONES OF THE ORGANIZATION
1999	• STC born as a small scale unit on February 2, 1999 to manufacture HSS tools. • Launched Hob Cutters, Milling Cutters, Thread Rolling Dies, Reamers, End Milling Cutters and Slitting Saws. • First unit of product manufactured in November, 1999. • PRTC Workshop and DCW, Patiala as first major customers. • Installed capacity to produce 2000 units/ month. • Production only in one shift (General Shift). • Design, Production and Sales established as separate departments.
2000	• Introduced Fine Teeth Metal Slitting Saws. • Started importing raw material from China. • Entered into tie-up with MSME-Tool Room (Central Tool Room), Ludhiana.
2001	• Launched its official website: www.superhobs.com • Import of raw material started from Austria and other European countries.
2002	• Launched Spur Gear Shaping Cutters. • Reached an installed capacity of 5000 units/ month. • Dynamic-Tightwell Limited (DT), Rohtak as a new major customer. • Established a separate Marketing Department to attend to specific customer needs.
2003	• Introduced Helical Gear Shaping Cutters (Disc, Hub and Shank type) • Majority of the inspection equipment (analogue type) replaced by digital instruments to improve accuracy. • Started importing raw material from Japan also. • Gauge Blocks, Surface Plate (Make: LS Starret Company) procured for inspection of jobs. • Enlarged dealer network for quick delivery to customers.
2004	• Launched Broaches (Straight Spline). • Created Finance Department as a separate facility. • Import of raw material started from France and Germany also. • Major process improvement through indigenous research efforts. Adopted salt bath treatment for enhanced product life.

YEAR	MILESTONES OF THE ORGANIZATION
2005	• Installed capacity reached 12,000 units/ month. • Musashi Auto-Hero Honda, Gurgaon established as a new customer. • Major increase in profits because of ban on outsourcing by the government. • Change in process from manual to retrofitting/ CNC for gear cutting tools. • Cylindrical Gauges (Plug and Ring Gauges) (Make: Kolb and Baumann Company) procured for all types of holes, roundness and concentricity measurements.
2006	• Entered the international arena. H.K Tools, Romania as first international customer. • Established a dedicated R&D Cell for Gear Shaving Cutters. • Started Employee Provident Fund (EPF) scheme for all permanent employees. • Obtained accreditation to the quality certification system, ISO 9001-2000. • Milling machine (Make: WMW Machinery Company; Capacity 250 units/ day) for gear cutting purchased to enhance the production rate. • Formulated and adopted R&D policy for better utilization of research function. • Major process improvement through in-house research. Adopted oil tempering by replacing dry tempering.
2007	• Introduced involute Profile Pull Type Broaches and Gear Shaving Cutters. • Quality Control, established as a new department. • Purchased Siemens's software for CNC working. • Product features of Gear Hobs, Spline Hobs and Chain Sprocket Hobs improved. • New variant of Hob Cutters called Timing Pulley Hob introduced. • Cylindrical Grinding machine (Make: Klingelnberg; Capacity: 500 units/ week) for broach sharpening purchased.
2008	• Introduced Push Type Broaches and Master Gears. • Reached an installed capacity of 20,000 units/ month. • Sona Koyo Systems Steering Limited (SKSSI) established as a new customer. • Profits reduced because of recession in the market. • Purchased Shaving Cutter Grinding Machine (CNC) for improved quality and higher production rates. • New features added in Gear Shaving Cutter (Conventional, Diagonal). Underpass and Plunge Cut variants introduced. Hydraulic grinding replaced by CNC grinding. • Gear Tooth Profile Grinder (Make: Hofler; Capacity 200 units/ week) purchased for gear profile and face grinding. • Raw material composition for some products changed from HSS to ASO-2030 to enhance product reliability.

5.3 SWOT Analysis of the Organization

The strategic importance of global competitiveness of cutting tool sector in the country is steadily increasing, and therefore tool manufacturers require effective corporate strategies to achieve sustainable competitive advantages.

Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis is one of the most effective approaches for analyzing the strategic management policy of an organization. This analysis is an effective means for analyzing internal and external environments in order to obtain systematic approaches and support for successful strategy formulation (Houben *et al.,* 1999).

On the basis of study carried out at Super Hobs and Broaches Private Limited, the following critical areas have been identified for assessment of 'Technology Development Implementation Program' in the organization:

- Recruitment
- Management
- Reward Structure
- Training
- Technology Infrastructure
- Innovation Process
- Finance Function
- Production Characteristics
- Regulatory Environment
- Work Culture
- Market Situation
- Marketing
- Production Characteristics
- Networking
- Research Function

The results of SWOT analysis conducted at Super Hobs and Broaches Private Limited (STC) are presented in Table 5.4.

Table 5.4 SWOT Analysis at STC

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Recruitment	▪ STC has multi-skilled workforce capable of working on different processes and machines.	▪ The company tends not to recruit from higher education sector because of financial reasons. ▪ The system of contract based employment is a major deterrent to upgradation initiatives. ▪ Recruitment process has dependence on local labour markets. ▪ Recruitment process is highly subjective.	▪ One of the largest pools of scientists and engineers in the region, which provides a competitive advantage in perusing R&D initiatives. ▪ Huge potential lies in the small scale sector to expand employment opportunities, further develop the industry and boost the exports.	▪ Medium and large enterprises offering better wages and salaries.
Management	▪ Functional and flexible management. ▪ Proprietors have sufficient experience and highly dedicated and technically trained workforce. ▪ High level of commitment from top management. ▪ Culture of experimentation and ownership feeling.	▪ Little career planning for employees. ▪ Lack of organized market channels and imperfect knowledge of market conditions. ▪ Lack of formalized contractual relations with customers. ▪ Lack of international exposure and sensitivity to implications of WTO regime.	▪ Opportunities for continued education as many reputed institutions are in close vicinity. ▪ 'Management Development Programs' (MDPs) can be organized in-house or executives can attend these at other places.	▪ Competitors are trying to continually improve and become more scientific and logical in their approach. ▪ Main competitors are having better international exposure.
Reward Structure	▪ The company uses intrinsic motivation tools to recognize contribution of employees towards process and product improvements and innovations.	▪ Though a reward system exists in the organization but it is not formal and well structured.	▪ Labour force in general is good, wants to take responsibility and show results. The employees are intelligent and can contribute to growth and development of the organization if utilized strategically.	▪ Employees whose involvement is not sought through a well defined recognition mechanism can sometimes work negative. Unchannelized energy can be destructive.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Training	▪ The company has a culture which promotes learning by watching and imitating.	▪ Little investment is made in training (with the exception of specific training for immediate use). ▪ There is very little formal training of employees after induction. Only on-the-job training is provided. ▪ Organization remains insular and autonomous and fails to recognize the underlying or latent skill deficiencies.	▪ STC can obtain support from National Institute of Small Industry Extension Training (NISIET). Principle activities of this institution include training, research and consultancy in fields of management, extension and information for development. ▪ Specialized training of employees at Honda and other large scale manufacturing units. ▪ Organized training groups/ institutions are available in the region.	▪ Trained employees have a tendency to move to other organizations which are offering better pay packages.
Technology Infrastructure	▪ The manufacturing organization has expertise in Surface Heat Treatment processes (Case Hardening Treatments) developed by employees through in-house research initiatives.	▪ State-of-the-art production m/cs, workstations, machining centres etc. are available only to a small extent. ▪ Dedicated laboratories for experimentation and subsequent analysis are not available. ▪ Low degree of automations. ▪ Rigid manufacturing facilities do not allow adaptation to changing market dynamics. ▪ Softwares for drafting, designing, modelling etc. are in limited use.	▪ Many cutting tool manufacturers are in close vicinity of the organization. All these firms realize the need of joining hands to build physical and technology infrastructure to upgrade processes and products. There is a need to take initiative and bring the cutting tool manufacturers together.	▪ There are wide gaps existing between technologies used by manufacturers in India and in developed economies.
Innovation Process	▪ There is more rapid movement of ideas around the firm. ▪ Routine procedures can be reduced to a minimum. ▪ Specific earmarking of funds is done by the organization for technology development initiatives.	▪ The unit adopts an unsystematic approach towards innovation. Innovation often happens by luck or accident. The process of innovation tends to leave too much to chance, and so evaluation is rarely given the significance it deserves. ▪ Most innovation groups formed at STC have a short life span. ▪ There is lack of awareness regarding Intellectual Property Rights (IPRs) to protect ideas/ strategies. ▪ Specific product innovation strategies are not adopted.	▪ Large scale industrial groups are grasping the fact that despite a lack of resources, small firms are an inexhaustible source of innovations. ▪ Small units can obtain support from 'Risk Capital and Technology Finance Corporation' (RCTFC). This government agency provides finance and venture capital to small scale manufacturing units for commercializing indigenous technologies and to adopt innovations.	▪ Copying of product innovations of the organization in the absence of patenting. ▪ Dynamism of the manufacturing sector may make the production facilities redundant very soon.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Finance Function	▪ A significant proportion of earned profits are reinvested to improve production operations and for technology upgradation initiatives.	▪ Access to finance (from external agencies) and presence of equity gaps are major barriers to innovation. ▪ Cost of bank finance is a significant factor in export pricing. Rates of interest, particularly for export, are very high in comparison to international rates. ▪ There are bureaucratic hurdles in obtaining financial assistance (at low interest rates) from financial corporations and other commercial banks. ▪ There is a lack of competitiveness when it comes to financial analysis. ▪ The manufacturing unit does not work with a defined financial strategy.	▪ Small units can avail one time capital grant of 50 percent from Ministry of Small and Medium Enterprises (MSME) for setting up testing laboratories. ▪ Government has enhanced excise duty exemption to ₹15 million (under the General Excise Exemption Scheme). It would make the products cost effective and strengthen the competitiveness of small scale sector. ▪ Small units can obtain financial assistance from Small Industries Development Bank of India (SIDBI) through direct assistance schemes as well as indirect assistance such as refinancing. ▪ Growing number of financial tools/ banks and increasing competition between them provides better opportunities of finance availability.	▪ Banks continue to insist on high collateral for any loans. ▪ Practice of delayed payment by larger corporates is still rampant in small scale sector and in turn dents their borrowing prospects. ▪ To avoid NPAs (Non Performing Assets), banks have become super cautious in lending.
Production Characteristics	▪ The manufacturing facility has a high installed capacity of 240,000 units per annum. ▪ The company uses advanced metrological equipment for inspection and quality control activities. ▪ All grinding operations are CNC based which provide better accuracy and precision.	▪ Sub-optimal scale of operation/ under utilization of capacity. ▪ OEM drawings of components, facilities for computer aided designing (CAD) are generally not available. Components are produced merely by copying samples. ▪ Low level of production technologies are in use which result in high cost and low productivity. ▪ Poor project management and small scale production skills are not enabling faster technology commercialization. ▪ Inability to reduce cost of manufacturing (to improve profit margins) has been a major problem.	▪ There is no dearth of orders for manufacturing firms which manufacture innovative-good quality, long life cutting tools. ▪ The manufacturing unit can obtain support from MSME-Tool Rooms (MSME-TRs) to improve its production characteristics. These tool rooms have been set-up under Indo-German and Indo- Danish collaborations. These provide good quality tooling through designing and producing tools, moulds, jigs, and fixtures etc.	▪ The manufacturing unit lacks in technological dynamism. ▪ Quality is a deciding factor in cutting tools. Today, quality can be achieved through sophisticated manufacturing and inspection equipment. Lack of continued modernisation initiatives can pose a great threat to the organization.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Regulatory Environment	▪ India's obligation as a member of WTO to bring down tariff and non-tariff barriers provides competitive environment for the sector.	▪ Adapting to the rules and regulations related to tax structure has been a problem for small units. ▪ Multiplicity of laws and frequent amendments restrict and create impediments in the way of growth. There is a need of a unified law to lessen grey areas in the policy environment. ▪ Capital subsidy schemes of government for technology upgradation in small scale sector do not reach the units because of bureaucratic hurdles. ▪ There is a lack of government support towards sponsoring of training programs for skill development, exposure to new production techniques etc. ▪ Import duty collection rates remain one of the highest in the world. ▪ There is no (official) data source to throw light on product innovations in the cutting tool sector. As a result, small units remain unaware of the latest developments in their field.	▪ Next few years promise to be eventful for the country's manufacturing sector. Full implementation of state VAT (Value Added Tax) along with phasing out of CST (Central Sales Tax) and eventually introduction of 'Integrated Goods and Service Tax' (GST) to eliminate cascading indirect taxes. ▪ With a view to ensure that exporters from small scale sector exhibit their products in international exhibitions and trade fairs etc, required support is provided by the government. Expenditure on account of space rent, handling and clearing charges, insurance and shipment charges etc are met by office of Development Commissioner.	▪ High alloy surcharge on raw materials severely increases the input costs. ▪ Interest rates on plant and machinery loans are extremely high. ▪ The present structure of labour laws does not encourage efficient performance by small units. It is difficult to manage the human resources optimally because of the constrained labour laws.
Work Culture	▪ Little bureaucracy, little real hierarchy and the significant amount of direct contact increases sense of responsibility and personal initiative. This improves creative output of employees and facilitates technology upgradation.	▪ Low competitiveness on account of lower labour productivity and higher input costs.	▪ Participation by entrepreneurs in international trade can lead to diversification of markets, more growth opportunities, and identification of technology gaps.	▪ Trade unions in the country. ▪ Exploitation tendencies.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Market Situation	▪ The management and staff realize the importance of technology as a resource for building competitiveness.	▪ Proprietors realize the importance of technology development through indigenous efforts but still are copying or importing technology. There is a lack of efforts for developing technology in-house or through association with others. ▪ Profit margins have not been increasing. ▪ Basic raw material has to be imported. ▪ Escalating prices of raw materials. It is difficult to finalize long term contracts for exports in view of frequent changes in steel prices. ▪ High cost of electricity with restricted and unreliable supply is affecting the industrial performance.	▪ Even in the recession period, the manufacturing industry including automobiles and component manufacturers has shown an uptrend. This has in-turn increased the demand for cutting tools.	▪ Stiff competition from high quality products from Germany, China, Czech Republic, Korea and Taiwan. ▪ Dual impact of increase in price of steel and no commensurate increase from OEMs and export customers.
Marketing	▪ STC has a separate marketing department to collect information on specific customer needs.	▪ Marketing function has not been performing effectively. Marketing, both for domestic and export markets, has all along been a major problem. ▪ The unit lacks in extensive sales and service network. ▪ A defined and formal procedure to collect information regarding customer needs does not exist.	▪ Improving upon marketing network to penetrate into new markets. ▪ Exploring global customers through product information on internet and using on-line trading for faster business transactions. ▪ Conducting extensive market surveys and participating in international exhibitions for identifying customer needs and developing business contacts. ▪ Adopting the Bar Code Certification to enable higher export price realization. The government scheme 'Marketing Assistance to MSEs' formulated by 'National Manufacturing Competitiveness Programme' (NMCP) reimburses 75% of annual fee (recurring) for the first three years.	▪ Marketing needs a back-up of production technology which is lacking at the moment. ▪ Cutting tool sector in the region is not organized to a great extent.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Product Portfolio	▪ The company has extensive product portfolio to satisfy various segments of customers. ▪ Competitive (cost effective) price of products is a big strength.	▪ Product range of the organization has increased only marginally over the last few years. ▪ The manufacturing facility is based on relatively old process technology to manufacture products.	▪ Large manufacturing base and proximity to fast growing Asian markets. ▪ Increasing export potential of Indian products. ▪ New avenues due to diversification to other product categories. The organization is exploring the feasibility of switching over to Plastic Gear Manufacturing. ▪ Additional price preferences for products from ISO certified firms.	▪ Unavailability of high quality raw material in the country. ▪ Packaging of products is not very effective.
Networking	▪ Strong relationship with existing customers.	▪ Lack of adequate infrastructure at technical institutes in the region to meet specialized training needs of industry. ▪ Very limited interaction with external research institutes for technology development projects. ▪ Lack of active collaboration between tool manufacturers. ▪ Lack of mutual trust among industrial units to discuss common problems and share specialized knowledge to improve technology. ▪ Lack of coordination between various organizations set-up by government to support small units. ▪ Lack of evaluation systems in place for these institutes and their programs.	▪ Small units can network with institutes called 'Technology Based Incubators' (TBI). These help the entrepreneurs to conduct their R&D programs in a professional environment, while receiving the guidance required in initial phases. TBIs help in incubating knowledge based start-ups into commercially viable products by offering affordable workspace, and shared facilities. These facilities are further supplemented with counselling, skills enhancement and networking services to access professional support & seed capital. ▪ The unit can network with 'Technology Bureau of Small Enterprises' (TBSE) established by collaboration between 'United Nations Asian and Pacific Centre for Transfer of Technology' and 'Small Industries Development Bank of India'. TBSE brings industry and research institutions closer to participate in mutually beneficial collaborations for technology transfers. This agency has facilitated several technical collaborations.	▪ In the absence of effective collaborations with other manufacturing units, research establishments, technical institutions and government agencies, it is difficult for the unit to compete with innovative and high quality cutting tool manufacturers.

ASPECT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Research Function	▪ The manufacturing organization is among those few small scale units which work with a well defined R&D policy for better utilization of research function. ▪ The unit has a dedicated R&D cell for Gear Shaving Cutters. ▪ The organization is accredited to the Quality Certification System (ISO 9002; QS 9000).	▪ Absence of technology support from any multi-national corporation or large scale manufacturing organization. ▪ Access to well researched database (pertaining to market intelligence or technology) is not available. ▪ Many R&D outputs do not get commercialized for want of initial investment and the needed enabling environment and networking.	▪ Small units can seek support from the system of information banks called 'National Information System for Science and Technology' (NISSAT). These information banks provide information, particularly regarding latest technological developments. ▪ Small units can obtain help from 'National Small Industries Corporation Limited' (NSIC). It has created a 'Compendium on Technologies' which is relevant for having information of different technologies available for use by small units. It also operates a scheme of providing sophisticated machinery and equipment on lease.	▪ Favouritism and other factors in disbursement of government grants is a great threat. ▪ The procedure for obtaining financial support for R&D from government agencies is cumbersome and tedious. ▪ Employees lack in education level and know-how to prepare proposals for funding. ▪ There is exploitation by middlemen and consultants.

5.4 SAP Analysis at STC

Flexible Systems Methodology has been used as a tool to conceptualize the research problem as a SAP-LAP (Situation-Actor-Process; Learnings-Action-Performance) paradigm. In this framework, the 'situation' aspect comprises of the present industrial situation in small scale manufacturing sector, whereas the organization constitutes the 'actor' aspect. The role of in-house research and innovation initiatives in building technological capabilities constitutes the 'process'. The 'process' aspect in the present case has been discussed under the following headings:

- *Manpower Competence and Management Commitment* Issues
- *Support Infrastructure* Issues
- *Regulatory Environment* Issues
- *Networking* Aspects
- *Technological* Aspects

SAP analysis consolidates the processes adopted by the actor under various situations while LAP synthesis brings out the learning issues from the approaches, actions and performance (Sushil, 1997a; 1997b; 2000).

Based on the business strategy decisions and initiatives taken by the manufacturing enterprise (STC) in the process of improving technological levels, the Situation-Actor-Process (SAP) analysis has been done. Table 5.5 shows the SAP analysis at the organization.

The performance of this manufacturing organization in various research constructs (as developed for empirical analysis of survey data in the previous chapter) has also been presented in this section. The status of key inputs *(Technology Input Success Factors)* for this manufacturing unit is presented in Table 5.6 and depicted in Figure 5.1.

Table 5.5 SAP Analysis at STC

SITUATION	PROCESS
▪ **Product Range:** The manufacturing company (STC) has a wide product range with several variants of high speed cutting tools manufactured to standards as well as to customer specifications. • Product mix of the organization has increased only marginally in the last few years. ▪ **Team Work:** A group of highly dedicated and experienced employees form a dynamic team to take up normal as well as challenging jobs in the manufacture of cutting tools. ▪ **Firm Size:** Management finds it difficult to match the wage rates, job-security and career development opportunities for employees with those available in large corporations. ▪ **Contract Based Employment:** Majority of the supervisory staff and labour are generally employed on a contractual basis. This promotes employee turnover because of small increments in wages offered by unscrupulous competitors. ▪ **Structure:** Tool sector in the region has an unorganized structure.	***Manpower Competence and Management Commitment Issues*** ▪ On-the-job training is provided to employees and workforce. Training generally relates to various production techniques. There is no training in areas of upcoming technologies, software usage etc. ▪ There is limited formal training to enhance innovation skills of employees. Training is provided on need basis, either by suppliers on purchase of new machinery from them or when problem in a specific area is recurring. ▪ If a research project fails, management does not discourage employees to undertake R&D initiatives. However, employees are advised to learn lessons from failures to improve for future. ***Support Infrastructure Issues*** ▪ The manufacturing facility has several inbuilt systems and mechanisms to ensure that products manufactured are of good quality. Each product is accompanied by a process data sheet and each process is followed by stage inspection. ▪ Machine operators make themselves and the workplace dirty. Clip conveyor systems are not used to clean the machines Leakage from hydraulic systems and absence of dust extraction systems lead to more noise and dirt. ▪ Tool designs are not continuously updated using Computer-Aided-Designing (CAD) and Finite Element Analysis (FEA) etc.

SITUATION	PROCESS
▪ **Capacity:** Production capacity of the manufacturing unit has increased over the years. ▪ **Process Technology:** Most of the process technology (machines, equipments) has been acquired from large scale Indian manufacturing organizations. ▪ **Modernization Initiatives:** Absence of adequate modernization initiatives is one of the major problems hindering efforts to develop technology. ▪ **R&D Infrastructure:** Lack of cutting edge R&D infrastructure does not allow development of superior technology products and faster commercialization of the same to emerge, 'first to market'. ▪ **Time for Innovation:** The proprietors are caught up in day-to-day matters of production and management of the unit and find it difficult to keep themselves abreast of various technological developments. ▪ **Support Infrastructure:** Inadequate economic and physical infrastructure are major factors affecting the performance of firm.	▪ All the analysis and testing work related to raw materials is carried out at Central Tool Room, Ludhiana. ▪ Production processes at the manufacturing unit are limited to conventional methods. Modern machining methods (such as laser machining, aqua-jet machining, plasma cutting etc.) which can provide greater accuracy and productivity are not available. ▪ Management clearly allocates funds for specific R&D initiatives (developing new product designs, improving heat treatment processes and bottleneck areas etc). Though allocation is done, but innovation often requires considerable front-end sunk costs, invariably beyond the scope of firm's internal resources. ▪ Small units are entitled for collateral free credit facility (term loan and/ or working capital) up to ₹10 million under the scheme called 'Credit Guarantee Fund Trust for Micro and Small Enterprises' (CGTMSE). However, in practice, the member lending institutions (banks which are members of CGTMSE) are never willing to lend free of collateral/ third party guarantees. ***Regulatory Environment Issues*** • High speed steel (HSS) of good quality for gear cutting tools is not available in the country. Raw material has to be imported from countries including Austria, China, France, Germany, and Japan etc. • The company obtains help from 'Small Industries Development Organization' (SIDO) for import of raw material. SIDO helps the small units by providing them with raw materials that are not readily available in market when needed (due to foreign exchange crisis, working capital problems etc.).

SITUATION	PROCESS
▪ **Financial Health:** Finance is a critical problem area reported as a major impediment for growth. Credit extended to the customers, trade and public sector enterprises blocks a major part of funds. • There is little financial support from government and other agencies for technology upgradation. ▪ **Credit Availability:** Banks have become extremely cautious in sanctioning loans. Priority has shifted to zero-risk high return consumer durable loans. • Faced with a lack of direct and collateral guarantees, banks tend to be over demanding in terms of security which has immediate and restrictive impact on innovative projects for which firm is seeking funds. ▪ **Labour Laws:** The same set of labour laws is applicable to all industrial undertakings, irrespective of their size. Many of these laws are very cumbersome for small scale entrepreneurs to understand and comply with. ▪ **Policy Environment:** Extremely cumbersome regulatory environment. • High tariffs compared to other economies.	• Regulatory environment is largely responsible for high price of raw materials. Addition of alloy surcharge by the government increases raw material price by up to 65 percent as compared to the original cost. • The country has bound tariffs (40 percent for finished goods; and 25 percent for intermediate items, machinery and equipment) and adding surcharge etc., actual tariffs are about 45 percent (on average). These tariffs are high as compared to those in many countries. • Uninterrupted power supply is not available. Availability is only for 4-6 hours per day, on average. The cost involved in alternate source (Diesel Generator Sets) is very forbidding. • Government does not provide adequate support to develop an appropriate strategy to enter international markets. The proposed marketing of mass consumption items under common brand names by 'National Small Industries Corporation Limited' (NSIC) has not taken off at all even after more than a decade of exclusive policy environment for this sector. • The interest rate charged for plant and capital equipment is 13 percent which is extremely high as compared to that in many emerging economies. • The preferential treatment given to small units is contingent on these units remaining small, thus there is no incentive for the units to expand. This is eroding the competitiveness of Indian manufacturing. ***Networking Aspects*** • The industrial unit (STC) has remained unwilling to explore external resources, as it associates this with a loss of control or as an embossing indictment of the value of its in-house expertise. • Sharing of information with other industrial units is informal. Information regarding latest developments and competency understanding is much less. Work sharing is not seen.

<table>
<tr><th>SITUATION</th><th>PROCESS</th></tr>
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Diverse Areas: Existence of a huge number of industrial units manufacturing a wide variety of products makes technology modernization a difficult task in the country.
Service Institutes: The functioning of various institutions and organizations set-up by Ministry of Micro, Small and Medium Enterprises (MSME), Government of India to support the industrial units is largely ineffective because of lack of knowledge of personnel and too many formalities involved.

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Government laboratories do not have state of the art technology infrastructure for testing and analysis. Further, these are available at very few selected locations only.
Technical institutes in the region have neither shown interest nor inclination to market their resources, and manufacturing industry mostly remains unaware of what institutes can deliver and how they can be helpful to the cutting tool sector.

Technological Aspects

The company formulated and adopted R&D policy in year 2006 for better utilization of research function.
The raw material composition of ‘Shaving Gears’ and ‘Master Cutters’ was changed from HSS to ASP-2030 to enhance reliability. Product life improved by 60 percent (on average).
‘Dry Tempering’ (heat treatment process) was replaced by ‘Salt Bath’ treatment through in-house research efforts in the year 2004. Product life improved by 10 percent (on average).
‘Salt Bath’ treatment was replaced by ‘Oil Tempering’ treatment in the year 2006. Product life improved by 15 percent (on average).
Patenting is not used as a strategic tool for increasing competitiveness. The organization (STC) has never even filed an application to obtain a patent in cutting tool technology.
The unit lacks in use of modern packaging system.
There is tough competition from imports (from countries including Germany, China, Czech Republic, Korea and Taiwan) in domestic markets in terms of new designs, new usages, reduced costs, improved quality, higher performance and variety, all delivered simultaneously to enhance value to the customer.

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<tr><th>ACTORS</th></tr>
<tr><td>

Proprietors and senior executives of the unit as key decision makers.
Skilled and innovative engineers/ supervisors of the unit as key knowledge providers.
Suppliers through their suggestions and participation at all levels of business operations.
All customers through their feedback.

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Table 5.6 Status of Technology Input Success Factors at STC (Key Inputs)

Key Input Issues	**Status**
I. *Manpower Competence and Management Commitment*	
Availability and effectiveness of multi-skilled workforce	+ + + +
Experience and dedication of employees	+ + + +
Culture of experimentation and ownership feeling	+ + + +
Education level of employees	+ + − −
Recruitment process and job security	− − + +
Career planning and wage rates	− − + +
Knowledge of market conditions	+ + − −
Formal contractual relations with customers	− − + +
Formal training of employees	− − − −
Reward structure	+ + − −
Use of cross functional teams	+ + + +
Awareness and use of Intellectual Property Rights	− − − −
Strength of R&D staff	+ + − −
Support in situations of project failures	+ + − −
International exposure to identify technology gaps	− − + +
OVERALL STATUS	**Moderately Effective**
II. *Technology Infrastructure*	
Modernization initiatives	− − − −
Specific earmarking of funds for technology development	+ + − −
Access to finance from external sources	− − − −
Use of defined financial strategy and analysis	− − − −
Availability of latest production technologies	− − + +
Availability of R&D infrastructure	− − − −
Expertise in heat treatment processes	+ + + +
Use of advanced metrological equipment	+ + + +
Utilization of available production capacity	− − + +
Small and continuous automations	− − + +
OVERALL STATUS	**Less Effective**
III. *Regulatory Support*	
Availability of raw materials at reasonable prices	− − + +
Availability of good quality physical infrastructure (electricity etc)	− − − −
Financial support by government institutes	− − − −
Effectiveness of government support mechanisms	− − − −
Tax policies and labour laws to support upgradation initiatives	− − − −
OVERALL STATUS	**Extremely Ineffective**
IV. *Interaction with Others*	
Active collaboration with other cutting tool units	− − − −
Mutual trust and cooperation with other units to share specialized knowledge	− − − −
Technology support from large scale manufacturing units	− − − −
Industry-institute interaction for technology upgradation	− − + +
Infrastructure at technical institutions to meet training needs of industry	− − + +
Interaction with external research institutions	− − − −
Support from service institutes	+ + − −
OVERALL STATUS	**Less Effective**

(+ + + + Extremely Effective; + + − − Moderately Effective; − − + + Less Effective; − − − − Extremely Ineffective)

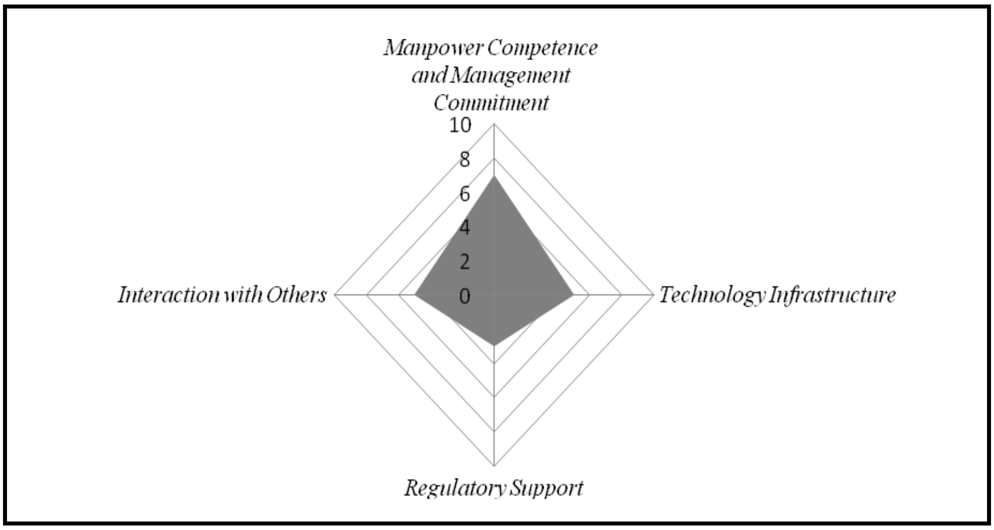

Figure 5.1 Status of Technology Input Success Factors at STC (Key Inputs)

The status of output performance parameters *(Development Indicators)* at the manufacturing unit is presented in Table 5.7 and depicted in Figure 5.2.

Table 5.7 Status of Development Indicators at STC (Key Outputs)

Key Output Issues	**Status**
Research Output (Development Indicators)	
Process technology in use	− − + +
Use of specific product innovation strategies	− − − −
Commercialization of R&D outputs	− − + +
Product range and variants	+ + − −
Cost effectiveness of products	+ + + +
Use of well defined R&D policy	+ + − −
Dedicated R&D cells for specific areas of expertise	+ + + +
Quality Leadership	+ + − −
Formal research groups in developing innovations	− − − −
Marketing management strategies	− − + +
Sales and service network	− − + +
Project management	− − + +
Increase in product mix over the years	− − + +
Efforts for change and Innovation	+ + − −
OVERALL STATUS	**Moderately Effective**

(+ + + + **Extremely Effective;** + + − − **Moderately Effective;** − − + + **Less Effective;** − − − − **Extremely Ineffective)**

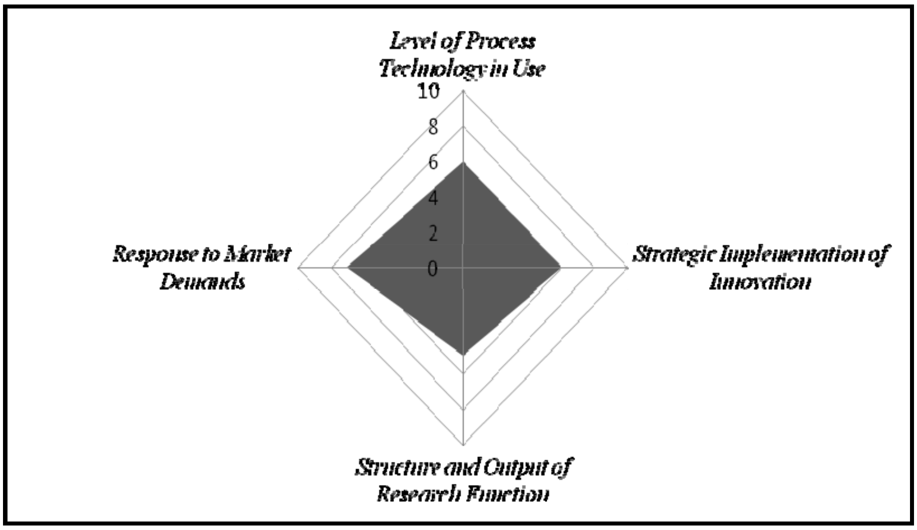

Figure 5.2 Status of Development Indicators at STC (Key Outputs)

5.5 LAP Synthesis at STC

This section presents the L-A-P (Learnings, Actions and Performance) synthesis at Super Hobs and Broached Private Limited.

5.5.1 Learning Issues

Based on the detailed study and analysis of initiatives taken by 'Super Hobs and Broaches Private Limited' (STC) for technology upgradation, the following learning issues have emerged.

Market Situation

- The industrial unit (STC) realizes the importance of technological innovation, but still believes in importing technology rather than developing it in-house or through association with other knowledge generators.
- Managerial standards, engineering capability and quality control activities are just of average measure, with the manufacturing organization getting the best out of what it has and what it knows.

Innovation Process

- The manufacturing unit (STC) possess a great capacity for unplanned innovation in its everyday activity, around issues like developing new processes. However, it is invariably less effective when it comes to planning and implementing innovation, or to establishing a formal research group or to allocating specific individuals to work exclusively on developing innovations.
- The organization needs to learn how to make innovation both a state of mind and a habit. It is not possible, in the long term, to leave this crucial motor of change in the hands of spontaneity or of chance. This is a fundamental area of weakness of this manufacturing unit. This weakness can be managed through use of a series of measures which make access to technology less alarming (by introducing a change culture).
- The organization needs to develop and implement a technology strategy in addition to financial, marketing and operational strategies and adopt the one that helps integrate operations with its environment, customers and suppliers.

Manpower Competence and Management Commitment

- There is supply-lag of technically qualified and trained manpower in the organization. To overcome this problem, specialized and need-based short term courses and training programmes are required at different levels.
- The proprietors encourage their employees to work in various departments and divisions in order to gain a well founded experience. The varied exposure helps in appreciating problems and pressures of different parts of the organization.
- The manufacturing enterprise (STC) prefers external recruitment of experienced staff rather than training the staff internally. Training in the organization is usually adhoc and underlines poor attitude towards learning.

Technology Infrastructure

- Inadequate financial support to research initiatives has been a significant problem. Generous research budgets and broad latitude to pursue projects without interference should be provided. The proprietors should ensure that good ideas do not languish due to a lack of resources.

- Fuel-efficient design of furnaces and other heating equipment should be available to achieve energy conservation. Power-efficient electric motors, lighting systems, welding equipment etc should be introduced.

Regulatory Support

- The manufacturing firm (STC) imports raw material to manufacture cutting tools. Government should take initiatives for reduction in import duty on steel. It should also consider lowering of duty on steel scrap. There should be provision of a 'Central Distribution System' to enable small scale units to purchase raw material at reasonable prices with concessions and duty benefits made available to such centres.
- The proprietors (of STC) find it difficult to manage the human resource optimally because of the constrained labour laws (especially, the complex, 'Industrial Disputes Act'). Instead of a plethora of labour laws, a unified law with simple provisions (to govern the relationship between employer and employees) should be legislated.
- Government should prepare a well planned strategy at the national level for developing exports from small scale sector, including identification of sub-sectors with high export potential (e.g. cutting tool, hand tool sector etc).

Interaction with Others

- The industrial unit (STC) has remained unwilling to collaborate with external sources. The proprietors do not realize that the inclination and ability of small units to innovate is linked to the extent to which they enter into interactive learning networks with other firms, their customers and suppliers, and various other external agencies.

5.5.2 Actions Suggested

The various initiatives taken at STC depict its strategy for survival in this era of cut throat competition. The company has an extensive product portfolio to satisfy needs of its large customer base. STC has an organizational culture which provides little hierarchy and significant amount of direct contact between the employees. This increases a sense of responsibility and personal initiative and promotes experimentation and ownership feeling. The management allocates specific funds for technology development initiatives. The unit has developed expertise in several operations through continuous in-house research efforts. All these initiatives have been effective and must be continued.

There are a few grey areas where the manufacturing unit needs to improve. STC should make more investments in training and research infrastructure. Poor project management and lack of international exposure are other problems which need to be overcome. The company should adopt well defined financial, marketing and technology strategies to climb-up the ladder of value chain. Like the Plan, Do, Check and Act (PDCA) cycle, the company should plan new initiatives further, implement them, check their results and act again.

5.5.3 Performance Expected

Major factors of importance that need to be closely monitored for assessing the implementation of technology development program in this case include building an organizational culture conducive for innovation, deployment of modern technology-infrastructure, and strategic collaborations with external agencies and institutes. These factors help in technology capability building and should result in increased domestic market share and export performance of the organization.

5.6 Pye Tools Private Limited (Case - II)

Pye Tools Private Limited has grown to be one of the leading hand tool manufacturing organizations of the country. The manufacturing facility is located at C-67, Phase III, Focal Point, Ludhiana in the state of Punjab. The organization came to existence in 1983. PTL is a registered trademark of the company. With continuing efforts towards perfection, the organization has conquered many heights, surviving comfortably in its area of operation and tough competition in the market. The company offers a comprehensive range of hand tools comprising screw drivers, pliers, wrenches, and hammers etc. The collective innovative efforts and knowledge sharing by employees has given new impetus to the organization which has achieved remarkable growth rates each year. The organization has continuously widened its product range, improved product features and attributes and has maintained high quality standards. It has even diversified into new areas and is engaged in the manufacturing and export of high quality garden tools also.

Table 5.8 presents the range and classification of products offered by the organization.

Table 5.8 Product Range offered by PTL

S.No	PRODUCT CATEGORY	VARIANTS
A) Hand Tools		
1.	Screw Drivers	PTL Screw Driver, Screw Driver Kit, Phillip Head, Slotted Head, Stubby, Screw Driver with Neon Bulb
2.	Pliers	Combination Pliers
3.	Wrenches	Pipe Wrenches, Adjustable Wrenches
4.	Nippers	Nippers
5.	Hammers	Ball Peen Hammers, Claw Hammers
6.	Chisels	Cold Chisels
7.	Spanners	DOE Spanners
8.	Miscellaneous Hand Tools	Hacksaw Frame, Centre Punch, Spare Mallet, Cable Cutter, Tool Kit
B) Garden Tools		
1.	Hedge Shear	Hedge Shear
2.	Purning Saw	Purning Saw Folding Type
3.	Purning Secateur	Purning Secateur Shearing Type

The fine quality products of the organization are highly appreciated by its valued customers in national and international markets. After achieving a good position in national markets through an efficient sales and marketing network, the company geared itself to penetrate into international markets in the year 2008.

PTL was started as a family business for manufacturing high quality hand tools with long lasting reliability, primarily with the focus on domestic (Indian) markets only. The company faced several problems in the initial years. These included scarcity of capital funds; availability of skilled manpower; costly and unreliable supply of power; and lack of technological support from large scale manufacturing industry, technical and other institutes in the region. However, with the growing experience over these years, the organization has overcome many of these barriers.

At present a team of well qualified engineers, supervisors, skilled and semiskilled workers form the backbone of the manufacturing unit and use latest techniques with modern machinery to maintain international quality.

The detail of customers of the company and products supplied to them is provided in Table 5.9.

Table 5.9 Customer Details of PTL

S.No	**CUSTOMER**	**YEAR** (in which customer was formed)	**PRODUCTS SUPPLIED**
1.	Direct customers through (appointed) regional distributors in the home state of Punjab (Ludhiana city); and national capital (New Delhi).	1983	Hand Tools (all types)
2.	Direct customers through (appointed) regional distributors in the states of Tamil Naidu and Uttar Pradesh.	1995	Hand Tools (all types)
3.	Direct customers through (appointed) regional distributors in the states of Madhya Pradesh and Gujarat.	2001	Hand Tools (all types)
4.	Direct customers through (appointed) regional distributors in the states of Rajasthan and Maharashtra	2002	Hand Tools (all types)
5.	Direct customers through (appointed) regional distributors in other states of the country.	2006	Hand Tools (all types)
6.	Maruti Suzuki India Limited (MSIL), Gurgaon, India (OEM Supplier)	2007	Ball Peen and Claw Hammers
7.	International Customers (USA and Latin America)	2008	All Products (Hand Tools and Garden Tools)

The company strives for excellence in all spheres through dedicated team work, efficient sales network and technological upgradation while supporting the principle of continuous improvement. It possesses good production and research infrastructure facilities to carry out continuous improvements and product innovations. A brief account of these facilities is presented in Table 5.10.

Table 5.10 Infrastructure Facilities at PTL

S. No	Infrastructure Facility	Area of Application
1.	Duplex Surface and Cutter Grinder	Making Shape of Pliers
2.	Power Press	Cutting Blanks for Wire Cutter and Coining
3.	Milling Machines (2 No.)	Cutting Teeth on Plier/ Pipe Wrench
4.	Hydromatic Press	Riveting Operations
5.	Heating Furnace (Induction Type)	Surface Heat Treatments
6.	Tempering Furnace	Annealing and Tempering Processes
7.	Electro Discharge Machine	Making Cavity in Dies
8.	Moulding Machine	Making Insulation Sleeve
9.	Slotting Machine	Cutting Slots in Adjustable Wrench
10.	Drilling Machine	Making Holes
11.	Hardness Testing Machine	Vickers Hardness of Raw Material and Finished Products
12.	Stamping Machine	Stamping on Final Product
13.	Die Loader	Loading and Unloading of Dies
14.	Main Broaching Hacksaw	Automatic Cutting
15.	Grinding Machine	Grinding of Surface
	Surface Grinder	Finishing of Surface
16.	Gattu Machine Addas	Making Shape of Pliers
17.	Magnetic Crack Detector	Detecting Cracks in Material/ Finished Product

The company plans to scale up the capacity further but primarily by bringing in new technology. The proprietors wish to expand their product range further based on continuous market feedback. The organization has its own design and quality department to check product characteristics at various levels during manufacturing and at the time of dispatch. By virtue of its high end professional approach, the organization has bagged many rewards at regional and national levels. The products of the company are accredited and certified by various agencies. The main certifications adopted by PTL are presented in Table 5.11. The business strategy decisions and milestones achieved by the organization are delineated in Table 5.12.

Table 5.11 Certifications adopted by PTL

S. No	Year	Certification	Certified by (Name of Agency)	Detail of Work
1.	2002	ISO 9001: 2004	TUV, Rheinland	Quality Certification System
2.	2004	CE Marking on Pliers	Moody ICL Limited	Safety Standard on Pliers Product Category
3.	2004	ROHS Compliance on Pliers	TCR Engineering Services Limited	Safety Standard for restriction of hazardous substances in the material used for Pliers

5.7 SWOT Analysis at PTL

The competitive strategy of any manufacturing enterprise is aimed at establishing a profitable and sustainable position against market forces that determine competition in the industrial sector. SWOT analysis is an effective means for analyzing the internal and external environments in order to obtain systematic approaches and supports for successful industry strategy formulation (Houben *et al.,* 1999), industrial strategies can be developed for the purpose of building in strengths, eliminating the weaknesses, exploiting the opportunities and/ or countering the threats. This analysis can provide an important foundation for formulation of a successful strategy. The results of SWOT analysis conducted at PTL are presented. Figures 5.3 to 5.6 depict the strengths, weaknesses, opportunities and threats of the organization respectively.

Table 5.12 Milestones and Business Strategy Decisions of PTL

Year	**Business Strategy Decisions and Milestones**
1983	▪ Pye Tools Private Limited (PTL) started as a hand tool manufacturing organization. ▪ First lot of products manufactured and launched in July 1983. ▪ Screw Drivers (assorted sizes) launched as the first major product category. ▪ Production only in general shift. ▪ Installed capacity of 3000 units/month. ▪ State of Punjab (mainly Ludhiana city) and national capital (New Delhi city) as first markets with direct customers.
1985	▪ ESI and EPF schemes for employees adopted by the organization.
1990	▪ Capacity reached 50000 units per annum.
1994	▪ Entered into Tie-up with Central Institute of Hand Tools, Jalandhar for calibration and inspection tasks. ▪ Pliers section established as a separate department in the organization.
1995	▪ Combination Pliers launched by the company. ▪ Spare Mallets launched by the company. ▪ Regional distributors appointed in states of Tamil Naidu and Uttar Pradesh. ▪ Capacity increased to 60000 units per annum.
1996	▪ Ball Peen Hammer introduced as a new product category by the company.
2000	▪ Claw Hammer introduced as a new variant under Hammers category. ▪ Pipe Wrench section established as a separate manufacturing facility. ▪ Capacity reached 70000 units per annum.
2001	▪ Pipe Wrenches and Adjustable Wrenches launched ▪ Wire Cutting, established as a separate manufacturing section. ▪ Market region extended to the states of Madhya Pradesh and Gujarat. ▪ 'Vision and Mission' statements formulated and adopted by the organization.
2002	▪ Wire Stipper and Wire Cutter product categories introduced in the market. ▪ Market region extended to the states of Rajasthan and Maharashtra. ▪ Adopted the Quality Certification System, ISO 9001: 2004.

Year	Business Strategy Decisions and Milestones
2004	▪ Adopted certifications related to safety standards on Pliers from two renowned international agencies. ▪ Entered into collaboration with MSME- Tool Room (Central Tool Room), Ludhiana for Heat Treatment applications. ▪ Entered into collaboration with Institute of Auto-parts and Hand Tool Technology, Ludhiana for Wire-cut and EDM operations. ▪ 'PAH' (Polycyclic Aromatic Hydrocarbons) testing for Pliers product category successfully passed.
2005	▪ Nippers and Cold Chisels launched by the company. ▪ Production capacity increased to 80000 units per annum. ▪ Inspection procedure changed from Visual Inspection to Crack Detection Machine. ▪ Adopted a defined R&D policy for in-house research activities.
2006	▪ Official website of the organization launched (www.pyetools.com) ▪ Reward scheme called 'Performance Appraisal System' launched to recognize employee contributions. ▪ Compact Hand Tool Kit introduced in the market.
2007	▪ Procured ERP software for accounting and resource planning. ▪ Grinding-Polishing section created as a separate facility. ▪ Spanners, Hacksaw Frames, Centre Punches and Cable Cutters launched. ▪ Maruti Suzuki India Limited (MSIL), Gurgaon established as a new major customer.
2008	▪ Separate Testing Laboratory established to facilitate in-house research. ▪ Diversified into Garden Tools sector also. ▪ Entered international arena with first international customers in Latin America.
2009	▪ Capacity increased to 90,000 units per annum. ▪ New induction coil design for Edge Hardening in Pliers.

AREAS OF STRENGTH (S)

- **Manpower Competence and Management Commitment**
  - Organizational culture of collective innovative efforts and knowledge sharing by employees
  - Increased sense of responsibility and personal initiative by employees for continuous improvements
  - Highly dedicated and well qualified team of engineers and supervisors
  - Adequate strength of R&D personnel
  - Extensive formal as well as in-house training of employees to remove skill deficiencies
  - Very efficient sales and marketing network
  - Well defined social security schemes for employees
  - Formal and structured reward system for employees
  - Active participation in international trade fairs for improving quality and identifying technology gaps
- **Technology Infrastructure**
  - Good research infrastructure and production facilities for product improvements and innovations
  - High production capacity to meet increasing demand requirements
  - Separate departments and manufacturing sections for specific functional areas
- **Interaction with Others**
  - Effective collaborations with several government agencies for process improvements and inspection tasks
- **Research Output**
  - Core competency and market leadership in product category of Pliers and Screw Drivers
  - Large market base, both domestic and international
  - Wide product range with several variants under each product category
  - Dedicated R&D department for process and product innovations
  - Specific product innovation strategies are practiced for technology development
  - Recognition by various agencies for high product quality and reliability
  - Well defined R&D policy for effective utilization of research initiatives
  - Several product categories comply with stringent safety and quality specifications of different certification and accreditation agencies
  - Small and continuous automations through in-house research initiatives lead to process improvements
  - Continuous improvement through in-house kaizen programs

Figure 5.3 Areas of Strength at PTL

AREAS OF WEAKNESS (W)

Manpower Competence and Management Commitment

- Reward system is based on extrinsic motivation tools/ monetary awards only
- Lack of formalized contractual relation with customers
- Proprietors and senior executives have limited knowledge regarding use of patents/ intellectual property rights as tools for technology upgradation to enhance competitiveness

Technology Infrastructure

- Lack of capital resources for modernization initiatives and development projects
- High overhead costs leading to lower profit margins
- Limited use of software packages for drafting, product designing, modeling and analysis tasks
- Lack of experience and knowledge of employees to write proposals for obtaining capital grants from various government schemes for small scale sector
- Lack of technology support from any large scale manufacturing organization
- Excessive user charges of support infrastructure services
- No thorough analysis of the investments made in R&D

Regulatory Support

- Shortage and high cost of electricity in the region
- Fluctuations in raw material prices create problems in finalizing long term export contracts
- Cost of bank finance is high in comparison to international rates
- Limited availability of information/ official data on product innovations in hand

Interaction with Others

- Lack of collaboration between hand tool manufacturers for technology upgradation
- Lack of coordination between various service institutes to support the hand tool sector

Figure 5.4 Areas of Weakness at PTL

AREAS OF OPPORTUNITY (O)

- **Technology Infrastructure**
  - Increasing the global presence of company by means of prompt product information on internet and online business transactions/ trading
- **Regulatory Support**
  - Submitting proposals for receiving capital grants from central government and its various funding agencies for technology development projects
  - Implementation of the proposed tax structure by government to eliminate cascading indirect taxes
  - Obtaining benefits from the numerous schemes formulated by government agencies to support small scale sector
- **Interaction with Others**
  - Forging a mutually reinforcing relationship with premier technical institutes can be a cost effective, maximum return option for technology upgradation
  - Training of employees through short term courses and apprenticeship programs at premier technical institutes
  - Preparation of roadmaps by academic experts for making R&D an integral part of firm's working
  - Expert lectures by academic professionals on upcoming key technologies
  - Learning and acquiring strategic support from international customers and large domestic customers like Maruti Suzuki India Limited
  - Exploring the possibility of supplying products to other multi-national and large scale manufacturing corporations in the country
  - Increasing participation in international events for technology modernization and identifying growth opportunities
  - Obtaining help from Sub-Contracting Exchanges (SCXs) set up by non-government organizations (NGOs) and industry associations to develop good relationship with large firms
- **Research Output**
  - Huge demand for high quality hand tools in the market
  - New avenues for the company because of diversification to the garden tool sector

Figure 5.5 Areas of Opportunity at PTL

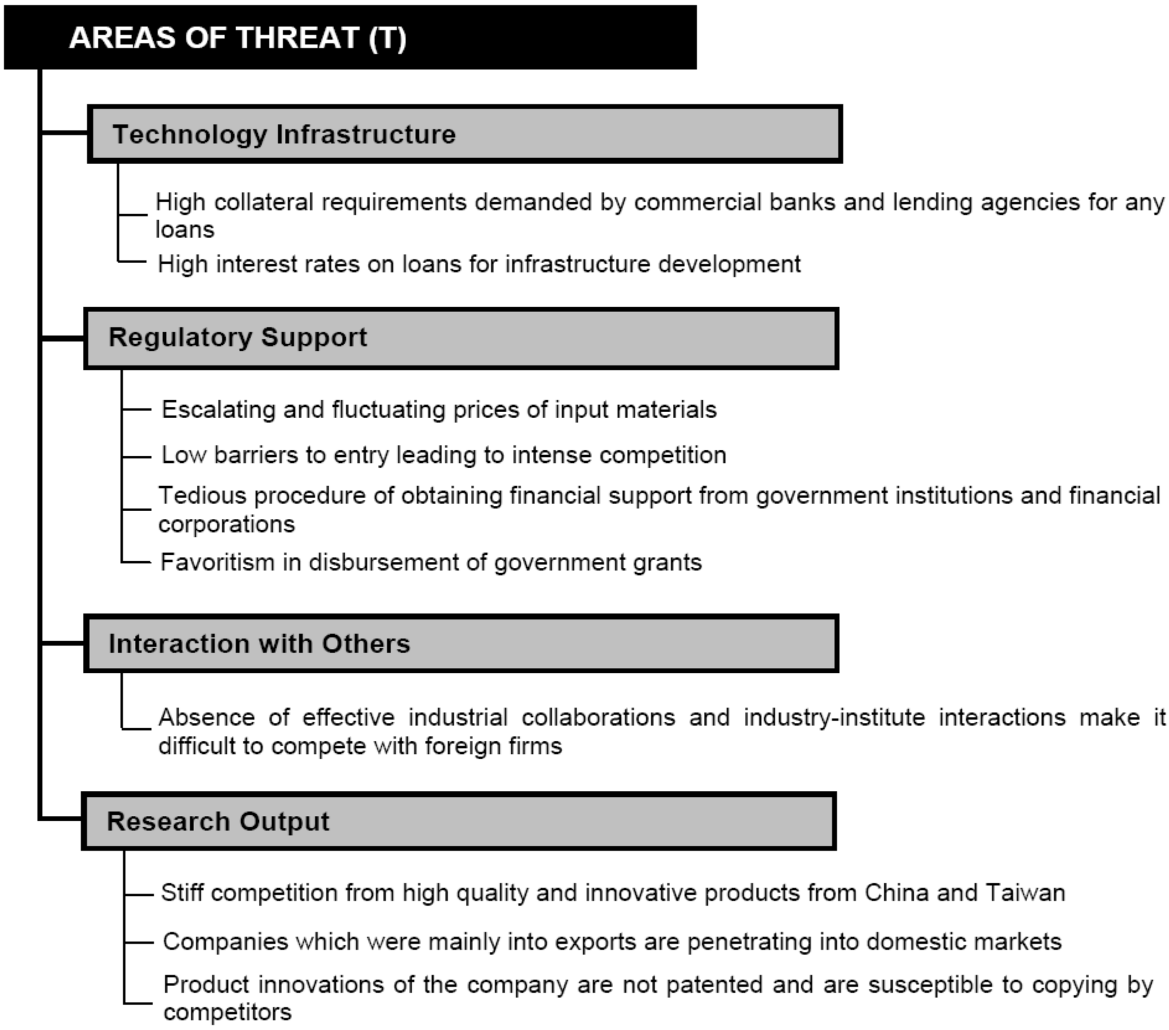

Figure 5.6 Areas of Threat at PTL

5.8 SAP Analysis at PTL

The research problem has been conceptualized as a SAP-LAP paradigm. The 'situation' aspect comprises of the present industrial condition in the hand tool sector in the region, whereas the organization (Pye Tools Private Limited) constitutes the 'actor' aspect. The role of in-house research and innovation initiatives in building technological capabilities constitutes the 'process'. Table 5.13 shows the SAP analysis at the organization.

Further, the performance of this manufacturing organization in various research constructs has also been presented in this section. The status of key inputs *(Technology Input Success Factors)* for this manufacturing unit is presented in Table 5.14 and depicted in Figure 5.7.

Table 5.13 SAP Analysis at PTL

SITUATION	PROCESS
• **Product Range:** The product mix (product types and variants) of PTL has improved continuously (seventeen product categories with several variants under each) over the years. • **Core Competency:** The manufacturing firm commands over 30 percent market share (in the organized portion of industry) for product categories of Screw Drivers and Pliers. • **Market Base:** The company has a large market base, both domestic as well as international. It is the main supplier to Maruti Suzuki India Limited (MSIL), Gurgaon (the leading auto maker in the country) for Ball Peen and Claw Hammers. • **Working Schedule:** The manufacturing firm runs only in one shift (8 hours, General Shift).	**Technological Aspects** • A well defined R&D policy is followed for effective utilization of research function. • R&D initiatives are mainly used for developing new products and processes. Occasionally, these are used for solving maintenance related problems also. • The company makes extensive use of specific product innovation strategies (Risky Research, Market Niche etc) for new product development and building technological competence. • The entrepreneurs develop new designs, drawings and prototypes prior to the development of final (new) product. Before launching a new product, a dedicated facility/ section and a formal team is created for it. • Proprietors make a detailed analysis before launching a new product. Several factors are considered which include: thorough understanding of customer requirements (with regard to the new product) through an extensive market survey, studying the key features and limitations of similar products offered by competitors etc. • Hydraulic riveting operation (for pliers) was replaced by hydro-pneumatic riveting operation through orbital action in June, 2007. This action eliminated the material cracking problem completely. • Manual power press operation for steel blank cutting (wire stripper and cutter section) was automated through installation of feeder at power press in January, 2008. This change resulted in efficiency improvement and manpower savings at the press. • Manual operation for teeth cutting at the milling machine was automated through installation of hydraulic power pack in May, 2009.

SITUATION	PROCESS
• **Diversification:** The organization has also diversified into garden tools sector and manufactures Hedge Shear, Purning Saw and Purning Secateur. • **Growth Rate:** PTL has grown both in terms of turnover and capacity over the years after inception. The company started with a capacity of 3000 units per month and presently has a high annual capacity of 90,000 units (assorted sizes of different product categories). • **Recognitions:** PTL has won several awards for maintaining high quality and safety standards. • **Social Security:** The company adopted 'Employee Safety Insurance' (EPF) and 'Employee Provident Fund' (EPF) schemes in the year 1985 for social security and welfare of employees.	• New induction coil design was adopted for edge hardening of Pliers (year 2009) to achieve hardness as per ISI. • The company adopted the Quality System, ISO 9001:2004 (in the year 2002) certified by the quality certification body, TUV, Rheinland (Germany). • The company adopted safety standards (CE Certification) on Pliers product category (in the year 2004) by Moody ICL Limited. Moody International group is a world wide technical services organization dedicated to reducing client's risk by providing technical inspection services, technical staffing services, consulting and training on a global basis and management system certification on a local basis. **Manpower Competence and Management Commitment** • There is adequate strength of employees with a significant proportion at supervisory and managerial levels. • Employees receive extensive formal training at premier government training institutions to reduce skill deficiencies. Training sessions relate to areas of upcoming technologies and new testing methods. • New employees undergo training during orientation period by senior employees of the organization. Training modules focus on production and inspection techniques. • Training is also provided on opportunity basis (when training programmes are announced at other places) or on need basis (if problems in a specific area are re-occurring). Occasionally, the company also hires services of retired personnel from large scale corporations to train its employees. • A formal reward scheme called, 'Performance Appraisal System' was launched in January, 2006 to encourage and motivate employees. • The company uses customized ERP software for accounting and resource planning functions.

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<tr><th>SITUATION</th><th>PROCESS</th></tr>
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- **Effective Collaborations:** The manufacturing unit works in close collaboration with Central Tool Room, Ludhiana.
- The unit works in collaboration with Institute of Auto Parts and Hand Tool Technology, Ludhiana.
- The company also takes the services of Central Institute of Hand Tools, Jalandhar.
- **Funds for R&D:** There is no financial support by the government for product and process innovation initiatives or other R&D efforts of the industry. The situation is different in China, Taiwan etc which are main competitors to Indian hand tool sector. In these nations, the tool sector is backed by strong government initiatives and support.

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- The owners and other senior officers gather information regarding customer requirements in a structured manner. The company owes its success to the development of innovative high quality hand tools successfully marketed and sold through an efficient sales network.
- In situations of project failures, top management does a thorough analysis to pin point the root causes and plans a future course of action by consensus.
- There has been extensive use of in-house innovation discussion forums (Kaizen Programs) for improving product features on a continuous basis.
- The company has adopted clear Vision and Mission statements.

Vision Statement: *To produce cost competitive and high quality innovative tools in a safe and motivating work environment, so that the brand 'PYE' is perceived as synonym to quality tools, globally.*
Mission Statement: *To build confidence in end users by using quality tools that increases their efficiency and extrapolates company's brand equity worldwide.*

These statements effectively communicate the management philosophy, future objectives and goals of the organization to the employees.

Support Infrastructure Issues

- Pliers section (established in the year 1994), Pipe Wrench section (2000), Wire Cutting section (2001), and Grinding and Polishing section (2007), exist as separate dedicated facilities.
- Separate 'Inspection and Testing' section (established in 2008) exists for mechanical and metallurgical examination of raw material and finished products.

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SITUATION	PROCESS
• **Competition:** Companies which were mainly into exports have started penetrating into domestic markets, owing to lesser incentives being offered now in exports. • **Physical Infrastructure:** Shortage and high cost of electric power are the most important factors impairing performance of industry. Electricity is available only for 6-8 hours (on average) daily. Alternative sources of electricity have to be used. • **Government Role:** Government laboratories lack in latest machinery and equipment etc for experimentation, testing and analysis. • Government laboratories do not complete the work/ project assigned by industry on time. Moreover, these do not change reasonably and are expensive.	• Visual inspection was replaced by Crack Detection Machine in June, 2005 for detecting cracks in products. • Oil-fired furnaces have been replaced by induction furnace which is environment friendly, reduces problem of scales, and results in better productivity. • The company invests between 2.5-5 percent of annual turnover in research and development projects. • The use of automatic tool changers and pallet changers to make the machines more productive is only to a small extent. • Consumables such as lubricants, welding electrodes etc are selected on a random basis and proper attention is not given to the required grade. • High interest rates and collateral requirements of financial institutions have been impediments in organization's effort to develop state-of-the-art research infrastructure. **Networking Aspects** • The manufacturing unit (PTL) obtains government support through 'Market Development Assistance Scheme' for getting exposure in international markets and exploring possible export opportunity of its products by exhibiting them in Trade Fairs under MSME India Stall. The company regularly participates in Canton Fair, China (latest participation was at Guangzhou, China from 15-19 October, 2009) and INDEE Exhibition, Brazil (latest participation was at Caxias do Sul, Brazil from 22-23 October, 2009). • The company also obtains the services of Indo-German Tool Room, Ludhiana for heat treatment facilities. The work relates to hardening and tempering treatment of moulds, blanking dies and broaches.

<table>
<tr><th>SITUATION</th><th>PROCESS</th></tr>
<tr><td>Government institutions do not arrange or sponsor training programs for employees of small scale sector.
Fluctuations in raw material prices are not being addressed properly by the government.
Trade Development Authority of India and state government organize trade fairs and exhibitions for small sector to exhibit their products.</td>
<td rowspan="3">The company obtains the services of Regional Testing Centre (RTC), New Delhi for standardization of products and calibration of metrological equipment. The unit also takes the services of Central Institute of Hand Tools, Jalandhar for calibration of all measuring and testing equipment.
The company seeks expert opinion from technical institutions in areas of modern manufacturing practices and optimal resource utilization.
The company also works in collaboration with Institute of Auto Parts and Hand Tool Technology, Ludhiana for improving Wire Cut/ EDM process.
These external agencies and institutions have time limitations, undertake only selected assignments (job limitations) and do not charge reasonably. But still, working with these service institutes has significantly contributed to the success of the company (PTL) in the area of technology development.
The company lacks in technical collaboration with any multinational or large scale manufacturing corporation to obtain guidance and support. There are no tie-ups even with any small scale unit. There is a lack of mutual trust among individual units to discuss common problems and share specialized knowledge to improve technology.
Government has set up several tool rooms across the country with support of UNIDO/ ILO or assistance from countries like Denmark and Germany. These tool rooms are equipped with sophisticated/ specialized machines (viz. CNC Wire Cutting, CNC Milling, Profile Grinding, Vacuum Heat Treatment etc.). The company (PTL) obtains help from Indo-German Tool Room, Ludhiana for heat treatment facilities and technical training of employees in CNC technology.</td></tr>
<tr><th>ACTORS</th></tr>
<tr><td>Top management and officials of the company.
Employees to manage changing needs of customers.
Strategic partners and dealer base of the company.
Vendors and other suppliers to PTL.
Reputed OEMs as demanding customers.
All customers through their suggestions and feedback.</td></tr>
</table>

Table 5.14 Status of Technology Input Success Factors at PTL (Key Inputs)

Key Parameter	Status
I. Manpower Competence and Management Commitment	
Availability and effectiveness of multi-skilled workforce	+ + − −
Experience and dedication of employees	+ + + +
Culture of experimentation and ownership feeling	+ + − −
Education level of employees	+ + + +
Recruitment process and job security	+ + − −
Career planning and wage rates	+ + − −
Knowledge of market conditions	+ + + +
Formal contractual relations with customers	+ + + +
Formal training of employees	+ + + +
Reward structure	− − + +
Use of cross functional teams	+ + + +
Awareness and use of IPRs	− − − −
Strength of R&D staff	+ + + +
Support in situations of project failures	+ + − −
International exposure to identify technology gaps	+ + − −
OVERALL STATUS	**Extremely Effective**
II. Technology Infrastructure	
Modernization initiatives	+ + + +
Specific earmarking of funds for technology development	+ + − −
Access to finance from external sources	− − − −
Use of defined financial strategy and analysis	+ + − −
Availability of latest production technologies	+ + − −
Availability of R&D infrastructure	− − + +
Expertise in heat treatment processes	+ + − −
Use of advanced metrological equipment	+ + + +
Utilization of available production capacity	+ + − −
Small and continuous automations	+ + + +
OVERALL STATUS	**Moderately Effective**
III. Regulatory Support	
Availability of raw materials at reasonable prices	+ + − −
Availability of good quality physical infrastructure (electricity etc.)	− − + +
Financial support by government institutes	− − + +
Effectiveness of government support mechanisms	− − + +
Tax policies and labour laws to support upgradation initiative	− − − −
OVERALL STATUS	**Less Effective**
IV. Interaction with Others	
Active collaboration with other hand tool units	− − + +
Mutual trust and cooperation with other units to share specialized knowledge	− − + +
Technology support from large scale manufacturing units	− − − −
Industry-institute interaction for technology upgradation	− − + +
Infrastructure at technical institutions to meet training needs of industry	− − + +
Interaction with external research institutions	+ + + +
Support from service institutes	+ + + +
OVERALL STATUS	**Extremely Effective**

(+ + + + Extremely Effective; + + – – Moderately Effective; – – + + Less Effective; – – – – Extremely Ineffective)

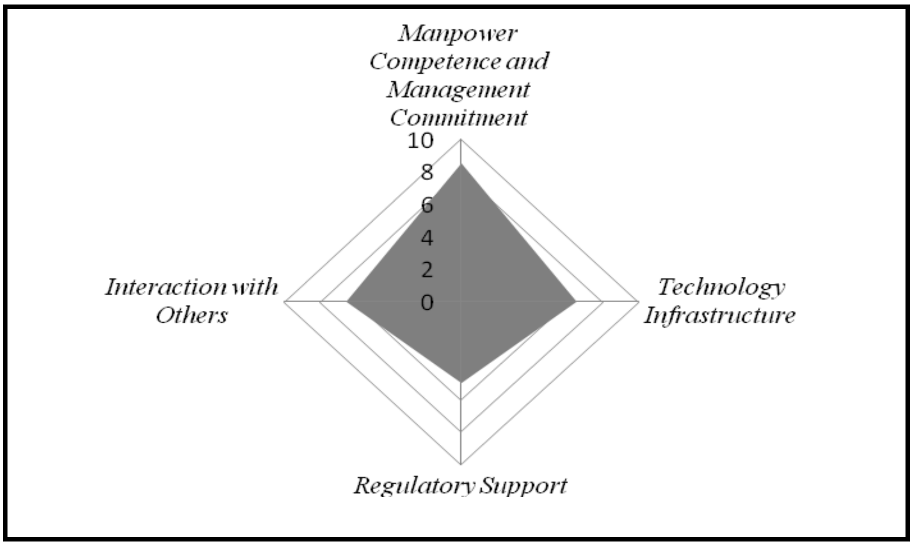


Figure 5.7 Status of Technology Input Success Factors at PTL (Key Inputs)

The status of output performance parameters *(Development Indicators)* at the manufacturing unit is presented in Table 5.15 and depicted in Figure 5.8.

Table 5.15 Status of Development Indicators at PTL (Key Outputs)

Key Output Issues	**Status**
Research Output (Development Indicators)	
Process technology in use	+ + − −
Use of specific product innovation strategies	+ + + +
Commercialization of R&D outputs	+ + − −
Product range and variants	+ + + +
Cost effectiveness of products	+ + − −
Use of well defined R&D policy	+ + + +
Dedicated R&D cells for specific areas of expertise	+ + + +
Quality leadership	+ + + +
Formal research groups in developing innovations	+ + − −
Marketing management strategies	+ + + +
Sales and service network	+ + + +
Project management	+ + + +
Increase in product mix over the years	+ + + +
Efforts for change and innovation	+ + + +
OVERALL STATUS	**Moderately Effective**

(+ + + + Extremely Effective; + + − − Moderately Effective; − − + + Less Effective; − − − − Extremely Ineffective)

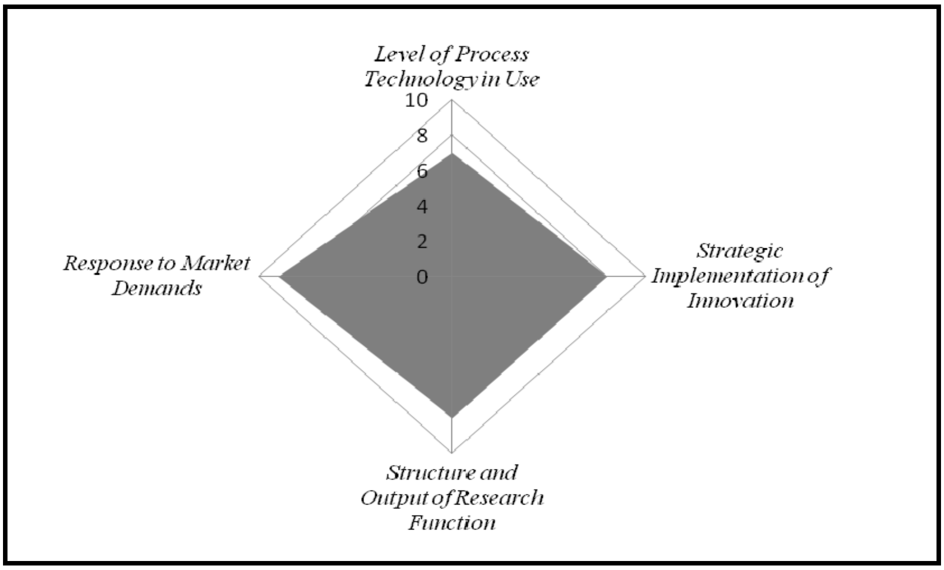


Figure 5.8 Status of Development Indicators at PTL (Key Outputs)

5.9 LAP Synthesis at PTL

This section presents the L-A-P (Learnings, Actions and Performance) synthesis at 'Pye Tools Private Limited' (PTL).

5.9.1 Learning Issues

Based on the detailed study and analysis of initiatives taken by 'Pye Tools Private Limited' (PTL) for technology upgradation, the following learning issues have emerged.

Market Situation

- Under the changing economic scenario, small scale sector has both challenges and opportunities before it. The business can compete at domestic and international levels only if ideal investment in technology, production processes, R&D and marketing are made.
- There is a need to explicitly recognize and exploit the innovation potential of small units. This sector has the specific advantages of flexibility, concentration and internal communications for carrying out technological innovations.

Innovation Process

- The manufacturing unit (PTL) has acquired reputation for its ability to develop high quality products. Primarily, its ability to innovate new products has significantly contributed to its growth and reputation.

- The company works with a highly effective strategy of developing a market niche. This involves developing a product which, by virtue of its own features, is able to defend itself against any competitor in the sector, whatever their size. Personalizing the product and addition of appropriate options is all part of this strategy.
- Some employees of the organization are exclusively devoted to technological upgradation initiatives and the product innovation strategy is directed entirely by the needs of customers. As a result, the company has been able to climb-up the ladder of value-chain, produce high value items and grow in size over time.

Manpower Competence and Management Commitment

- PTL owes its competitiveness to the foresight and planning of its proprietors and subsequent acquisition of technology capability, product innovations, commitment to quality and deliverability.
- The flexibility of the unit, its simple organizational structure, and receptivity to changes are essential features enabling it to be innovative both within the organization and in external market.
- In-house training of labour and employees has been a continuous process. Training greatly compresses the time to acquire skills and achieves this condensation through a process involving careful analysis of job requirements; determination of skill needs; specification of objectives; and the design, delivery and evaluation of an instructional programme.
- The proprietors and senior employees actively participate in international events like trade fairs, exhibitions etc. The major objectives of participation are to exhibit company’s products, learn about latest development and develop business contacts. This initiative has significantly contributed to company’s exports and turnover.

Technology Infrastructure

- The manufacturing unit (PTL) lacks in availability of capital resources for modernization initiatives and development projects. It can avail term loans from ‘Small Industries Development Bank of India’ (SIDBI) through ‘Credit Linked Capital Subsidy Scheme’ (CLCSS) for technology upgradation. This scheme provides 15 percent capital subsidy on institutional finance for cost of purchasing capital equipment, acquisition of land for expansion, expenditure in obtaining quality certifications, and cost of improving packaging. The ceiling of capital subsidy under this scheme is ₹1.5 million.

- Timely availability of adequate finance crucially determines the survival and growth of small firms. Reserve Bank of India (RBI) has directed banks to meet working capital needs of small units at the rate of 20 percent of annual output (subject to annual upper limit of ₹20 million).
- The company makes limited use of software packages for product designing and modelling etc. Large investments in CAD/CAM techniques are needed for improved designing and manufacturing of hand tools.

Regulatory Support Issues

- Shortage and high cost of electric power are important factors impairing performance of the manufacturing unit (PTL). Uninterrupted power supply should be ensured to save large cost burden because of capital investment/ running expenses of stand-by generator sets.
- There are several government institutions (supported by Ministry of Micro Small and Medium Enterprises, MSME) to deal with small units in the country. At present, there is lack of coordination among these institutes and their activities overlap each other. The role of these organizations should be re-evaluated and clearly defined.
- Technology development in small scale sector has been the thrust of industrial promotion policy in the country. However, the efforts pursued for technology development have relied heavily on technology transfer rather than on in-house technological innovations. The focus of policy has been on removal of technological obsolescence through technology upgradation and modernization rather than technological innovation.

Interaction with Others

- The manufacturing unit (PTL) does not have technical collaboration with any large scale manufacturing enterprise. The proprietors do not realize that collaboration with large organizations can provide resources, in the form of finance and/ or expertise, as well as future sales and international opportunities.
- The company does not have tie-ups even with other small scale units. Promotion of inter-firm linkages is a critical issue deserving more recognition. The characteristics of a successful linkage include inter-firm cooperation; cooperation blended with competition; importance of local value systems, flexibility and innovative capacity; willingness to work together to resolve potential clashes of interest; and wide spread entrepreneurial spirit and ability.

5.9.2 Actions Suggested

The business initiatives taken up by PTL depict its success against competition. PTL has been the market leader (in Screw Drivers and Pliers product categories) and holds nearly 30 percent market share in organized portion of small scale sector in the region. If this pre-eminent position is to be maintained, the manufacturing unit has to continue with technological innovations.

Presence of good research infrastructure, use of specific product innovation strategies, extensive training of employees to remove skill deficiencies, and small and continuous automations through knowledge sharing by employees has helped the organization in building core competency and sustaining market leadership. Regular participation in international trade fairs and diversification to the garden tool sector for foreign customers has provided more international exposure and has helped the organization in identifying technology gaps and growth opportunities. All these initiatives taken by PTL have been quite effective and must be continued.

5.9.3 Performance Expected

The manufacturing unit should increase cost cutting measures and decrease overheads by effective utilization of its production resources. It should further enhance its technological competence by obtaining support from large scale manufacturing corporations (through technical collaborations or subcontracting relations). The company should obtain patents for its product innovations to prevent commercial exploitation of the same by unscrupulous competitors.

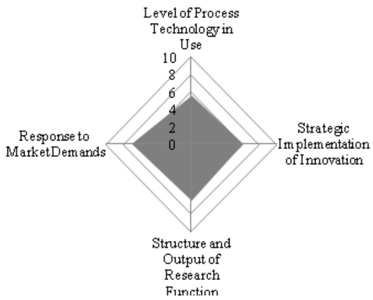
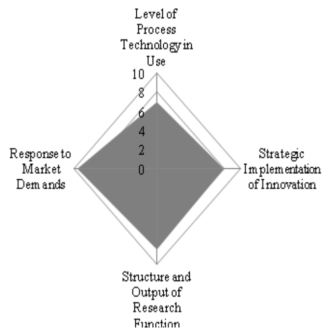
5.10 Comparison of Organizations in Managing Technology Upgradation Initiatives

This section compares the relative performance of the two organizations (STC and PTL, where case studies have been conducted) in managing their 'Technology Development Implementation Program'. The status of various key issues ('Technology Input Success Factors' and 'Development Indicators') in the organizations has been evaluated. Specific information related to commitment to business initiatives and performance, manpower competence and management commitment, technology infrastructure, interaction with other agencies, and various output performance parameters has been presented in the digest. The results of this comparative analysis are presented in Table 5.16.

Table 5.16 Comparison of Status of Technology Input Success Factors and Development Indicators

	SUPER HOBS AND BROACHES PRIVATE LIMITED (STC)	PYE TOOLS PRIVATE LIMITED (PTL)
A. Business Initiatives and Performance		
Product Category	Cutting Tools	Hand Tools
Product Mix of the Company	Gear Hob Cutters, Shaper Cutters, Saws, Shaving Cutters and Broaches	Screw Drivers, Pliers, Wrenches, Nippers, Hammers, Spanners and Garden Tools
Product Range and Variants	High	Very High
Price of Products	Extremely Cost Effective	Moderately Cost Effective
Customer Focus	Moderate	Very High
Efforts for Change and Innovation	Moderate	Very High
Social and Environmental Commitment	Emphasis on Employee Involvement and Knowledge Sharing; Social Security Schemes for Employees	Emphasis on Team Building and Knowledge Enrichment; Social Security Schemes; Eco-friendly Initiatives
Sales & Marketing Function	Not Very Effective Lack of Defined and Formal Procedure to Collect Information	Highly Effective Extensive Sales and Service Network
Quality Leadership	Moderate (ISO 9002)	Very High (ISO 9000-2004; CE Marking; ROHS Compliance)
Production Capacity	High (240,000 units/ annum)	High (90,000 units/ annum)
Specific Product Innovation Strategies	Low (Unsystematic approach towards Innovation)	Very High (Specific Strategies are Practiced)
In-house research and development efforts	Moderate	High
Vision &Mission Statement	Not Present	Present and Very Effective

	SUPER HOBS AND BROACHES PRIVATE LIMITED (STC)	PYE TOOLS PRIVATE LIMITED (PTL)
B. Manpower Competence and Management Commitment		
Availability and Effectiveness of Multi-Skilled Workforce	Very High	Moderate
Education Level/ Technical Know-how of Employees	Moderate	High
Formal Training of Employees	Low	Very High
Availability of R&D Personnel	Moderate	High
Cross-Functional Competence	High	High
Type of Reward Structure	Intrinsic Motivation Based	Extrinsic Motivation Based
Learning Environment	Based Largely on Experiential Know-how, Watching and Imitating	Based on Extensive Training, Innovative Efforts and Knowledge Sharing by employees
International Exposure to identify Growth Opportunities	Moderate	Very High
C. Technology Infrastructure		
Production Capacity	240,000 units/ annum	90,000 units/ annum
Manufacturing Competence	Specialization in Heat Treatment Processes; Use of Advanced Metrological Equipment; Very Effective Quality Control Function; Local Generation of Technology through Culture of Experimentation	Very Effective Production and Research Infrastructure; Small and Continuous Automations; Regular In-House Kaizen Programs
Modernization and Renovation Initiatives	Moderate	Very High
Financial Support to Research Initiatives	Low	Moderate

<table>
<tr><th></th><th>SUPER HOBS AND BROACHES PRIVATE LIMITED (STC)</th><th>PYE TOOLS PRIVATE LIMITED (PTL)</th></tr>
<tr><td>Availability of Dedicated Labs for Research and Analysis</td><td>To a Very Small Extent</td><td>To a Reasonable Extent</td></tr>
<tr><td>Main Barriers to New Technology Adoption</td><td>Company Policy; Skill Deficiencies for New Technology; Cost of Training and Education</td><td>Cost of New Technology Adoption; Ineffectiveness of Capital Subsidy Schemes</td></tr>
<tr><td colspan="3">D. Interaction with Others</td></tr>
<tr><td>Extent of Collaboration with other Industrial Units</td><td>Nearly Absent</td><td>Low</td></tr>
<tr><td>Extent of Industry-Institute Tie-ups</td><td>Low and Ineffective</td><td>Low and Ineffective</td></tr>
<tr><td>Networking with R&D Institutes</td><td>Very Limited Interaction</td><td>Highly Effective</td></tr>
<tr><td>Interaction with Service Institutes</td><td>Moderate
(Procurement of Raw Material and its Testing)</td><td>Highly Effective
(Calibration and Inspection Tasks; Heat Treatment Applications; Non-Conventional Machining Operations)</td></tr>
<tr><td colspan="3">E. Status of Development Indicators (Output Performance Parameters)</td></tr>
<tr><td>▪ Level of Process Technology In Use (Y1)
▪ Strategic Implementation of Innovation (Y2)
▪ Structure and Output of Research Function (Y3)
▪ Response top Market Needs (Y4)</td><td>
</td><td>
</td></tr>
<tr><td>OVERALL PERFORMANCE</td><td>MODERATELY SATISFIED</td><td>HIGHLY SATISFIED</td></tr>
</table>

5.11 Chapter Summary

Case studies have been conducted at two manufacturing organizations (Super Hobs and Broaches Private Limited; and Pye Hand Tools Private Limited) which are actors in the present research problem. The cases have been carried out in a phased manner and provide general information on company policies, product portfolio, customer details, growth and diversification plans etc. as well as specific information regarding business strategy decisions, milestones achieved, status of 'Technology Input Success Factors' and 'Development Indicators' in each organization. The case studies focus upon the step-by-step implementation procedure adopted by organizations towards achieving global competitiveness through management of innovation in research initiatives. In each case study, the practices and techniques adopted by organizations for technological improvements, success achieved and modifications made in the future plans have been complied. The main tools used for analysis of cases have been SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, SAP (Situation-Actor-Process) analysis and LAP (Learnings- Actions-Performance) synthesis.

It has been observed that the two manufacturing organizations have considerable variation in priority of objectives for managing the technology development program and as a result their status in accruing performance improvements is also appreciably different. This signifies the importance and contributions of 'Technology Input Success Factors' in achieving performance improvements ('Development Indicators') in manufacturing organizations.

The outcomes of case studies and survey based results are used in the next chapter for designing a technology development program for the manufacturing industry.

CHAPTER - VI

SYNTHESIS AND DESIGN OF TECHNOLOGY DEVELOPMENT PROGRAM

6.1 Introduction

This chapter presents a synthesis of learning issues and outcomes of survey and case studies and their utilization through a qualitative model to evolve a technology development program for small scale industry.

Qualitative modeling used in this study involved deriving expert opinion and using this along with findings of previous phases (literature review, survey and case studies) in a structured manner. For this purpose, experts were invited to participate in the exercise. The panel of experts was drawn from the participating industry and academic institutes. The detailed findings of previous phases were shared with the experts. A triggering question was asked, 'in the present scenario, how can technology development through in-house research initiatives be accomplished in the small scale sector?'

The present work uses four main techniques for modeling of the research problem. These include Options Field Methodology (OFM), Options Profile Methodology (OPM), Analytic Hierarchy Process (AHP) and Fuzzy Set Theory (FST) technique. The modeling began with a consensus methodological study in which modified idea writing was used to create a list of options as a solution to the present research problem. Initially, a large number of options emerged as a result of brainstorming by experts. The repeating options were removed. This resulted in independent options. These options were then categorized. Suitable names (dimensions) of the categories were decided by the experts. The dimensions thus made were clustered together based on their proximity and affinity to each other. Sequencing of clusters, dimensions and categories within clusters and options within dimensions were carried out to complete the Option Fields. The technique used for this purpose is called Options Field Methodology (OFM).

The next technique used in qualitative modeling was Options Profile Methodology (OPM). Here, various courses of actions (profiles) of the design were developed which can be employed to achieve the objective of technology development in small scale industry. Complete options profiles were generated by deriving options from each cluster.

The completed options profiles represented alternative approaches and courses of action to be adopted in each approach.

The next step in modeling was the use of Analytic Hierarchy Process (AHP). Here, various sub-objectives of the main objective of research problem were made by experts. Analytic Hierarchy Process was employed to decide the relative weightage of these objectives using paired comparison.

Finally, Fuzzy Set Theory (FST) technique was employed. This approach quantified, from the qualitative feedback provided by experts, the contribution of each profile towards each objective.

6.2 Synthesis of Learning Issues

The outcomes of previous phases (survey based empirical study and case studies) have been synthesized and presented in the form of issues in this section. These learning issues have been utilized to develop various options and courses of actions for qualitative modeling.

6.2.1 Market Situation and Business Strategy Issues

The learning issues related to this aspect are as follows:

- The ability of manufacturing organizations to acquire and deploy technology from outside sources can not sustain competitiveness over a longer period. Competitiveness depends upon the ability to create and then commercialize novel products and processes.
- Under the changing economic scenario, small scale sector has both challenges and opportunities before it. Small units can compete at domestic and international levels only if ideal investments are made in technology and R&D function.
- The main production characteristics in this category of small firms include:
  - inability to reduce cost of manufacturing because of high overheads and frequent increase in raw material prices
  - sub-optimal scale of operation
  - poor project management

- The main factors resulting in high input costs include
  - multiplicity and high level of taxes
  - high cost of capital
  - poor quality and excessive user charges of support infrastructure services
  - poor knowledge of market conditions
- Absence of large scale manufacturing industry in the region has also been a significant factor affecting performance of small units.
- Lack of formalized contractual relations with customers has also been a major deterrent. Industrial units have not been able to establish and maintain long term formal relationships with customers.
- Small units in the region have come up in an unplanned and uncontrolled manner. The units lack in reliable and efficient infrastructural facilities. It is essential to provide a level playing field to small enterprises through infrastructure development.

6.2.2 Manpower Competence and Management Commitment Issues

The learning issues related to this aspect are as follows:

- Availability of workforce with multiple-skill base has facilitated organizations to harness significant improvements in the level of technologies.
- Employees are encouraged to work in various departments and divisions in order to gain a well founded experience. The varied exposure helps in appreciating problems and pressures of different parts of the organization.
- Small scale units tend not to recruit from higher education sector because of financial reasons. There is dearth of qualified professionals in designing, overseas marketing and financial management.
- The system of contract based employment is a major deterrent to upgradation initiatives. There is little career planning even for permanent employees.
- Formal training to enhance innovation skills of employees has emerged as one of the lowest concerns for the organizations. The units remain insular and autonomous and fail to recognize the underlying or latent skill deficiencies.

- Inadequacy of R&D personnel has emerged as a key factor impairing efforts for technology modernization. Small units have to increasingly rely on external knowledge sources to build up technological competence.
- Majority of the units recognize contributions of employees through rewards, in case profits result from their efforts. However, reward schemes have failed to upgrade technology levels because they are largely based on extrinsic motivation tools (monetary awards) and not on intrinsic rewards (increased autonomy, more freedom to experiment etc.).
- Technological innovations require departure from routine activities and risk taking. Management should delineate the level of risks that employees can take safely. This helps them to define the space within which they are allowed to act in an empowered manner, and the occasions where they need to approach organizational ratification for engaging in actions.
- Project failures are generally discarded by the manufacturing units. Instead, the results should be stored for possible adoption at a later time.
- Active participation by a few organizations in international events like trade fairs, exhibitions etc has significantly contributed to their exports and turnover. The main objective of participation is to exhibit company's products, learn about latest developments in the field and develop business contacts.
- The proprietors lack in awareness regarding Intellectual Property Rights (IPRs). There is an urgent need to adopt patenting as a means to protect novel ideas and product innovations from being copied by competitors.
- Marketing function has not been performing effectively in the absence of defined procedures to collect information regarding customer needs.
- Proprietors of small units find it difficult to manage their human resources optimally because of the constrained laws. Instead of a plethora of labour laws, a unified law with simple provisions should be legislated.

6.2.3 Technology Infrastructure Issues

The learning issues related to this aspect are as follows:

- Majority of the organizations have shown a poor rating in terms of availability of state-of-the-art production equipment and machinery. The units also lack in facilities for experimentation and analysis for in-house research.
- Small units have been making very limited use of software packages for product designing etc. Large investments in CAD/ CAM are needed to improve product designs and production processes.
- Manufacturing units have been facing acute shortage of funds for development work. Access to finance from financial corporations and commercial banks has been a major barrier to innovation. There are bureaucratic hurdles in obtaining financial assistance. The cost of finance (particularly, interest rates for exports) is also very high.
- Lack of knowledge of employees regarding government (capital grant) schemes for small sector is also a major problem. Employees should submit proposals to obtain funds through these schemes for in-house research initiatives.
- Organizations have also shown lack of competitiveness when it comes to financial analysis or adopting a defined financial strategy.

6.2.4 Regulatory Support Issues

The learning issues related to this aspect are as follows:

- Government policies have been largely ineffective in assisting availability of raw materials at reasonable prices. Further, the units face difficulty in finalising long term contracts for exports in view of frequent changes in steel prices. To eliminate these problems, there has to be provision of a ‘Central Distribution System’ with concessions and duty benefits made available to such centres.
- Small firms lack in appropriate strategy to enter international markets. Government should identify sub-sectors with high export potential and formulate well planned strategies for them to enter international markets.
- Small units should be allowed to come up only in designated industrial areas or estates to enable efficient monitoring and provision of infrastructural facilities. State government along with industry associations should involve private sector in the development of infrastructure in existing industrial estates and permit provision of infrastructure services on payment.

- There are several institutions set up by the government (referred as, *Service Institutes* in the present work) to support small scale units. The functioning of these government subsidiaries has been largely ineffective because of lack of knowledge of personnel and too many formalities involved. Also, there is lack of coordination in these institutes and their activities overlap each other. The role of these institutes should be re-evaluated and clearly defined.
- There are several capital subsidy schemes formulated by government to promote technology upgradation in small scale sector. However, the benefits of these schemes have not reached the units because of following reasons:
  - tedious procedures and other bureaucratic hurdles in obtaining support
  - favouritism in disbursement of funds
  - lack of experience and knowledge of entrepreneurs to write proposals for obtaining capital grants
- To promote healthy competition, there is need to bring a greater degree of coordination between the centre and state governments and among the state governments themselves regarding policy issues and fiscal concessions being offered by different states.
- There is lack of organized official data pertaining to product innovations (of past years) in specific sectors. In the absence of this information, small units remain unaware of the latest developments in their field.
- Manufacturing units should be encouraged to submit information regarding production, employment, flow of working capital, term loans and performance on a quarterly basis. This information should be used in preparation of suitable policy measures for growth of the sector.

6.2.5 Interaction Issues

The learning issues related to this aspect are as follows:

- Innovative organizations choose to maintain their competencies only in selected core technologies and obtain additional capabilities through partnerships and alliances with other organizations, government laboratories, universities and R&D organizations.

- Collaboration with much larger organizations can provide resources, in the form of finance and expertise, as well as future sales and international opportunities.
- Study visits of entrepreneurs to various technically advanced manufacturing units in the country and developed nations can create awareness of prevailing technologies and latest manufacturing techniques.
- Industrial units have been facing difficulty in building credibility with a potential partner. Effective collaborations require sharing or changing of some established practices, and learning across different organizational cultures. Small units in the region have failed to adopt these measures.
- Inter-firm communication and cooperation have been cumbersome because of poorly developed physical infrastructure and an information-poor environment.
- Most of the manufacturing units have not experienced positive results through industry-institute collaborations. Small units and technical institutions in the region have lived and grown apart developing diverse views and wide communication gaps.
- Provision of expert lectures by academic professionals on upcoming key technologies has emerged as the most preferred interaction mode between industry and institutes for technology upgradation.
- Training of employees in specialized skills through short term courses, apprenticeship programs has also been considered as an important business initiative for effective industry-institute acquaintance.
- Formation of combined project teams (with members from industry and institutes) to work on research projects has also been considered significant in increasing technological capabilities of small units.
- Industrial ties with research institutes have contributed very little to technology modernization. This is because units have been collaborating with R&D establishments for solutions to production-maintenance problems and not for product-process innovations.
- Small units in developed countries depend greatly on ‘Regional Innovation Systems’ (RIS). RIS approach stresses on providing soft infrastructure (facilitating organizational change, qualification of human resources, supporting social capital etc).

This approach relies on interactive arrangements of horizontal and vertical character that assure appropriate information and knowledge transfer.

6.2.6 Research Output Issues

The learning issues related to this aspect are as follows:

- Technological innovation involves development and introduction of knowledge driven artifacts. The advantage of in-house technological innovation is that it can be firm specific and continuous.
- The process of innovation in small organizations tends to leave too much to chance. Majority of the units adopt an unsystematic approach towards product innovations. They are less effective when it comes to planning and implementing innovation, or to establishing formal research groups, or to allocating specific individuals to work exclusively on developing innovations.
- There are a few organizations which have been working with specific product innovation strategies and have been extremely successful.
- Small units have been very successful in developing small and continuous automations leading to process improvements.
- Adoption and implementation of a well defined R&D policy has been considered as a highly significant business initiative for affecting technological innovations.
- Small organizations have lacked in access to well researched database, whether it pertains to market intelligence or technology. There is need to provide this information proactively on a regular basis through a dynamic portal. There should be provision for small units to become members and obtain value added services on supply databases, market intelligence, technology providers and linkages with relevant institutions.
- Most of the R&D outputs do not get commercialized for want of initial investment and the needed enabling environment and networking.

6.3 Methodology of Modeling

The analysis of survey data and results of case studies have revealed a number of shortcomings in the working and systems of manufacturing organizations. A number of solutions have also been suggested. It is however difficult to implement all the suggestions. Therefore a need is felt for a methodology which generates alternate solutions to the problem and helps in choosing a set of most effective solutions. To meet this objective, a qualitative model has been developed in the present work using Options Field Methodology, Options Profile Methodology, Analytic Hierarchy Process, and Fuzzy Set Theory. A brief description of techniques used in modeling is presented in Figure 6.1 and discussed in the subsequent sections.

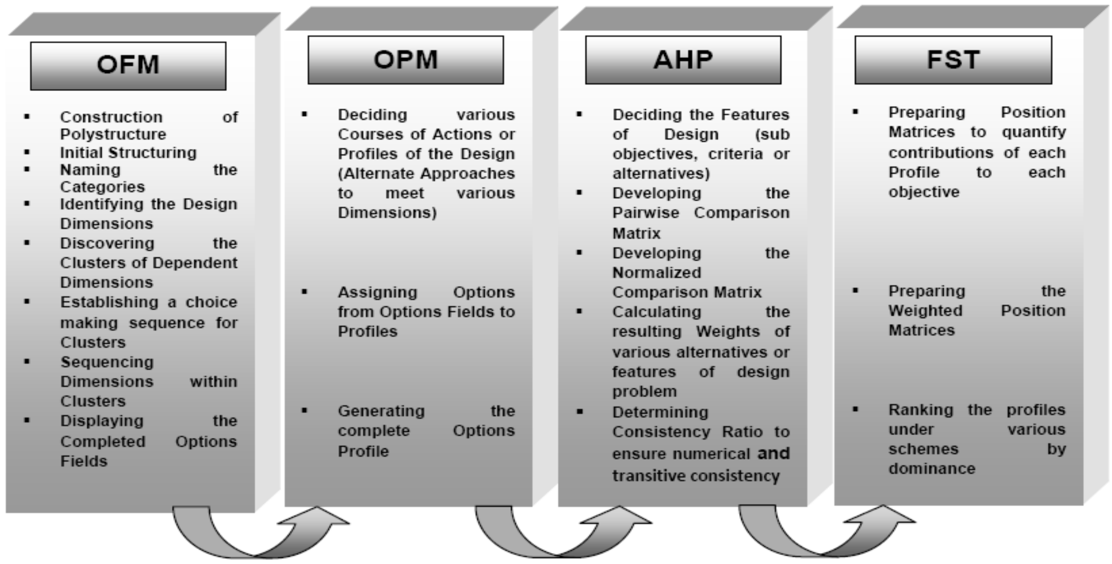


Figure 6.1 Techniques used in Qualitative Modeling

6.3.1 Options Field/ Options Profile Methodology

Qualitative modeling begins with listing of options using modified idea writing as a solution to the present research problem. The list of options is converted into a conceptual design. Options Field Methodology (OFM) and Options Profile Methodology (OPM) are largely used as a basis for this purpose. These techniques provide means for thorough development of the design situation, descriptions and design target description. They involve discovery and identification of dimensionality of the situation, and facilitate matching dimensionality of the target with dimensionality of the design situation (Warfield, 1979; 1982; 1990).

6.3.1.1 Options Field Methodology

The main steps in Options Field Methodology (OFM) are discussed as follows:

a) *Construction of a Polystructure*: The completed options field is a polystructure. Its construction begins with the generation and classification of a set of options. This set may be generated using modified idea writing in response to a carefully formulated triggering question. This question defines the context and must, therefore, reflect substantial insight into the design situation. The question must be neither too broad nor too narrow. It must stimulate creative and productive responses that do not stray from the research topic under consideration.

b) *Initial Structuring*: Once a set is developed, the initial structuring begins. The initial structuring is for placing the options into categories. A relationship that may be used for this initial structuring is 'in the same category as'. Theory of dimensionality is used for placing the options into categories. The structural theory of dimensionality of situations and processes introduces options field and options profile as byproducts of the design activity. Options field is a triply structured-quad. Its structure incorporates three distinct relationships described as '*membership in a dimension*' for classifying the options into dimensions, '*interdependence*' for classifying dimensions into interdependent clusters and 'time preference relationship' for relating dimensions to each other in clusters. Options field comprises of a four level structure (as shown in Figure 6.2), whose levels are named: Target, Clusters, Dimensions, and Options.

c) *Naming the Categories*: After placing them into categories, the options are displayed as sets, arrayed vertically in anticipation of developing a name for each category that is placed at the head of the appropriate column of options.

d) *Identifying the design Dimensions*: After the set of categories has been achieved, it is reasonable to believe that learning has occurred. At this point, it is appropriate to ask whether every category should be taken as a dimension of the design. The criteria for making this decision is to ask whether some option(s) in that category really must be specified in order to provide adequate definition of the alternative represented by choosing one or more options from each dimension, or whether any particular category is not essential to the definition of the target.

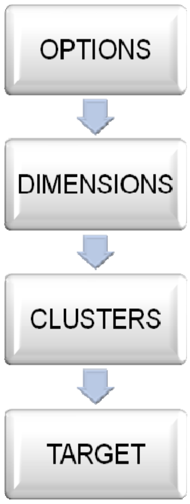


Figure 6.2 Options Profile Methodology Quad

e) *Discovering Clusters of dependent dimensions***:** Once the group has settled on the dimensions of the target, a second structuring occurs. Now the set of dimensions is structured. The relationship used is 'independent of'. Two dimensions are defined to be independent if a choice of one or more options in one of the dimensions does not rule out any choices in the other dimension. If two dimensions are interdependent, the choice of options in one may be restricted by the choice of options in the other. Following this structuring, there is a defined set of clusters, each cluster consisting of a set of dimensions, and each dimension consisting of a set of similar options.

f) *Establishing a choice-making sequence for clusters*: Now the third structuring begins. This structuring takes clusters as elements to be structured. The structuring relationship involves the sequence in which choices of options should be made. A suitable relationship is 'should be considered first in making choices of options'.

g) Sequencing dimensions within clusters: In this step, structuring is carried out separately for each cluster and initial decision-making sequence among dimensions in each cluster is defined.

h) *Displaying the completed Options Field*: It is then appropriate to organize the options field by placing dimensions in the order determined with name of each dimension heading a list of options therein and with the cluster clearly identified.

6.3.1.2 Options Profile Methodology

The next technique used in qualitative modeling is Options Profile Methodology (OPM). It comprises of the following main steps:

a) Deciding various courses of actions (profiles) of the design. These profiles represent alternative approaches which can be employed to meet various dimensions of the research problem.
b) Assigning options from options fields to profiles. This step involves generation of complete options profiles by deriving options from each cluster.

Options Profile is the visual representation of an alternative consisting of a set of chosen options with at least one option coming from each dimension in the options field. Each option that has been selected is designated by a line drawn from the bullet in front of it down to the tie line. In applications, it is common to construct several options profiles for a given options field. Each options profile represents one design alternative. In choosing options, choices are made in the sequence determined in formulating the way the options field is represented.

6.3.2 Analytic Hierarchy Process

The next technique used in qualitative modeling is Analytic Hierarchy Process (AHP). This technique provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions (Saaty 1980; Saaty and Vergas, 1982; Saaty and Kearns, 1985; Saaty, 1990). AHP decomposes the decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of hierarchy can relate to various aspects that apply to the decision at hand. Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another, two at a time. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of AHP that human judgments and not just the underlying information can be used in performing the evaluations. AHP converts these evaluations to numerical values that can be processed and compared over entire range of the problem. Finally, numerical priorities are calculated for each of the decision alternatives. The numerical rankings represent the alternatives' relative ability to achieve the decision goal.

The main steps involved in Analytic Hierarchy Process are as follows:

a) *Decide the 'Features of Design'*: Decompose the decision problem into a hierarchy of several sub-problems (alternatives or criteria or features of design) which can be evaluated independently.

b) *Develop the 'Pairwise Comparison Matrix'*: Suppose we get 'f' alternatives or features of design from the previous step. It is these alternatives whose relative importance to achieve the decision goal is to be determined using the AHP technique. In this step, a 'pairwise comparison matrix' is developed. It is a matrix of dimensions 'f x f'. The various alternatives or criteria are compared to each other in pairs and the subjective assessments are recorded in the matrix. The number (numerical rating) in the i_{th} row and the j_{th} column of this matrix gives the relative importance of i_{th} alternative as compared with j_{th} alternative. For example, in Table 6.1, 'a_{12}' is the numerical rating assigned to alternative 1 when compared to alternative 2. To complete the matrix, '$(f^2-f)/2$' values are needed. The assessor gives values (in cells) only in the upper part of the matrix (above the diagonal). The cells on the diagonal are assigned a value equal to 1, and values in cells under the diagonal are reciprocal of values filled in corresponding cells in upper part of the matrix (Frie and Harker, 1999).

Table 6.1 Pairwise Comparison Matrix

Alternatives (Features of Design)	1	2	…….	f
1	**1**	$\mathbf{a_{12}}$	…….	$\mathbf{a_{1f}}$
2	$\mathbf{a_{21}}$	**1**	…….	$\mathbf{a_{2f}}$
.	.	.	…….	.
.	.	.	…….	.
f	$\mathbf{a_{f1}}$	$\mathbf{a_{f2}}$	…….	**1**

In the matrix, one begins with an element on the left and compares how much more important it is than an element on top. When compared with itself, the numerical rating provided is one. When compared with another element, if it is more important than the other element, an integer value is used. If, however, it is less important, then reciprocal of the previous integer value is used. In either case, reciprocal value is entered in the transpose position of the matrix. Thus, only 'f (f-1)/2' judgments are considered. The scale used for pair wise comparisons in AHP is presented in Table 6.2.

Table 6.2 Scale for Pairwise Comparison

Judgment of Preference (Definition)	Explanation	Intensity of Importance (Numerical Rating)
Equal Importance	Two elements contribute equally to the objective	***1***
Moderate Importance	Experience and judgment slightly favour one element over another	***3***
Strong Importance	Experience and judgment strongly favour one element over another	***5***
Very Strong Importance	One element is favoured very strongly over another; its dominance is demonstrated in practice	***7***
Extreme Importance	The evidence favouring one element over another is of the highest possible order of affirmation	***9***
Intensities of **2, **4, 6**, and **8** can be used to express intermediate values*		

c) *Determine weights of each alternative:* Obtain weightage (relative importance to achieve the decision goal) of each alternative by using the following steps:

- Compute the sum of each column of 'pairwise comparison matrix' and divide each cell value in respective columns by the corresponding column sum. The resulting matrix is termed as 'normalized comparison matrix'.
- Compute the average value of each row of the 'normalized comparison matrix'. These average values are the resulting weights of various alternatives or features of the design problem (e.g. the average of first row is the resulting weightage of the first alternative).

d) *Check consistency of results:* An index of consistency, called *'Consistency Ratio'* is calculated to check if numerical and transitive consistency has been maintained. The results can be used to seek additional information and re-examine the data used in constructing the scale in order to improve consistency. This step begins with calculation of a parameter called 'Consistency Index' (C.I).

$C.I = (X_{max} - n) / (n-1)$ ------------- Equation 6.1

In equation 6.1, n is the number of elements being compared; X_{max} is the largest eigen value (it is the sum of products of each column sum (of 'paired comparison matrix') and respective row weights (of 'normalized comparison matrix').

'Consistency Ratio' (C.R) is obtained by the following equation.

$C.R = C.I / N$ ------------ Equation 6.2

In equation 6.2, N is the random consistency number. Its value depends on the size of matrix (number of alternatives under consideration). Table 6.3 provides values of random consistency number (N).

Table 6.3 Value of Random Consistency Number

Size of Matrix	1	2	3	4	5	6	7	8	9	10
Random Consistency Number	**0.00**	**0.00**	**0.58**	**0.90**	**1.12**	**1.24**	**1.32**	**1.41**	**1.45**	**1.49**

The value of 'Consistency Ratio' (C.R) should be less than 10% to be acceptable. If the value is not within this range, participants should study the problem and revise their judgment (Saaty and Kearns, 1985).

6.3.3 Fuzzy Set Theory

The next technique used in qualitative modeling is Fuzzy Set Theory (FST). This technique has been used to quantify the contribution of each profile (course of action) towards various objectives (features of design) and to rank the profiles under different situations.

Fuzzy Set Theory (FST) is based on the recognition that certain sets have imprecise boundaries. Fuzzy sets and sub-sets are those ill specified and non-distinct collection of objects which don't have sharp boundaries and in which transition from membership to non-membership is gradual rather than abrupt. A fuzzy set is characterized by a membership function, defined as a real number in the interval (0, 1). For example, a membership measure of X = 0.5 suggests that X is a member of set A to a degree 0.5 on a scale where 0 is no membership at all, and 1 is complete membership. Thus, fuzzy set can be reduced to a crisp set by transforming memberships to extremes of the range 0 or 1 (Zadeh, 1965). FST approach has successfully been applied to system analysis problems, decision theory, man-machine systems, modeling of industrial processes etc. In the present research work, it has been used for the purpose of ranking of options profiles in an integrated form with Analytical Hierarchy Process.

The fuzzy set methodology for multi-criteria decision making is used to analyze various options. The technique is designed such that quantitative and non-quantitative factors, and view points of the interest groups can be readily incorporated into the decision making process. Ranks of options in a group process are achieved through a dominance matrix designed for the purpose.

In order to represent the views of each of the interest group, a position matrix is prepared from the responses of all the experts in the group by giving numerical values to the qualitative assessment. Average value of each element representing the group response is worked out by multiplying membership function value of each alternative as given by the respondents with assigned weight (eigen vector weight as determined by AHP).This way some of the bias in the matrix is eliminated. The weighted matrices for each of the interest groups are thus, prepared. There are three ways to aggregate the weighted matrix viz. optimistic, average and pessimistic aggregation. The highest value among various group responses represents the optimistic value, the lowest value represents the pessimistic value and the average of all the values represents the average value.

Dominance Matrix (D) of dimensions 'n x n' is prepared to display the dominance structure between all possible pairs of options. The element 'd_{ij}' is the number of features for which membership value of option 'j' dominates or is greater than option 'i'. A dash is entered for the diagonal 'd_{ij}' element. If the K_{th} column is summed, the total number of dominances of option K over all options is obtained. Similarly, if the K_{th} row is summed, the number of times the K_{th} option is being dominated by all other options is determined. Outcomes that are more favorable have higher column sums and lower row sums. In cases where an option is very close to another option on the basis of aggregate weighted position matrix, the dominance among the options exists only if the membership value of second option is outside the specified limit. The options can be considered as equivalent with respect to that feature. This range may be set for each problem (for example ± 0.5 percent of the membership value) but should not be too large; otherwise a lot of information is likely to be lost. As in case of weighted position matrices, three dominance matrices namely optimistic dominance matrix, pessimistic dominance matrix and mean dominance matrix are prepared. The ranks of options are normally decided by examining the ranks obtained from extent of dominance and also extent of being dominated by other options. Although any of the optimistic, pessimistic and average approaches can be used but there are shortcomings in each. The best course of action for a decision maker in such a situation may be to use the Hadley's criteria of cautious optimism (Hadley, 1967). The decision maker may choose different coefficients of optimism (α). If 'A' is the dominance weight of the option as determined from optimistic matrix and 'B' that of the pessimistic dominance matrix, the weight of option according to Hadley's criterion is determined by the relationship:

$$W = \alpha \times A + (1 - \alpha) \times B \qquad \text{------------ Equation 6.3}$$

Since the process of choosing the coefficient of optimism (α) in Hadley criterion of 'Cautious Optimism' is a judgment based approach, ranks of options from the dominance matrix are considered on the basis of dominance and ignoring the considerations of being dominated.

6.4 OFM based Modeling

The learning issues synthesized in the previous chapter have been structured here to convert them into options of the Options Field Methodology (OFM). A total of 209 options were initially proposed by the experts as solution to the present research problem. Some of these options were overlapping. After scrutinizing and combining them, 114 independent options were made and the polystructure was completed. These options have been presented in Appendix – H and displayed in the completed options profiles in Figure 6.3.

6.4.1 Putting the Options into Categories

These options were then put into various categories and the categories were named. The categories are:

- Innovative and knowledge driven products
- Improved project management and production skills
- Defined financial strategy
- Adequate level of project resources
- Well structured reward schemes
- Adequate strength of R&D staff
- Job security and career planning for employees
- Formal research groups to work exclusively on innovations
- Project based approach for product innovations
- Competencies only in core technologies and additional capabilities through alliances
- Collaborations with other small units for sharing specialized knowledge
- Collaborations with larger firms for finance and expertise
- Mutual reinforcing relationships with premier technical institutes
- Focus of academia on applied education and R&D, linked to industry needs

- Collaborations with research institutes for technology transfers
- Integrated tax structure to reduce multiplicity and high level of taxes
- Broad financial infrastructure and simple procedures for finance availability
- Good quality physical infrastructure at reasonable prices
- Planned strategies to enter international markets for sectors with high export potential
- Formal training to eliminate latent skill deficiencies
- Cross-functional teamwork
- High value customized products and wide product mix
- Long term contractual relations with customers
- Extensive sales and service network
- Education levels and technical skills of employees
- Examining latest technology trends and identifying gaps

6.4.2 Dimensions of the Design

The above categories were scrutinized to include them or exclude any of them for the design. All of these have been included and considered as dimensions of the design.

6.4.3 Clusters of the Design

The dimensions were put into broader categories called clusters. Eight main clusters have been identified in the present work through clustering of dimensions. These clusters are presented in the next section and shown in Figure 6.3.

6.4.4 Sequencing of Clusters

Following the clustering of dimensions, the clusters were put into sequence as per the importance of an area. The sequencing of dimensions within clusters was then carried out. The resultant clusters with sequenced dimensions are given below:

1. ***Business Strategy for Competitive Excellence***
   - *a.* Innovative and knowledge driven products
   - *b.* Improved project management and production skills
   - *c.* Defined financial strategy

2. ***Organizational Support***
    a. Adequate level of project resources
    b. Well structured reward schemes
    c. Adequate strength of R&D staff
    d. Job security and career planning for employees
3. ***Product Innovation Strategies***
    a. Formal research groups to work exclusively on innovations
    b. Project based approach for product innovations
    c. Competencies in core technologies and additional capabilities through alliances
4. ***Networking and Joining Hands***
    a. Collaborations with other small units for sharing specialized knowledge
    b. Collaborations with larger firms for finance and expertise
    c. Mutual reinforcing relationships with premier technical institutes
    d. Focus of academia on applied education and R&D, linked to needs of industry
    e. Collaborations with research institutes for technology transfers
5. ***Policies and Directives***
    a. Integrated tax structure to reduce multiplicity and high level of taxes
    b. Broad financial infrastructure and simple procedures for finance availability
    c. Good quality physical infrastructure at reasonable prices
    d. Planned strategies to enter international markets
6. ***Employee Involvement and Learning***
    a. Formal training to eliminate latent skill deficiencies
    b. Cross-functional teamwork
7. ***Market Responsiveness***
    a. High value customized products and wide product mix
    b. Long term contractual relations with customers
    c. Extensive sales and service network
8. ***Continuous Improvement and Development***
    a. Education levels and technical skills of employees
    b. Examining latest technology trends and identifying gaps

6.5 OPM based Modeling

In this phase of modeling, various profiles (courses of actions or strategies) are planned to meet various dimensions of the research problem. These profiles represent alternative approaches which can be employed to achieve different dimensions of technology development at the strategic level. The details regarding different approaches are discussed as follows:

1) **Strategic Stimulation based Approach (S_{ba}):** This approach focuses on building a conducive and supportive internal milieu to encourage and motivate employees for technology capability building of the organization. The course of action is based on the following:
   - Enhancing the technical know-how, managerial and production skillfulness of employees for faster technology commercialization.
   - Providing adequate management support and commitment to utilize human resources effectively for technology development initiatives.

2) **Technology based approach (T_{ba}):** This approach focuses on building an adequate research infrastructure for product and process innovations. The course of action is based on the following:
   - Providing adequate financial support to the research function.
   - Providing resources (latest production machines, labs for experimentation and analysis, materials, time etc.) for project work.

3) **Regulatory Environment based approach (R_{ba}):** This approach emphasizes on providing a supportive policy framework for technology development programs of small scale sector. The course of action is based on the following:
   - Broadening the financial, physical and technology infrastructure and ensuring their easy access.
   - Providing tax policies that encourage enterprises to invest in technological innovations.
   - Strengthening the capabilities of government subsidiaries for better professional support to industry.

4) **Nucleus based approach (N_{ba}):** This approach focuses on obtaining operational support and capabilities through alliances and interactive learning networks. The course of action is based on the following:
   - Forging a mutually reinforcing relationship with other manufacturing enterprises, technical universities, R&D institutes for co-developing advanced futuristic technologies.
   - Building strategic partnerships for finance, expertise and international opportunities.

5) **Mixed approach (M_a):** This approach uses a mix of features of the above profiles. It strategically utilizes the key elements of different profiles to implement required options to meet an objective.

After deciding upon various profiles, the next task has been to find out the options from each cluster contributing to each profile. The completed 'options fields' have been displayed in Figure 6.3 (enlarged view of Figure 6.3 attached after appendices). A tie line has been drawn on the bottom. Each option contributing to a profile has been joined to the tie line through its bullet.

Business Strategy for Competitive Excellence

- Develop and introduce knowledge driven products through in-house technological innovations
- Promote knowledge based entrepreneurial skills
- Set up short term and long term organizational goals
- Develop a market niche through creation of innovative products having distinct features
- Improve project management/ production skills for faster technology commercialization
- Adopt a defined financial strategy and allocate specific proportion of annual budget for research projects
- Reduce manufacturing costs by decreasing overheads and using value analysis techniques
- Take short term risks (Risky Research Strategy) for long term pay-offs
- Adopt patenting as a means to protect ideas and product innovations from being copied by competitors

COURSES OF ACTIONS (PROFILES)

- Strategic Stimulation based Approach
- Technology based Approach
- Regulatory Environment based Approach
- Nucleus based Approach
- Mixed Approach

Organizational Support

- Reduce contract based employment and provide job security to employees
- Maintain adequate strength of R&D staff to undertake technology development projects
- Introduce well structured reward schemes based on intrinsic motivation tools to recognize employee contributions
- Incorporate skill based learning and principles of market economy in education cycle to develop entrepreneurial skills
- Create a tolerant atmosphere in which mistakes are accepted as part of taking the initiative for product innovations
- Provide adequate level of resources (finance, time etc) for research projects to convert innovative ideas into successful commercial products
- Develop flexible manufacturing facility to adapt to changing market dynamics
- Increase investments in CAD/ CAM and software packages for improved product designing and modelling
- Encourage low cost automations for process improvements through indigenous efforts
- Implement quality system procedures
- Create a mechanism to evaluate cost of investments in R&D
- Obtain credit rating of the unit through 'Credit Rating Scheme' (to identify strengths, weaknesses etc.) for hassle free flow of credit
- Define the level of risks that employees can take safely

Product Innovation Strategies

- Use latest technology in products and processes to compete effectively
- Establish a separate research department with well defined R&D policy and procedures
- Utilize research function for innovations and not for production-maintenance problems
- Establish formal research groups or allocate specific individuals to work exclusively on developing innovations
- Formulate and practice specific product innovation strategies to increase effectiveness of research function
- Adopt a systematic project based approach for product innovations
- Acquire technology only when indigenous development costs are forbidding
- Maintain competencies only in core technologies and obtain additional capabilities through alliances with others
- Promote higher R&D spending for specialized scientific and technical expertise
- Attend workshops/ short term courses on IPRs to increase awareness of employees regarding patents
- Formulate 'Vision and Mission' statements for long term strategic decision making
- Ensure economic justification of the developed technology

Networking and Joining Hands

- Build longstanding strategic partnerships with key technology providers
- Bring large scale manufacturing sector to the region to provide operational support to small units
- Collaborate with larger firms for finance, expertise and international opportunities
- Establish mutual trust and credibility with other small units to discuss common problem and share specialized knowledge
- Educate employees to learn across different organizational cultures for effective industrial collaborations
- Develop an information rich environment and physical infrastructure to promote inter-firm communication
- Promote subcontracting relations with large firms through Sub-Contracting Exchanges (SCXs) scheme of government
- Forge a mutually reinforcing relationship with premier technical institutes
- Train employees in specialized skills through short term courses and apprenticeship programs at institutes
- Form project teams with members both from industry and technical institutes to work on research projects
- Encourage universities to reshape curriculum for fostering creativity, team working and perseverance
- Undertake projects to receive financial grants (from DST etc.) for providing institutional framework for R&D to small units
- Arrange expert lectures of academic professionals at small units on upcoming key technologies

Policies and Directives

- Implement a unified law (integrated tax structure) to reduce multiplicity and high level of taxes
- Broaden the financial infrastructure and simplify the procedures for finance availability
- Provide prompt information regarding various financial schemes through regular advertisements
- Make access to finance from banks and financial corporations easy by reducing interest rates
- Provide financial assistance (soft loans, grants) and professional support to units attempting commercialization of indigenous technologies
- Improve access to capital subsidy schemes of government
- Provide financial assistance to units for obtaining quality system certification
- Grant custom duty exemption on capital equipment/ materials for R&D projects
- Develop a unified labour law with simple provisions to reduce constrained relations between employer and employees
- Develop a 'Central Distribution System' for raw material availability at reasonable prices
- Restrict frequent changes in steel prices to allow units to finalize long term contract for exports
- Allow units to come up only in designated industrial areas in a planned and controlled manner
- Provide good quality and reliable physical infrastructure at reasonable prices
- Ensure continuous and reliable supply of electricity at reasonable prices

Tie line

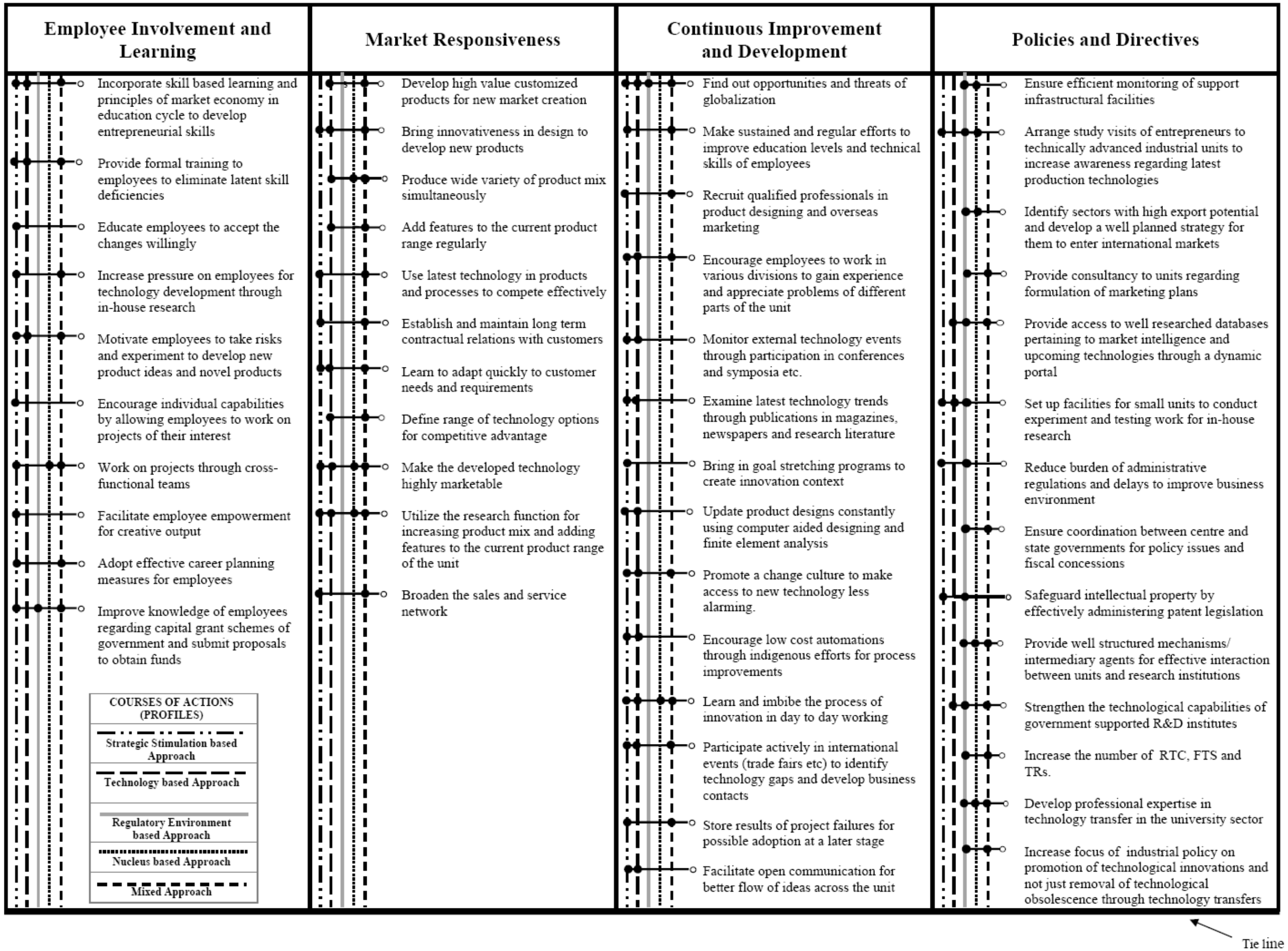


Figure 6.3 Completed Options Profiles

6.6 AHP based Modeling

The next step in modeling is the use of Analytic Hierarchy Process (AHP). Here, the decision problem (main objective of research problem) is decomposed into a hierarchy of sub-problems (sub-objectives or goals) by the experts. The sub-objectives formulated by the panel are as follows:

Goal A. To make the industry receptive (and interested) to participate in technology development initiatives through in-house research efforts.

Goal B. To develop skills of creativity and innovation among employees of small scale industry.

Goal C. To create an environment within the industrial units conducive to technological innovations.

Goal D. To create an enabling environment in the whole industrial sector and society for technology development.

Goal E. To create a supportive policy framework to facilitate technology upgradation initiatives of industry.

Analytic Hierarchy Process (AHP) has been employed to decide the relative weightage of these sub-objectives in achieving the overall objective of technology development in the industry. Paired comparison method of AHP has been applied to find the weightage of each goal. Three respondents participated in the process and compared each goal with another, independently.

The respondents included an industrial expert (Proprietor of Pye Tools Private Limited, Ludhiana); an academic expert (a Senior Professor of Industrial Engineering Department, National Institute of Technology, Jalandhar) and the researcher himself.

The 'pairwise comparison matrices', 'normalized comparison matrices', and values of eigen vector, consistency index, consistency ratio obtained against values filled by each respondent are provided in Appendix - I. The numerical ratings given by respondents were quite consistent and consistency ratio (C.I) was found well within permissible limits (less than 10%) in each case. The resulting weights of different goals as decided by various respondents using AHP is shown in Table 6.4.

Table 6.4 Weights of various sub-objectives using AHP

Respondents ⇨ Objectives ⇩	**Researcher**	**Industrial Expert**	**Academic Expert**
Goal A. To make the industry receptive to participate in technology development initiatives through in-house research efforts.	**0.13**	**0.16**	**0.14**
Goal B. To develop skills of creativity and innovation among employees of small scale industry.	**0.26**	**0.26**	**0.24**
Goal C. To create an environment within the industrial units conducive to technological innovations.	**0.50**	**0.42**	**0.48**
Goal D. To create an enabling environment in the whole industrial sector and society for technology development.	**0.03**	**0.06**	**0.04**
Goal E. To create a supportive policy framework to facilitate technology upgradation initiatives of industry.	**0.07**	**0.10**	**0.09**

The results reveal that to achieve the overall objective of technology development through in-house research, it is most important to create an environment within industrial units conducive to technological innovations (sub-objective C). This refers to building an organizational culture which emphasizes that creative effort is a top priority and constantly guides employees to strive for innovation. Organizational structure should be such that it provides a mechanism for developing and sharing new ideas. Management should make strategic choices with regard to human resources and motivate employees through well structured reward schemes. Providing adequate level of resources, including people with necessary expertise, sufficient funds, material resources, systems and processes for work, and relevant information are also a part of this criterion. The decision to innovate must be backed by actions that build an environment in which employees are so comfortable with innovation that they create it.

The next criterion in order of importance is to develop skills of creativity and innovation among employees. A highly skilled and educated workforce is the key to increased competitiveness. Industrial units should create and maintain a learning environment by keeping knowledge and skills of employees up to date. Training and education programs should be operated extensively to identify strategies to face the competition. Small units should ensure that each employee spends at least some fraction of his payroll on training.

The next criterion is to make the industry receptive (and interested) to participate in technology development initiatives through in-house research. Industrial units should realize that in this era of globalization and liberalization, survival is possible only through indigenous technological innovations. Industry should be open to internal changes and put more pressure on employees to undertake projects for new product developments.

The next criterion in order of importance is to create a supportive policy framework to facilitate technology upgradation in small sector. Government should create the right economic, fiscal and regulatory framework within which innovation and entrepreneurship can prosper. Government assistance can basically be divided into two sub-groups: financial and technical. Financial assistance includes various forms of investment incentives and soft policy loans. It includes contributions in capital accounts and interests, financing at concession rates, guarantee concessions, etc or tax incentives. Technical assistance consists of human resource training, export promotion initiatives, and quality and technology programs.

The last criterion in order of preference is to create an enabling environment in the whole industrial sector and society for technology development. Here, the overall objective of technology development is achieved through networking and joining hands with others. This includes entering into alliances with large scale industrial units, other small units in the region, premier technical institutes, and research establishments etc.

The results have clearly indicated that internal capability (sub-objective: A, B, and C) is decisive for product innovations to emerge from small scale sector. External support (sub-objectives D and E) can only play a complementary role.

6.7 FST based Modeling

The next technique used in qualitative modeling is Fuzzy Set Theory (FST). This technique quantifies the contribution of each profile (course of action or strategy) towards various objectives (features of design) and ranks the profiles under different situations.

This stage of modeling starts with preparation of ‘position matrices’. In these matrices, the qualitative value of contribution of each profile towards each objective (goal) is decided by experts. Again, this exercise has been done by the three respondents. The position matrices are presented in Appendix – J. From the position matrices, the ‘weighted position matrices’ are determined. To obtain the weighted values, weight of each objective as determined earlier (through AHP approach) has been multiplied by value of each position of position matrix. The weighted position matrices are provided in Appendix – K. From the weighted position matrices, the ‘optimistic’, ‘average’ and ‘pessimistic’ weighted position matrices have been made using Fuzzy Set Theory. For optimistic matrix, the highest value of each position has been selected, for pessimistic the lowest values and for average matrix, the average values have been selected. Table 6.5, Table 6.6 and Table 6.7 show these values respectively.

Table 6.5 Optimistic Weighted Position Matrix

Profile ⇨ Objectives ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
Goal **A**	0.070	0.048	0.112	0.098	0.098
Goal **B**	0.234	0.182	0.130	0.130	0.182
Goal **C**	0.450	0.350	0.150	0.150	0.250
Goal **D**	0.018	0.030	0.054	0.042	0.042
Goal **E**	0.050	0.030	0.090	0.045	0.050

Table 6.6 Pessimistic Weighted Position Matrix

Profile ⇨ Objectives ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
Goal **A**	0.048	0.039	0.091	0.039	0.065
Goal **B**	0.168	0.078	0.072	0.078	0.120
Goal **C**	0.378	0.294	0.126	0.126	0.210
Goal **D**	0.009	0.009	0.015	0.015	0.015
Goal **E**	0.027	0.021	0.063	0.021	0.035

Table 6.7 Average Weighted Position Matrix

Profile ⇨ Objectives ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
Goal **A**	0.061	0.043	0.100	0.072	0.081
Goal **B**	0.212	0.127	0.093	0.109	0.144
Goal **C**	0.420	0.327	0.140	0.140	0.233
Goal **D**	0.013	0.017	0.035	0.028	0.026
Goal **E**	0.037	0.026	0.078	0.032	0.043

The manufacturing sector in the country, at present, is passing through a transition phase. A manufacturing revolution is underway in the Indian economy, spurred on by the increasing presence of multinational corporations and scaling up of operations by domestic companies. The country's manufacturing base, which is fourth largest among emerging economies, is among the fastest growing and has seen more investments as a proportion of Gross Domestic Product (GDP) than any other country except China. Also, India's obligation as a member of WTO to bring down tariff and non-tariff barriers provides a competitive environment for small scale sector. However, global competition has reached an unprecedented level and the country needs to develop its manufacturing sector in line with global leaders. Small scale sector in the region is facing stiff competition from high quality innovative products from Germany, China, Czech Republic, Korea and Taiwan. In such circumstances a pessimistic approach for designing a technology development program may not succeed. On the other hand, a purely optimistic approach may also not yield desired results because of the following reasons. Small units in the region lack in adequate physical and technology infrastructure. Government has formulated several schemes to facilitate technology upgradation but benefits have not reached the industrial sector because of lack of awareness and initiative of proprietors. Also there are bureaucratic hurdles and tedious procedures involved in accessing government support. Further, the current scenario in global market in terms of economic imbalances and manufacturing recession also puts a cap for implementation of a purely optimistic approach. In such a situation, a cautious optimism approach with relatively high degree of optimism may be employed.

The outcomes of weighted position matrices (Hadley's matrices of cautious optimism are provided in Appendix - L) computed at various degrees of optimism have been compiled and results are presented in Table 6.8. The results present the preferred strategies for achieving various sub-objectives (goals) under specific levels of optimism situation.

Table 6.8 Preferred Strategies under Cautious Optimism for achieving various Goals

Objectives ⇩	**Optimistic**	**80% Optimistic**	**60% Optimistic**	**40% Optimistic**	**20% Optimistic**	**Pessimistic**	**Average**
Goal **A**	R_{ba}-M_a-N_{ba}	R_{ba}-M_a -N_{ba}	R_{ba}-M_a -N_{ba}	R_{ba}-M_a -N_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -N_{ba}
Goal **B**	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}	S_{ba}-M_a -T_{ba}
Goal **C**	S_{ba}-T_{ba} -M_a	S_{ba}-T_{ba} -M_a	S_{ba}-T_{ba} -M_a	S_{ba}-T_{ba} -M_a	S_{ba}-T_{ba} -M_a	S_{ba}-T_{ba}- R_{ba}	S_{ba}-T_{ba} -M_a
Goal **D**	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a	R_{ba}-N_{ba} -M_a
Goal **E**	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}	R_{ba}-M_a -S_{ba}

The following observations have been outlined from Table 6.8.

- To make the industry receptive (and interested) to participate in technology development initiatives (Goal A), 'regulatory environment based approach' (R_{ba}) shows maximum contribution under various conditions of optimism. Government has been imploring enterprises of all kinds to embrace technological innovation as a matter of survival in the globalized, knowledge economy. A favourable regulatory environment helps in raising the awareness of benefits of innovation and adopting a progressive strategic management practice for technology upgradation. Also, to meet this objective, it is important that various (small scale) industry associations put pressure on manufacturing units to join hands and work in mutual collaborations for technology development. Thus, 'nucleus based approach' (N_{ba}) also significantly influences this objective.

- 'Strategic stimulation based approach' (S_{ba}) and 'technology based approach' (T_{ba}) primarily influence the development of creativity and innovation skills among employees (Goal B) and facilitate in creating an environment conducive to technological innovations (Goal C). Innovative organizations have a significant approach towards manpower development in order to achieve long-term organizational goals.
- 'Regulatory environment based approach' (R_{ba}) and 'nucleus based approach' (N_{ba}) are the preferred strategies to create an enabling environment in the whole industrial sector and society for technology development (Goal D).
- To create a supportive policy framework for facilitating technology upgradation initiatives of industry (Goal E), 'regulatory environment based approach' (R_{ba}) is the most preferred strategy. It is government which has to design and formulate an encouraging policy framework for small scale sector. The benefits of government schemes can reach industrial units only through awareness of proprietors and active participation of employees to access support through these schemes. Thus, 'strategic stimulation based approach' (S_{ba}) is also required to meet this objective.

The next step has been preparation of dominance matrices under different situations of optimism. Dominance matrix indicates the dominance of each course of action over its counterparts in meeting various criteria under a given condition of optimism. The cell value (numerical value entered in a cell for comparing two profiles) in the dominance matrix signifies the number of criteria in which one course of action dominates over the other. In the matrix, profile written on the top, dominates the profile written on the left. The column sum in each matrix helps in ranking the various courses of actions. Higher is the column sum for a given course of action (profile), more is its dominance over other profiles under a given situation.

The dominance matrices under conditions of pure optimism, pure pessimism, and average optimism are presented in Table 6.9 to Table 6.11.

In the optimism dominance matrix (Table 6.9), 'regulatory environment based approach' has emerged as the most preferred strategy for achieving the overall objective of technology development in small scale sector. 'Strategic stimulation based approach' and 'mixed approach' have occupied the second and the third positions.

Table 6.9 Dominance Matrix under Pure Optimistic Situation

Profiles ⇨ ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
S_{ba}	--	1	3	2	2
T_{ba}	4	--	3	3	3
R_{ba}	2	2	--	0	2
N_{ba}	3	2	3	--	3
M_a	2	1	3	0	--
Column Sum	*11*	*6*	*12*	*5*	*10*
RANK	**II**	**IV**	**I**	**V**	**III**

For a completely pessimistic situation, the 'mixed approach' is the most preferred situation followed by 'strategic stimulation based approach' and 'regulatory environment based approach' respectively.

Table 6.10 Dominance Matrix under Pure Pessimistic Situation

Profiles ⇨ ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
S_{ba}	--	0	3	1	3
T_{ba}	4	--	3	1	4
R_{ba}	2	2	--	1	2
N_{ba}	4	1	2	--	4
M_a	2	1	2	0	--
Column Sum	*12*	*4*	*10*	*3*	*13*
RANK	**II**	**IV**	**III**	**V**	**I**

The average dominance matrix shows 'mixed approach', as the most preferred strategy followed by 'regulatory environment based approach' and 'strategic stimulation based approach' respectively.

Table 6.11 Dominance Matrix under Average Optimistic Situation

Profiles ⇨ ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
S_{ba}	--	1	3	2	3
T_{ba}	3	--	3	2	4
R_{ba}	3	2	--	1	2
N_{ba}	3	2	3	--	4
M_a	2	1	3	2	--
Column Sum	*11*	*6*	*12*	*7*	*13*
RANK	**III**	**V**	**II**	**IV**	**I**

Dominance matrices for various degrees of optimism (80%, 60%, 40% and 20%) have been compiled in Appendix – M. The results of all these dominance matrices have been summarized in Table 6.12.

Table 6.12 Compiled outcomes of various Dominance Matrices

Degree of Optimism ⇨ Profile ⇩	**Optimistic**	**80% Optimistic**	**60% Optimistic**	**40% Optimistic**	**20% Optimistic**	**Pessimistic**	**Average**
	Rank under various degrees of Optimism						
S_{ba}	II	**II**	III	III	II	II	III
T_{ba}	IV	**V**	V	V	IV	IV	V
R_{ba}	I	**III**	II	II	II	III	II
N_{ba}	V	**V**	V	V	V	V	IV
M_a	III	**I**	I	I	I	I	I

In the present work, a cautious approach with high degree of optimism has been considered as most appropriate. Thus, dominance matrix with 80% degree of optimism has been considered as providing the most realistic industrial situation in the region (*highlighted in Table 6.12*). This dominance matrix has been used to identify preferred strategies for meeting the overall objective of technology development in small scale sector.

6.8 Preferred Approaches for Technology Development

The results indicate that 'mixed approach' is the most preferred course of action to solve the present research problem. 'Strategic stimulation based approach' and 'regulatory environment based approach' have occupied second and third positions respectively. 'Technology based approach' and 'nucleus based approach' have been the least preferred profiles.

To sum up, the following three strategies in order of their importance have emerged to be significant in meeting the objective of technology development through in-house research initiatives in small scale sector.

1. Mixed Approach
2. Strategic Stimulation based Approach
3. Regulatory Environment based Approach

6.8.1 Mixed Approach

The results of qualitative modeling clearly show that to facilitate technology upgradation in industrial sector, the most preferred strategy is 'mixed approach'. This strategy has also emerged as the second most preferred profile to meet majority of the sub-objectives (Goal A, Goal B and Goal E) of the research problem. For the remaining two criteria (Goal C and Goal D), 'mixed strategy' is ranked third.

'Mixed Approach' signifies that to meet the overall objective of technology development in small scale sector, a judicious mix of several courses of actions is required. Though, pure strategies (i.e. strategies other than the 'mixed approach') have been most beneficial in achieving specific sub-objectives (as discussed in Table 6.8) but to achieve the overall objective, 'mixed approach' has shown maximum contribution. Managing the strategic implementation of technology development program from a current state to a desired future condition is a complex process. The various goals and objectives must be fully understood and integrated into the strategic and business plans of the organization. To enhance the probability of success through such initiatives, a structured approach has to be employed. For this, performance evaluation is based on multiple inputs and multiple outputs. Since evaluation involves multiple inputs and outputs, it is a multi-criteria decision problem. Pure strategies have been effective in meeting individual criterion, but the overall objective of technology development through in-house research needs elements of various profiles and hence the 'mixed approach'.

6.8.2 Strategic Stimulation based Approach

'Strategic stimulation based approach' has emerged as the second most preferred strategy for meeting the overall research objective. It is also the most preferred profile to create an environment within industrial units conducive to technological innovations (Goal C) and to develop skills of creativity and innovation in employees (Goal B). However, for the remaining criteria (or sub-objectives), this approach has not shown a significant contribution.

'Strategic stimulation based approach' focuses on building a conducive internal milieu which encourages employees for technology capability building of the organization. It stresses on having appropriate systems and procedures which emphasize that creative effort is a top priority within the company and an organizational structure which provides a mechanism for developing and sharing new ideas. Creating and maintaining a learning environment by keeping knowledge and skills of employees up to date is an important element of this approach. Providing training to develop operative and intermediate level skills is also a crucial constituent of this strategy. It also focuses on developing multi-skilled workforce through job rotation programs to perform varied tasks. Employees should be encouraged to work in various divisions in order to gain a well founded experience and to appreciate problems of different parts of the organization.

The approach emphasizes on the need of making strategic choices with regard to human resources. Industrial units should explicitly strive towards the attraction, development and retention of creative talent and employ people with broader interests, who are eager to learn and prepared to take some risks. Providing job security and better career planning measures are also important constituents of this strategy.

'Strategic stimulation based approach' emphasizes on having in-house reward systems to recognize contributions of employees. An effective reward system motivates employees to take risks, generate new product ideas, experiment and develop new products. With 'strategic stimulation based approach', extrinsic rewards (i.e. pay hikes, bonuses, shares and stock options etc.) have to be present at a base level to ensure that individuals are at least comfortable with their salary. Beyond the base salary thresholds, innovation is primarily driven by intrinsic motivation (increased autonomy and improved opportunities for personal and professional growth).

The approach stresses that there should be freedom to experiment, and to challenge the status quo. A tolerant atmosphere should exist in which a few mistakes are accepted as part of taking the initiative. Individual capabilities should be encouraged by allowing employees to work on projects of their interest. Employees should know the amount of time and effort they can spend on their pet projects so that their routine operations are not made sub-optimal.

Industrial units should learn and imbibe the process of innovation in day to day working. Research department should be established as a separate division working with a clearly defined policy and specific product innovation strategies. Manufacturing units should develop a market niche by creation of innovative products having distinct features. They should offer a wide variety of product mix simultaneously and should add features to the current product range regularly. Finally, 'strategic stimulation based approach' emphasizes on establishing and maintaining long term contractual relations with customers.

6.8.3 Regulatory Environment based Approach

The results of qualitative modeling indicate that 'regulatory environment based approach' is the third most preferred strategy for achieving the overall objective of technology development in small scale sector. This strategy is also the most preferred profile for meeting majority of the sub-objectives of research problem. Thus, to make the industry receptive (and interested) to participate in technology development initiatives (Goal A), to create an enabling environment in the industrial sector and society for technology development (Goal D), and to create a supportive policy framework for facilitating technology upgradation initiatives (Goal E), 'regulatory environment based approach' has shown maximum contribution.

'Regulatory environment based approach' focuses on creating the right economic, fiscal and policy framework within which innovation based entrepreneurship can flourish. It stresses on the need to continually examine the policies, regulations and laws from the perspective of whether they support or constrain innovation. It emphasizes on the need of implementing a unified law to reduce multiplicity and high level of taxes. It also accentuates to develop a unified labor law with simple provisions to reduce constrained relations between employer and employees of small units.

The approach focuses on government's role in providing reliable and high quality physical infrastructure at reasonable prices. It stresses that small units should be allowed to come up only in designated areas to enable efficient provision and monitoring of infrastructural facilities. Private sector should be involved in the development and management of infrastructure and there should be provision of services on payment. Government should ensure availability of raw materials at reasonable prices and restrict frequent changes in prices to allow units to finalize long term contracts for exports. The strategy also focuses on bringing large scale manufacturing sector to the region to provide operational support to small units. Further, there should be proper coordination between the centre and state governments regarding policy issues and fiscal concessions being offered by different states.

'Regulatory environment based approach' stresses on the need of broadening the financial infrastructure, simplifying the procedures for finance availability, providing prompt information regarding various financial schemes, and making access to finance easy by reducing interest rates and collateral requirements. Resources (grants, soft loans) and professional support should be provided to manufacturing units attempting commercialization of indigenous technologies.

'Regulatory environment based approach' seeks to provide direct and practical support in execution of innovative projects and successful exploitation of their results by effectively administering patent legislation. It stresses on increasing government investments in universities to enhance industrially-relevant research/ training and provision of well structured mechanisms for effective interaction between industrial units and research institutions.

'Regulatory environment based approach' requires government to act as a facilitator of technical change and leveraging, working in collaboration with other stake holders rather than dictating policies from above.

6.9 Development of a Conceptual Framework

This section discusses the development of a conceptual framework representing main elements of the technology development program for small scale industrial sector. The framework is based on outcomes of earlier phases of work including literature review, sample based survey, case studies and qualitative modeling. It represents the linkage between essential components of technology development program and elaborates on their relative contribution in meeting the overall research objective. The framework is presented in Figure 6.4 (enlarged view of Figure 6.4 is attached after appendices).

The key inputs (Technology Inputs Success Factors) and output performance parameters (Development Indicators) have been shown in the conceptual model. 'Technology Input Success Factors' are the independent research constructs and 'Development Indicators' are the dependent constructs of the decision problem.

The model also depicts the overall objective of research problem having decomposed into a hierarchy of sub-objectives or goals. It further represents the relative weightage of these sub-objectives in achieving the overall research objective. For this, the sub-objectives have been shown in varying intensities of color, where darkness of color represents higher weightage of a sub-objective in meeting the main objective of technology development in small scale sector.

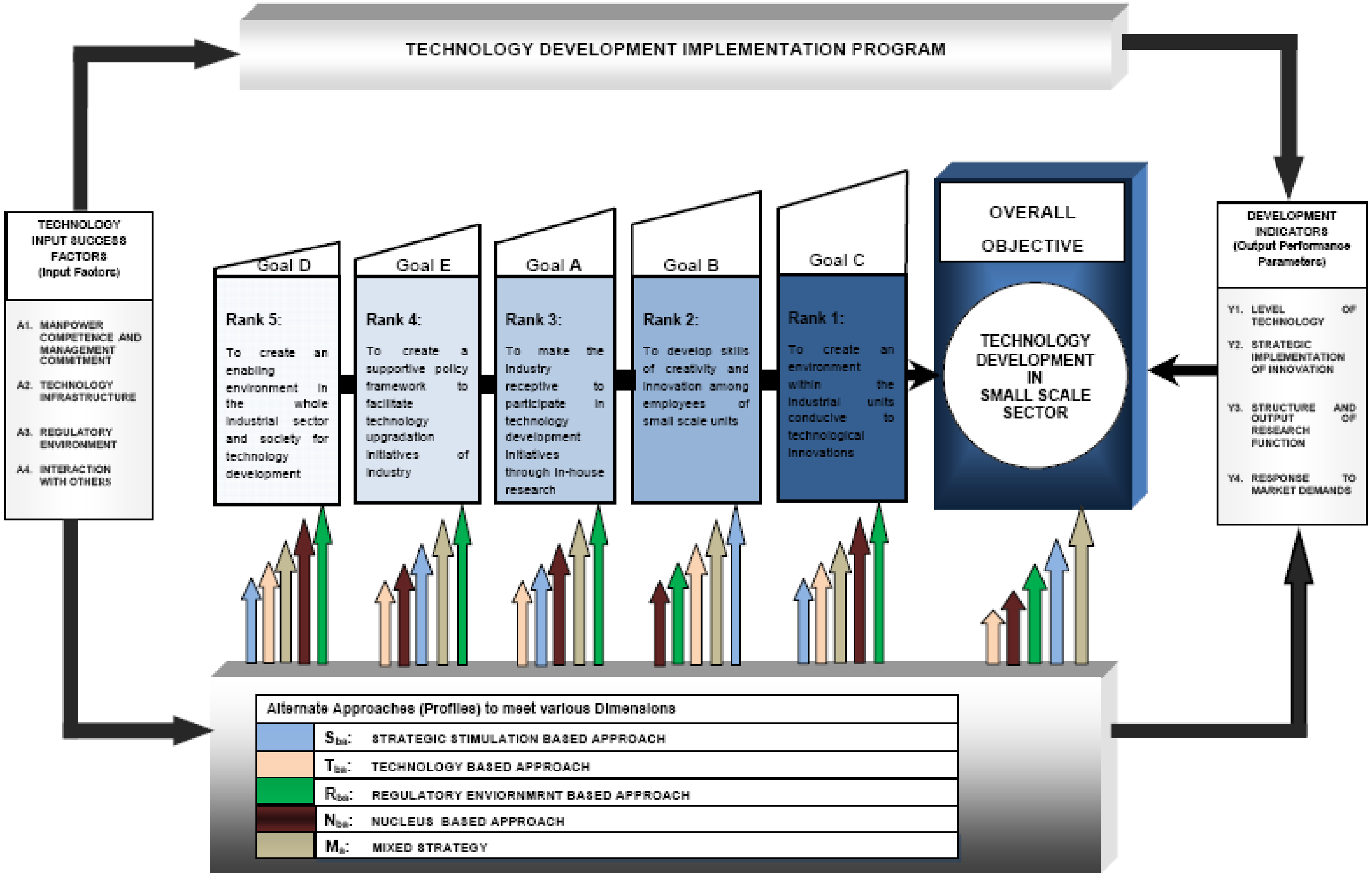


Figure 6.4 Technology Development Program for Small Scale Sector

Finally, the conceptual framework presents different profiles or strategies which can be used to meet various dimensions of the research problem. The model depicts the relative contribution of each profile in meeting different sub-objectives and also the overall objective under the realistic situation (of high degree of optimism, 80%). The contribution of profiles has been represented with the help of vertical arrows (vertically upward and colored arrows). The length of an arrow signifies the extent of contribution of a strategy in meeting a goal. Greater is the length of an arrow for a given goal, higher is the relative contribution of the profile it represents, in meeting that goal.

The conceptual framework indicates that to meet the overall objective of technology development in small scale sector, 'mixed approach' has shown maximum contribution and hence is the most preferred strategy.

6.10 Chapter Summary

This chapter presents a synthesis of learning issues of all previous phases (literature review, survey and case studies) of the research work. The outcomes have been utilized through a qualitative model to evolve a technology development program for small scale industry. Qualitative modeling involved deriving expert opinion and using this along with findings of previous phases in a structured manner. Four main techniques have been utilized in qualitative modeling. Options Field Methodology converted the learning issues into independent options (114 options were generated) as a solution to the research problem. Options Profile Methodology planned five different profiles or courses of actions to meet various dimensions of the research problem. Analytic Hierarchy Process decomposed the decision problem into a hierarchy of five sub-problems and decided their relative weightage in achieving the overall objective of technology development. Fuzzy Set Theory quantified the contribution of each profile towards various features of design and ranked the profiles under different situations of cautious optimism. Finally, a conceptual framework has been developed which represents the linkage between essential components of 'Technology Development Implementation Program' and elaborates on their relative contribution in meeting the overall research objective.

The findings of qualitative modeling are in the context of small manufacturing units of the region (state of Punjab in northern India), yet their implications and suggested management approaches are generic and can also be applied to industrial units in other parts of the country.

CHAPTER - VII
RESULTS AND CONCLUSIONS

7.1 General

This chapter covers the summary of research work and presents the results and conclusions. It also discusses the limitations and lists various areas which can be taken up for further research.

The summary has covered the methodology, tools and techniques used in the work. The results of survey, case studies, and qualitative modeling have been presented and major inferences and learnings drawn from them have been discussed. Based on the results and findings, conclusions have been drawn and recommendations have been made. The main limitations of the study have also been covered. Finally, the scope of present study for future work has been discussed.

7.2 Summary of the Research

The present work has been carried out with a purpose to analyze the technology development capabilities of industry through indigenous research initiatives and to develop an effective strategic technology development program for small scale manufacturing sector in the region. The study has been carried out under the overall framework of 'flexible systems methodology' which involves use of an optimal mix of qualitative and quantitative techniques of system analysis and design. The problem has been conceptualized as a SAP-LAP (Situation-Actor-Process; Learnings-Action-Performance) paradigm. In this framework, the 'situation' aspect comprises of the present industrial situation, whereas small scale units constitute the 'actor' aspect. The role of in-house research and innovation initiatives in building technological capabilities constitutes the 'process'.

Based on flexible systems methodology, the research work has been carried out in four phases. The first phase comprises of clarifying the context. In this phase, an extensive review of existing literature has been carried out on technology development capabilities of industry with regard to organizational cultural issues, investments in research function, infrastructure facilities, regulatory environment and strategies adopted for technology upgradation.

The second phase consists of understanding and assessing the situation. In this phase, an extensive (questionnaire based) survey has been conducted in manufacturing units that have successfully implemented or are in the process of implementing proactive technology innovation initiatives. For survey, a relevant and detailed questionnaire containing objective type questions with multiple choice answers pertaining to the desired conceptual framework was designed. To ensure the relevance and effectiveness of questions to the manufacturing industry, the questionnaire was pre-tested on a representative sample and suggestions received were incorporated. The survey instrument was mailed to 227 manufacturing units in the sample frame. A total of 91 responses were received and elimination of incomplete or unusable responses resulted in 83 cases. The survey has primarily been conducted through mails but personal visits have also been undertaken to the extent possible. The analysis has been carried out to assess the status of main factors impairing performance of small scale sector, to review the status of each component of technology development implementation program (TD Program), and to assess the overall standing of manufacturing units in different components of technology development. Further, correlation and regression analysis has been carried out to evaluate the contributions of technology development initiatives (technology input success factors) towards achieving manufacturing performance improvements (development indicators). For this, independent and dependent constructs (variables) have been formulated based on literature review and objectives of the research problem. The four distinct input constructs include '*manpower competence and management commitment*', '*technology infrastructure*', '*regulatory support*', and '*interaction with others*'. The output constructs comprise of '*level of technology*', '*strategic implementation of innovation*', '*structure and output of research function*', and '*response to market demands*'. Various statistical tools and techniques have been employed using SPSS software (SPSS 14.0) for analysis. Cronbach's Alpha coefficient has been used for convergent validity to assess the internal reliability of items (inter-item analysis) under each output parameter. To find the relationship between key inputs and key outputs, Pearson's correlation coefficient values (r values) between various input and output parameters have been calculated. The correlation values obtained have been further corroborated using t-test. Further, canonical factor loading analysis and multiple regression analysis have been performed. These tools describe the combined effect of multiple inputs on individual output variables.

The third phase involves conducting case studies for assessing the actor's capabilities. The purpose of case studies has been to analyze those aspects of management of technology development program which have been reflected as potential areas requiring further investigation. The case studies have focused upon the step-by-step implementation procedure adopted by organizations towards achieving global competitiveness through management of innovation in research initiatives. Case studies have been analyzed to determine the practices and techniques adopted by manufacturing units towards effective technology development and the results accrued by them through such programs.

The fourth and final phase of research work presents a synthesis of outcomes of survey and case studies for their utilization through a qualitative model to evolve a technology development program for manufacturing industry. Qualitative modeling involved deriving expert opinion and using this along with findings of previous phases in a structured manner. This phase has used four main techniques for modeling of the research problem. These techniques include options field methodology, options profile methodology, analytic hierarchy process, and fuzzy set theory. Finally, an implementation plan has been worked out to manage technology upgradation initiatives effectively in manufacturing industry. A conceptual framework has been developed which represents the linkage between essential components of 'Technology Development Implementation Program' and elaborates on their relative contribution in meeting the overall research objective under different situations.

7.3 Results and Major Learnings

The main results of present research work have been derived from the descriptive and empirical analyses of primary data collected through questionnaire based survey and the case studies.

7.3.1 Results of the Survey

The findings and learning issues from questionnaire based survey have been listed below:

Concerning general areas

- The response to survey has been 37 percent.
- The status of industry with regard to existence of facilities and programs for technology development through indigenous research efforts has not been very impressive.
  - A department entrusted with the task of research and development (R&D) activities exists in only 41 percent units. Well defined R&D policy for technology development is practiced in 18 percent units only.
  - State of the art infrastructure facilities for R&D are available in only one tenth of the manufacturing units.
- Inadequate government support to the industrial sector for technology development initiatives and use of old technology (lack of technology dynamism) to manufacture products have been the prime reasons decreasing competitiveness of small scale sector.
- Absence of large scale manufacturing organizations in the state of Punjab, shortage and high cost of electricity have also been major factors impairing the performance.

Concerning 'manpower competence and management commitment'

- Small scale sector has been doing fairly well (PPS = 73.42) with regard to availability of multiskilled workforce for performing wide-ranging tasks. Majority of the units have this workforce in adequate strength.
- Education level of employees has been helpful (PPS = 72.15) in enhancing their creative potential.
- Majority of the units (66 percent) do not provide formal training to employees to enhance creativity and innovation skills. 29 percent units provide training either during orientation period through senior executives or provide on-the-job training. Only 5 percent units have been providing formal training just after induction of employees into the organization.

- Inadequacy of R&D personnel has been a serious concern (PPS = 48.49). Majority of the units (74 percent) do not have R&D staff in adequate strength to undertake development projects.
- The level of encouragement to employees by senior management for undertaking research initiatives and obtaining patents has been very low (PPS = 42.77 only). In the last fifteen years, none of the units in the region has obtained a patent in a relevant technology.
- Most of the units have been adequately recognizing employee contributions (PPS = 75.00) in case profits are made because of their efforts. In 92 percent units, recognition is based on extrinsic motivation tools (fixed monetary reward, increment in salary or share in profits). In the remaining units, recognition is based on intrinsic motivation means (promotion in designation, more freedom to experiment etc).
- In situations of research project failures, management's role has been observed to be largely supportive. Most of the units (75 percent) counsel their employees to learn from current failures to improve for future and encourage them to continue with technology development efforts. 18 percent conduct a through analysis to find the root causes of failures. The remaining 7 percent are however not supportive and take strict action against members of project team when a failure occurs.

The average score of 'manpower competence and management commitment' component is 2.30 (out of 4.00). The analysis has revealed that formal training of employees, availability of scientific personnel, and use of patents to protect product innovations are critical areas needing improvement.

Concerning 'technology infrastructure'

- Majority of the units have only little financial support for technology development projects.
- Absence of modernization and renovation programs has been an important aspect preventing development. Only 16 percent units have been regularly implementing modernization and renovation measures on the shop floor.

- Most of the units (79 percent) do not have dedicated laboratories with facilities for experimentation and analysis. There are only 3 percent units which have proper R&D infrastructure.
- State of the art production equipment, machining centers, robots etc. are not available in most of the industrial units and thus a very low (PPS = 34.15) rating. Only 11 percent units have these facilities at a desired level.
- Nearly half of the units do not have latest software for drafting, designing, modeling etc. Another one third is using these only to a small extent. It is only less than one tenth of the organizations which work with state of the art software packages for R&D work.
- The strategic initiative of earmarking specific funds for research activities has to be strengthened. 78 percent units do not specifically allocate funds for research and development initiatives. There are only a few units (6 percent) where management clearly assigns funds for projects aimed at innovations for new product and process developments.
- The investments in research function by the industrial units have been very low (PPS = 37.19 only). Two thirds of the organizations do not spend even 0.5 percent of annual turnover on R&D. The number of units whose spending compares global standards is less than 4 percent.
- Small scale sector is not financially self-contained and largely depends upon support from other agencies for research and development activities. Despite this fact, for majority of the organizations (83 percent), the major source of funds has not been government or any other agency but the organization itself.

The average score of 'technology infrastructure' component is 1.97 (out of 4.00). The analysis has revealed that substantial improvements need to be affected for ensuring effectiveness of this component.

Concerning 'regulatory environment'

- Government has to make improvements (PPS = 57.59) in its policies to ensure availability of raw materials at appropriate prices. Most of the units (85 percent) have considered raw material prices to be high and significant in impairing performance.

- Availability and cost of electric power in the region has also shown a relatively low rating (PPS = 58.33). 65 percent units consider this factor as a major hurdle in their progress.
- Good transportation infrastructure in the region (PPS = 83.86) has played a vital role in increasing competitiveness of manufacturing industry. Government has performed fairly well as far as rail and road infrastructure in the region is concerned.
- Government has performed poorly (PPS = 33.13) in providing financial support to industry for technology development initiatives. 80 percent of the units have never received any financial grant from government institutions.
- Most of the industrial units have expressed their opinion that government should suitably reward entrepreneurs for contributions in the field of technological innovations. It should support industry by organizing seminars to increase awareness regarding upcoming technologies, provide labs for research work, and lend assistance in acquisition of imported technologies. Government should regularly sponsor employee training programs on skill development, new production techniques etc.

The average score of 'regulatory support' component is 2.67 (out of 4.00). Major improvements need to be made regarding effective deployment of various government support mechanisms in the manufacturing industry.

Concerning 'interaction with others'

- Small scale sector has remained greatly dependent on external help for its process technology needs. More than three fourths of the organizations have acquired almost all process technology from large scale Indian manufacturing units. About 5 percent units have depended largely on foreign industry.
- Industrial sector has shown an extremely poor rating (PPS = 30.72 only) with regard to interaction with external research institutes for technology development projects. Most of the units have never collaborated with external agencies. There are only 6 percent units where most of the product/ process technologies have been developed through collaborations.
- Small units have a mixed opinion with regard to creating and maintaining relationships with technical institutes for managing the changing demands of industrial society.

Nearly half of the units consider that interaction with regional academic institutes can solve their technology related problems to a large extent.

- Industry-institute interactions have failed (PPS = 31.33) to bring desired outcomes. 85 percent units have not experienced positive results through industry-institute interface programmes. Only less than one tenth of the units have successfully collaborated with regional technical institutions for technology development.
- More than half of the organizations have suggested that academic experts can prepare roadmaps to make research function an integral part of firm's working.
- Majority of the organizations consider that technical institutes can help manufacturing industry through expert lectures on upcoming key technologies. This seems to be the most preferred interaction mode (PPS = 73.80) by the industry.
- Formal training of employees in specialized skills through short-term courses and apprenticeship programs has been considered as an important feature of industry-institute acquaintance.
- Project teams comprising of members both from industry and technical institutions to work on projects of mutual benefits by sharing specialized knowledge has been regarded as an important interaction (PPS = 71.34) mode by majority of the organizations.
- Service institutions set up by the government have remained largely ineffective (PPS = 37.65 only) in providing support to small scale sector.

The average score of 'interaction with others' component is 2.31 (out of 4.00). The performance of industry in developing new products and processes through collaboration with academic institutes, research establishments, and service institutes has been below the desired levels.

Concerning 'research output'

- Most of the organizations have valued (PPS = 94.58) the fact that technology is the most important resource and the main driver of survival and growth.
- 82 percent units have considered technology development through indigenous efforts as the only option to face global competition.

- Industrial sector has appreciated the importance of technology as a resource for building competitiveness, but a lot needs to be done on the practical front. At present, not even one tenth of the units have been employing latest technology to produce products. More than one third has been producing products based on old technology.
- Manufacturing organizations have concurred that their over dependence on external sources has rendered their available technologies and skills incompetent and archaic.
- The performance of organizations in responding to market demands by increasing product mix and adding features to current product range has not been satisfactory (PPS = 54.52 and PPS = 54.82 respectively). Majority of the units (62 percent) have not increased the number of variants and type of products offered. Only one tenth of the units have increased their product mix or product features considerably in the last few years.
- The performance of industry in developing indigenous technology through in-house R&D has not been encouraging (PPS = 46.99 only). Nearly half of the industrial units have never developed any process or product technology in-house through indigenous research. There are only 8 percent units which have met their technology needs completely through indigenous technology development programs.
- The working of units has not been very effective in collecting data on customer requirements. 40 percent perform this job in a structured manner. Out of these, 28 percent have marketing function as a separate department and in the remaining 12 percent, a team of senior executives performs this job. In nearly one fourth, information is collected in an informal manner from the existing customers. The remaining (36 percent) units do not make any special efforts to collect information on customer needs.
- 18 percent of the units have formulated and adopted a well defined R&D policy. These organizations have largely developed their product technologies at their own and thus establish the importance of having a clearly defined policy for research function. Majority of the units (57 percent) have not been using a defined policy.
- Industrial units have been utilizing the research function for various errands. 42 percent tend to develop all new processes through in-house research efforts. About 39 percent tend to use it for developing new products. However, the units mainly use their

research initiatives to solve maintenance related problems (fire fighting of production problems) and not for technological improvements.

- 41 percent of the organizations have R&D function as a separate department. In 7 percent units, teams are formed by top management for specific research projects and in another 6 percent, design department is responsible for product innovations. The remaining (46 percent) units do not have a clearly defined structure for R&D function.
- The response of industry to the ‘risky research’ Japanese strategy for product innovations has been mixed. 58 percent of the organizations have been using this strategy to a large extent. The remaining 42 percent have not used this strategy much.
- Manufacturing units have obtained a low rating (PPS = 48.88) in the use of ‘imitation for creation’ strategy for technological innovations. 42 percent units have never used this thriving Japanese strategy. Another 37 percent have used it occasionally. It is the remaining one fifth of the units that have used this strategy more than often.

The overall score of ‘research output’ component is 2.61 (out of 4.00). There is an urgent need to utilize research initiatives for technological improvements rather than using them for solving production and maintenance problems. Further, effective implementation of strategic approaches for technology development and adoption of defined R&D policy can greatly improve the research output.

Concerning classification of manufacturing organizations

- The performance of organizations in ‘*manpower competence and management commitment*’ component has not been very encouraging with an average score of only 57.37%. More than one third of the organizations (34 percent) fall in *poor* category in this component. Only 1 percent of the units are in *good* category.
- The performance of organizations has been worst in ‘*Technology Infrastructure*’ component with an average score of only 49.68%. Most of the units (69 percent) are at a *poor* level in this component.
- The average score of organizations in ‘*Regulatory Support*’ *component* has been 66.87%. One tenth of the organizations are in *very poor* and one fifth in *poor* category as far as seeking government support for development activities is concerned.

31 percent units are doing *fairly well* and 37 percent fall in *good* category. 4 percent units are in *very good* class.

- The average score of organizations in the component '*interaction with others'* has been 57.89%. Not even one tenth of the organizations are at a *good* level in this component. 34 percent are in *poor* class and another 7 percent in *very poor* class as far as collaborating with external agencies for product innovations is concerned.
- The average score of organizations in '*research output'* component has been 65.22 %. 17 percent units are performing *poorly* in managing their research function. Most of the units (60 percent) are in the *fair* category and the remaining 23 percent are at a *good* level.

Results of correlation and regression analysis of survey

The main learnings from correlation and regression analysis of survey data are as follows:

Concerning 'manpower competence and management commitment' issues

- Availability of workforce with multiple-skill base (M1) to run manufacturing operations has facilitated organizations (r = 0.26) to harness significant improvements in the level of technology (Y1). It has also improved (r = 0.29) the firm's response to market demands (Y4).
- Higher education levels and better technical know-how of employees (M2) helps in upgrading (r = 0.21) technology levels (Y1) and in competing effectively (r = 0.22) in the global market place (Y4).
- The role of formal training (M3) has been statistically significant (r = 0.31) in proper implementation of technology strategies (Y2). Training (M3) also facilitates manufacturing organizations (r = 0.30) to harness significant developments through improved structure of the research function (Y3).
- Adequacy of R&D personnel (M4) for undertaking research initiatives has been influential (r = 0.25) in the realization of improved technology (Y1) and in responding (r = 0.21) to the changing customer requirements (Y4). It has also contributed effectively (r = 0.39) in improving the structure and output of research function (Y3).

- Reward schemes for innovative efforts (M5) and strategic implementation of innovation (Y2) are significantly associated (r = 0.29). The reward structure adopted by organizations to recognize innovation efforts of employees (M5) also improves (r = 0.21) the output of research function (Y3).
- Technological levels (Y1) and organization's response to market demands are significantly affected (r = 0.25 and r = 0.21 respectively) by the manner in which top management reacts in situations of project failures (M6).

Concerning 'technology infrastructure' issues

- Modernization and renovation programs for technology development (T1) significantly contribute towards improving (r = 0.52) the level of technology employed in organizations (Y1). These programmes also help (r = 0.53) in building core competencies for facilitating enhanced service to the customers (Y4).
- Availability of dedicated research infrastructure (T2) facilitates organizations (r = 0.25) to harness major technological improvements (Y1) through experimentation and subsequent analysis. The presence of adequate technology infrastructure (T2) significantly contributes (r = 0.30) towards improved structure and output of research function (Y3). It facilitates (r = 0.23) organizations in enhancing their product range and improving product features to respond to the market demands (Y4).
- Earmarking specific funds for development initiatives (T3) significantly improves (r = 0.21) the research output (Y3). Different activities of R&D function can be organized and utilized effectively if an explicit financial plan is apportioned for each.
- The investments made by organizations in their R&D function (T4) make a significant impact (r = 0.32) on realization of improved technology (Y1). Adequate financial support to development initiatives (T4) is also influential (r = 0.28) in improving organization's response to changing needs of the marketplace (Y4).

Concerning 'regulatory support' issues

- A significant association (r = 0.22) has been exhibited between availability of materials at appropriate prices (G1) and level of technology (Y1). Prices of basic inputs (G1) have also affected (r = 0.23) response of small scale sector to market demands (Y4).

- The subsidies provided by government to industrial units for development initiatives (G3) strategically contribute (r = 0.31) towards realization of improved process and product technologies (Y1).
- The role of support mechanisms (G4) has been statistically significant (r = 0.34) in improving the level of technology (Y1) and facilitating (r = 0.29) organizations in responding to the stiff competition (Y4). These mechanisms (G4) have also been very influential (r = 0.61) in effective implementation of strategic approaches for technology development (Y2).

Concerning 'interaction with others' issues

- Collaborations between manufacturing organizations for technological innovations (I1) have exhibited a significant negative correlation (r = -0.27) with level of technology (Y1). The results have indicated lack of mutual trust among manufacturing units to share specialized knowledge to improve technology.
- Collaborations with R&D institutions (I3) have exhibited a significant association (r = 0.39) towards implementation of strategic approaches for technology development (Y2).
- Collaborations with R&D institutes (I3) have also contributed effectively (r = 0.32) towards a more organized research function (Y3) in the industrial units.

7.3.2 Learnings from Case Studies

The main learning issues from case studies have been presented as follows:

Concerning 'market situation'

- Proprietors of small units realize the importance of technological innovation, but most of these still import or copy product technologies rather than developing in-house or through association with others. Small units have ignored R&D and have not embarked on new product development and technology upgradation.
- Small units in the region have come up in an unplanned and uncontrolled manner. The units lack in reliable and efficient infrastructural facilities such as power,

communication, information and technical inputs etc. It is essential to provide a level playing field to small enterprises through infrastructure development.

- Lack of formalized contractual relations with customers has also been a major deterrent. Industrial units do not establish and maintain long term formal relations with customers.

Concerning 'manpower competence and management commitment'

- The proprietors encourage their employees to work in various departments and divisions. The varied exposure helps the employees in appreciating problems and pressures of different parts of the unit.
- Small units have a tendency not to recruit from higher education sector because of financial reasons. Further, the system of contract based employment has been a major deterrent to upgradation initiatives. There has been little career planning even for permanent employees.
- Formal training has emerged as one of the lowest concerns. Manufacturing units have preferred external recruitment of experienced staff rather than training the staff internally.
- Inadequacy of R&D personnel has emerged as a key factor impairing efforts for technology modernization.
- Project failures are generally discarded by the manufacturing units. Instead, the results should be stored for possible adoption at a later time.
- Active participation by a few organizations in international events like trade fairs, exhibitions etc has significantly contributed to their exports and turnover. The main objectives of participation are to exhibit company's products, learn about latest developments in the field and develop business contacts.
- The proprietors have lacked in awareness regarding Intellectual Property Rights (IPRs). There is an urgent need to adopt patenting as a means to protect novel ideas and product innovations from being copied by competitors.
- Marketing function has not been performing effectively in the absence of defined procedures.

Concerning 'technology infrastructure'

- Manufacturing units have been facing acute shortage of funds for development work. Access to finance from financial corporations and commercial banks has been a major barrier to innovation. There are bureaucratic hurdles in obtaining financial assistance. The cost of finance (particularly, interest rates for exports) is also very high.
- Lack of knowledge of employees regarding various government (capital grant) schemes has been a major problem. Employees do not submit proposals to obtain funds through such schemes for in-house research initiatives.
- Organizations have shown lack of competitiveness when it comes to financial analysis or adopting a defined financial strategy. The strategic initiative of allocating specific funds for research projects aimed at innovations has not been adopted by most of the units.

Concerning 'regulatory support'

- Government policies for assisting availability of raw materials at reasonable prices have been largely ineffective. Further, the manufacturing units have been facing difficulty in finalising long term contracts for exports in view of frequent changes in steel prices.
- Small firms have lacked in appropriate strategy to enter international markets. Government should identify sub-sectors with high export potential and formulate well planned strategies for them to enter international markets.
- High cost of electricity with restricted and unreliable supply has been a critical factor impairing industrial performance.
- State government along with industry associations are not involving private sector in the development of infrastructure in existing industrial estates and are not permitting provision of additional infrastructure services on payment.
- Several capital subsidy schemes have been formulated by the government to promote technology upgradation in small scale sector. However, benefits have not reached the units because of tedious procedures and other bureaucratic hurdles involved in obtaining support.

- There are several government institutions to support small scale units. There is a lack of coordination in these institutes and their activities overlap each other. The role of these institutes needs to be re-evaluated and clearly defined.
- There is a need to bring a greater degree of coordination between the centre and state governments and among the state governments themselves regarding policy issues and fiscal concessions being offered to industrial sector by different states.
- There has been lack of organized official data pertaining to product innovations (of past years) in specific sectors. In the absence of this information, small units have remained unaware of the latest developments in their field.

Concerning 'interaction with others'

- The inclination and ability of small units to innovate has been linked to the extent to which they enter into interactive learning networks with other firms, their customers and suppliers, government laboratories, universities, and R&D organizations.
- Innovative units maintain competencies only in selected core technologies and obtain additional capabilities through partnerships and alliances.
- Small units in the region have remained dependent on large scale manufacturing organizations in the country rather than foreign firms for their process technology needs.
- Collaboration with large scale units provides resources, in the form of finance and expertise, as well as future sales and international opportunities.
- Study visits of entrepreneurs to various technically advanced manufacturing units in the country and developed nations creates awareness about prevailing technologies and latest manufacturing techniques.
- Industrial collaborations between small units in the region have remained ineffective because of lack of mutual trust to discuss common problems and share specialized knowledge. There has been lack of willingness to work together to resolve potential clashes of interest.
- Effective collaborations require sharing or changing of some established practices, and learning across different organizational cultures. Small units have failed to adopt these measures.

- Inter-firm communication and cooperation have been cumbersome because of poorly developed physical infrastructure and an information-poor environment.
- Manufacturing organizations have not experienced positive results through industry-institute collaborations. Small units and technical institutions in the region have lived and grown apart developing diverse views and wide communication gaps.
- Academic institutions in the region have lagged behind in clearly understanding the current and potential future needs of industry. They have neither shown interest nor inclination to market their resources and areas of expertise.
- Industrial ties with research institutes have contributed very little to technology modernization. This is because units have been collaborating with R&D establishments for solutions to production and maintenance problems and not for product-process innovations.

Concerning 'research output'

- Small firms have been less effective when it comes to planning and implementing innovation, or to establishing formal research groups to work exclusively on developing product innovations.
- The process of innovation in small units tends to leave too much to chance. Majority of the units adopt an unsystematic approach towards product innovations.
- In-house research and development efforts have not enabled manufacturing units to substantially increase their product mix or add features to their product range regularly. However, the units have been very successful in developing small and continuous automations leading to process improvements.
- Small units have lacked in access to well researched databases pertaining to market intelligence and technology. There is a need to provide this information proactively on a regular basis through a dynamic portal. There has to be provision for small units to become members and obtain value added services on supply databases, market intelligence, technology providers and linkages with relevant institutions.
- Most of the R&D outputs do not get commercialized for want of initial investment and the needed enabling environment and networking.

- Manufacturing organizations need to develop and implement a technology strategy in addition to financial, marketing and operational strategies and adopt the one that helps integrate operations with its environment, customers and suppliers.

7.3.3 Development of a Management Process

To achieve the overall objective of technology development in small scale sector, a management process has been developed using qualitative modeling in the present work. Qualitative modeling involved deriving expert opinion and using this along with findings of previous phases (outcomes of survey and case studies) in a structured manner. Four main techniques have been used for the purpose. The first technique called options field methodology generates a list of options as solution to the present research problem. It places the options into a set of categories and develops suitable names for each category. It identifies the dimensions of the target and puts them into various clusters. This is followed by sequencing of clusters and sequencing of dimensions within clusters. Finally the completed 'options fields' are displayed. In the present work, 114 options have been generated. The next technique used is options profile methodology. Here, various courses of actions (profiles/ strategies) of the design are developed which can be employed to achieve the overall objective of research problem. In the present work, five different profiles have been planned using this technique. These included, '*strategic stimulation based approach*', '*technology based approach*', '*regulatory environment based approach*', '*nucleus based approach*', and '*mixed approach*'. The various options generated through options field methodology are then allocated to these alternate profiles to complete the 'options profiles'. The completed options profiles represent alternative approaches and courses of action to be adopted under each. The next technique used is analytic hierarchy process. It decomposed the decision problem into a hierarchy of five sub-problems and decided their relative weightage in achieving the overall research objective. The fourth technique used for qualitative modeling has been fuzzy set theory. This approach has been used to quantify the contribution of each profile towards each objective and to rank the various profiles under different situations. For this, position matrices and weighted position matrices have been prepared. The weighted position matrices have been aggregated in three ways: optimistic, average and pessimistic aggregation. Following this, dominance matrices have been prepared to display dominance structure between all possible pairs of profiles. Based on these matrices, the ranks of various profiles under different situations of cautious optimism have been determined.

In the present work, a cautious approach with high degree of optimism has been considered as most appropriate. Thus, dominance matrix with 80% degree of optimism has been considered as providing the most realistic industrial situation in the region. The results have indicated that a 'mixed approach' is the key strategy to solve the present research problem. 'Strategic stimulation based approach' and 'regulatory environment based approach' have occupied the second and third positions respectively. 'Technology based approach' and 'nucleus based approach' have been the least preferred profiles.

7.4 Conclusions and Recommendations

This section presents the conclusions, in a digest form, in the light of research objective and results of survey, case studies and qualitative modeling. The following conclusions have been drawn:

- The process of technology development has been viewed as a multi-level and multi-dimensional concept rather than as an independent variable that can be defined and measured in isolation.

- The status of '*Technology Input Success Factors*' in the industrial sector has not been very satisfactory. Their average score in the surveyed industry varies between 1.97 (out of 4.00) for '*Technology Infrastructure*' to 2.67 for '*Regulatory Support*'.

- Small scale sector has not given adequate attention to the aspect of '*manpower competence and management commitment*' with the result that innovation and creativity skills of employees have not fully flourished.

- Employee training in small units has usually been adhoc and underlines poor attitude towards learning. The units have relied on their own experiential know-how, and train up their own operative and intermediate level skills. They have remained insular and autonomous and have failed to recognize the underlying or latent skill deficiencies.

- Most of the units have been adequately recognizing employee contributions. However, these in-house reward schemes have failed to upgrade technology levels as they have been largely based on extrinsic motivation tools (monetary awards) and not on intrinsic rewards (increased autonomy, more freedom to experiment etc.).

- The industrial sector has been doing fairly well with regard to availability of multiskilled workforce for performing wide ranging tasks. Majority of the units have this workforce in adequate strength developed through job rotation programmes.

- In most of the units, management's role has been supportive in situations of project failures. This is a good change but has failed to bring positive results. Employees have not responded favorably to this good gesture. They do not learn from past mistakes and experiences with the result that despite management support, technological levels have remained low.

- In the absence of any collective effort, industry has been finding it difficult to invest in R&D. As a result, *'technology infrastructure'* required for modernization and technology upgradation is not available up to the desired level.

- It is essential to provide the much needed 'level playing field' to small enterprises through availability of reliable and efficient infrastructural facilities such as power, transportation, communication, information and technical inputs etc.

- Technology infrastructure and resources are important not only for functional support but also because having an adequate level of resources for the research project influences workers perception that the project is valuable and worthy of organizational support.

- Government does have programs to support technology development initiatives in the industry. However, considering the size, structure, and growth pattern of small scale sector, the support being provided is quite inadequate. There is a need to broaden the financial infrastructure to take care of technological transformations of small units. Government's role has not been very effective in providing financial assistance (soft loans, equity and grants) to industrial concerns, attempting commercialization of indigenous technologies.

- Multiplicity of laws and frequent amendments has also created impediments in the way of growth. There is a need for a unified law to lessen grey areas in policy environment. Further, an integrated tax structure is needed to eliminate cascading indirect taxes.

- The efforts pursued by government for technology development in small scale sector have relied heavily on technology transfer rather than on in-house research and development initiatives. The focus of industrial promotion policy has been on removal of technological obsolescence and not on technological innovations.

- Small scale industry seems to be fighting its battle all alone in an unorganized manner. Either it has not sought support from educational institutes/ universities/ industry associations/ service institutes etc. or it has not been provided by these organizations whatsoever asked for.

- Majority of the manufacturing units have been working in isolation and not joining hands for technological improvements. Promotion of inter-firm linkages is a critical issue deserving more recognition. The characteristics of a successful linkage include inter-firm cooperation; cooperation blended with competition; willingness to work together to resolve potential clashes of interest; and wide spread entrepreneurial spirit and ability. The industrial collaborations between small units in the region have remained ineffective because of lack of mutual trust to discuss common problems and share specialized knowledge.

- Technical institutions have lagged behind in clearly understanding the current and potential future needs of small units. They have neither shown interest nor inclination to market their resources and areas of expertise.

- Industrial ties with research institutes have contributed very little to technology modernization. This is because units have been collaborating with R&D establishments for solutions to production-maintenance problems and not for product-process innovations.

- There is a need to explicitly recognize and exploit the innovation potential of small units. This sector has the specific advantages of flexibility, concentration and internal communications for carrying out technological innovations.
- The aim of small firms has frequently been to know how to refine, improve and vary technologies and products, rather than to reach new goals. This situation has diminished the capacity of small firms to extend and identify new technological boundaries.
- Five main profiles or strategies have been planned through qualitative modeling in the present work to meet different dimensions of technology development at the strategic level. Under the different economic and industrial conditions, different approaches can be applied. The first two profiles (*strategic stimulation based approach and technology based* approach) focus on building a conducive and supportive internal milieu to encourage and motivate employees for technology capability building. Both these strategies concentrate only on internal issues and thus are under the direct control of top management of the manufacturing enterprise. The next two profiles (*regulatory environment based approach and nucleus based approach)* are however more dependent on the external environment. The last profile (*mixed approach*) strategically focuses on a mix of features of various profiles.
- The results of qualitative modeling have shown that to facilitate technology upgradation in industrial sector, the most preferred strategy is 'mixed approach'. This approach needs to be applied in a phased manner. 'Mixed Approach' signifies that to meet the overall objective of technology development in small scale sector, a judicious mix of several courses of actions is required. There is a need to utilize the key elements of different strategies with more emphasis on internal factors (strategic stimulation etc.) and less on external factors (regulatory environment etc.). Ultimately, technological improvements and development have to come from internal factors. Though proprietors have been taking initiatives but response is not there because of lack of maturity.

- To achieve the overall objective of technology development through in-house research:
    - It is most important to create an environment within industrial units conducive to technological innovations. This refers to building an organizational culture which emphasizes that creative effort is a top priority and constantly guides employees to strive for innovation.
    - The next criterion is to develop skills of creativity and innovation among employees. Industrial units have to create and maintain a learning environment by keeping knowledge and skills of employees up to date. Training and education programs have to be operated extensively to identify strategies to face the competition.
    - The next objective is to make the industry receptive (and interested) to participate in technology development initiatives through in-house research. The proprietors need to widen their thinking horizon. They have to be open to internal changes and put more pressure on employees to undertake projects for new product developments.
    - The next criterion is to create a supportive policy framework. Government has to create the right economic, fiscal and regulatory framework within which innovation and entrepreneurship can prosper.
    - The last criterion in order of preference is to create an enabling environment in the whole industrial sector for technology development through networking and alliances with others. This includes entering into alliances with large scale industrial units, other small units in the region, premier technical institutes, and research establishments etc.

7.5 Limitations of the Study

The main limitations of the study are as follows:

- The work has been limited to small scale manufacturing organizations in the state of Punjab (in northern region of India). The study covers tool industry and auto-component units only.
- The study has been limited to industrial units which have direct customers in the market and are not ancillaries to larger corporations.
- Manufacturing organizations in the study have been treated alike, irrespective of the specific requirements of different sectors.
- The study has not focused on the linkages and externalities that give rise to clusters. As a result the role of cluster approach in technology upgradation of small units has not been covered.
- The item measures for various research constructs have been considered to be of equal weightage. However, under practical situations, some item measures may be contributing more towards a construct than its counterparts.
- No mathematical model or quantitative relationship has been derived to calculate the contribution of technology input success factors in achieving performance improvements.

7.6 Scope for Future Work

While carrying out the present study, a number of areas have come to focus, where detailed research can be taken up. These areas demand more exploration and analysis through further research. The scope for future work has been presented as follows:

- The study has been limited to small scale manufacturing units. It can be conducted for medium and large scale manufacturing organizations also.
- The present work has concentrated on manufacturing industry only. The work can be extended to other categories like process industry, service industry etc.
- Similar studies can be carried out for analyzing the impact of technology development practices on other competitive priorities like quality and cost individually.
- The item measures for various research constructs have been considered of equal weightage. The study can be extended by attaching appropriate weights to these item measures through qualitative techniques.

- All manufacturing units have been treated alike, irrespective of the specific requirements of various sectors. Minor changes might have to be incorporated for effectively managing technology upgradation initiatives in varying situations. Thus, sectors wise analysis can also be conducted for appropriately dealing with varying requirements of different sectors.
- Research can be extended further to compare the organizational cultures with regard to R&D and technology development practices in different industries viz. privately managed enterprises, joint venture companies, public sectors, and foreign subsidiaries in the country.

7.7 Concluding Remarks

Amongst the several problems faced by small scale manufacturing organizations in the region, technological obsolescence is one major predicament. The industry, in general, still lacks in an innovative environment in terms of infrastructure as well as policy support. It is appropriate to incorporate schemes in the existing policy and institutional network to provide technical and financial assistance to in-house technological innovations at the district levels and make it easily accessible to small scale industrial units. There is a need to create ‘research and development fund’ at the state levels for disbursement as margin money through District Industrial Centres (DICs) to small units for encouraging them to undertake formal R&D and technological innovations. Further, government should provide funds to engineering institutes which could provide institutional infrastructure for R&D or undertake development projects for small units at the regional level. However, it needs to be emphasized that technological transformation of the industrial sector is an enormous task and the government alone can not achieve the objective, however gigantic its infrastructure may be. Internal capability is decisive for product innovations to emerge from the industrial sector. External support can only play a complementary role. Therefore, major initiative has to come from industry itself, particularly through industry associations. The importance of ‘achieving and sustaining competitiveness in the long run’ and ‘investing self efforts and resources’ needs to be realized by the industry. This will play a crucial role in their long term development in future.

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APPENDIX-A

QUESTIONNAIRE

This questionnaire has been specially designed to collect information regarding various aspects related to R&D capability of Small Scale Manufacturing Industry (SSMI) of the state of Punjab, particularly the machine tool, cutting tool and the auto-component industry. The aim of this information collection is to assess the status of R&D in Small Scale Industry, find out the reasons of deficiencies, if any and develop strategies for improving the technology development capability for turning around the selected class of industry.

The questionnaire is divided into two sections; Section 1 solicits general information about the company, its products, location etc. Section 2 is designed to collect information regarding various aspects related to R&D capabilities. Most of the questions in both the sections are of multiple choice. Kindly encircle [O] the choice appropriate for your company in each question.

We assure that the confidentiality of the information provided by you will be maintained. It is hoped that the result of the study and the analysis being carried out by us will help the small scale industry of Punjab in improving their R&D capability to become more competitive.

SECTION 1

General information about the Organization.

Name of the Organization		
Address		
Name and Designation of the Respondent		
E-mail Address		
Phone Number(s)		
Fax. No.		
Type of Organization (Please Tick)	Cutting Tool Manufacturer	
	Machine Tool	
	Auto Component	
	Any Other (please specify)	
List of Main Products		
Year of Inception		
Annual Turnover		

SECTION 2

1. Which type of markets are served by the products made in your organization?
a) Local markets
b) Regional markets
c) National markets
d) International markets

2. The products made by your company compare well with
a) Imported products
b) Products made by best in India
c) Products made by best in region
d) Local products

3. In your range of products, are you
a) Market leader with highest percentage share
b) Among the first few market leaders
c) Have a reasonably large market share
d) Have a very small market share

4. Do the products (of same class and same price range) made by your company have features and quality
a) Better than your competitors
b) Almost at par
c) Slightly below
d) Appreciably below

5. Have your profits, in the last few years
a) Gone up considerably
b) Gone up marginally
c) Gone down marginally
d) Gone down considerably

6. Please tick the appropriate combination of percentage profit margins and the time period

Time Period	Profit Margins			
	Above 10%	5-10%	2-5%	Below 2%

7. Has the number of competitors
a) Gone up considerably in the last few years
b) Gone up marginally
c) Gone down marginally
d) Gone down considerably

8. Has the product-mix (number of models and types of products) offered by your company
a) Gone up considerably in the last few years
b) Gone up marginally
c) Gone down marginally
d) Gone down considerably

9. In the past few years have you succeeded in retaining the existing customers/markets (market share) with you
a) A great success
b) A satisfactory degree of success
c) Some success
d) No success worth mentioning.

10. If you are losing / have lost the market share, the main gainers are
a) Mainly in the state of Punjab
b) In some other states (mention the states, please)
c) Distributed in various states, including Punjab
d) No such analysis carried out.

11. Have the 'Product Life Cycles' reduced?
a) To a great extent
b) Reasonably
c) To some extent
d) Not at all

12. Are the customers demanding from you, products with new features?
a) Not at all
b) Occasionally
c) Usually
d) Always

13. Are your competitors introducing new and improved products at a faster pace?

a) All of them
b) Majority of them
c) Some of them
d) No, none of them

14. In the recent past, have you introduced rapid changes in features of the product in response to the market demand.

a) More than the competitors
b) Almost at par with the competitors.
c) Less than the competitors
d) Not many changes worth mentioning

15. Has the advent of liberalization and globalization brought economic and technological pressures on the organizations?

a) To a large extent
b) Reasonable
c) Somewhat
d) Not at all

16. If you agree that small scale industry (machine tool & cutting tool) in the state of Punjab has suffered , then out of the following which reasons are the most significant and least significant.

Factors	Most Significant	Very Significant	Significant	Least Significant
Inavailability/ Shortage of Raw Material				
High Prices of Raw Materials as compared to other States				
Shortage of Power and cost of Power				
Non-Availability of Multi-skilled Labour				
Use of obsolete Process Technology				
Shortage of Finance				
Poor Education Level and Technical Know-how of workers				
Underutilization of Capacity, Shortage of Orders				
Absence of Modernization and Renovation Programs				
Absence of Big and Large scale Industry in Punjab				
Competition from China and other countries because of liberalization and globalization				
Poor infrastructure of Roads and Rail Transportation				
Geographical Location				
Poor Marketing Management				
Lack of Government Support/ Subsidies				
Unorganized Sector				
Inability to reduce the Cost of Manufacturing				

17. In this competitive scenario, do you feel Technology is the most important resource to the organization and is the main driver for survival and growth?

a) Absolutely
b) To a large extent
c) To a small extent
d) To some extent

18. Do you feel that the over dependence of the Indian firms on external technology acquisition has rendered their available technologies and skills inefficient, obsolete and outdated?

a) Completely
b) To a large Extent
c) To a small extent
d) Not at all

19. Do you feel the need of doing in-house Research and Development (R&D) to develop new technology products and process?

a) Dire need
b) Appreciable need
c) Some need
d) No

20. Are you using the latest process technology?

a) Latest
b) Almost new
c) Not very old
d) Old

21. The process and product technologies being employed in the organization are

Source of Technology	Completely	Most of it	Partially	None
Acquired from abroad				
Acquired from within the country				
Developed in collaboration with some external agency				
Developed In-house through indigenous R&D				

22. Due to liberalization, the foreign firms, which used to sell their state of art technology to borrowing Indian firms, have now become their competitors. In such a situation, to meet the competition, which option do you recommend for your organization?

a) Technology development through in-house R&D to generate new products & processes
b) Still technology acquisition from external organizations to generate new products
c) Innovations in existing products and processes.
d) R&D through consortium/ joining hands

23. Do you have a marketing department/ a team or some defined strategies to gather information regarding the customer requirements in your product range.

a) A department/ team does this job
b) The owners and other senior officers do the job in a structured manner.
c) Some information is collected in an informal manner from only the existing customers.
d) No such special efforts are made

24. Does your organization have collaboration with some external organization for technology acquisition? If yes, what types of expenses are involved?

Expenses	Major Component	Large Component	Small Component	Nil
Royalty				
Recurring expenses in renewal of license				
Expenses in training manpower for the new acquired technology				
Expenses in adaptation of technology (changes in infrastructure)				
Recurring expenses in maintenance etc.				

25. Does your organization have a well-defined R&D policy?

a) No
b) Exercise started
c) Almost decided
d) Yes

26. For what purpose Research and Development activities are used in the organization

Activities	Wholly	To a large Extent	To a small extent	Not at all
Develop new processes				
Develop new products				
Solve maintenance related problems				
Improve product quality by suggesting new materials etc				

27. What type of infrastructural facilities are available for R&D work

Facility Available	Wholly	To a large Extent	To a small extent	Not at all
Dedicated labs with state of the art equipment etc for experimentation and subsequent analysis				
State of the art production equipment, workstations, machining centers, CNC m/c's, Robots etc.				
Latest software for CAD etc. viz. PRO-E, IDEAS etc				

28. Does the organization provide any formal training to the employees to enhance their creativity skills, innovation skills and education levels?

a) Proper formal training just after induction into the organisatation

b) Training during orientation period by senior employees

c) On the job training where employees are believed to learn through experience

d) No such training is provided

e) Use of Standard creativity tests from time to time.

f) Employees attend international/national conferences/workshops

29. Has the management clearly earmarked funds for R&D activities aimed at innovations for new product and process developments?

a) Clearly earmarked specifically for R&D activities.

b) Clubbed with other developmental activities

c) Some earmarking is done subject to availability

d) No specific consideration.

30. The investments in R&D, as a percentage of total turnover is

a) Less than 0.5 %

b) Between 0.5-2.5%

c) Between 2.5-5%

d) More than 5%

31. The main source of funds for R&D activities is

Source of Funds	Main	Major	Minor	Not at all
Government				
Organization itself				
Any other, please specify				

32. It has been seen that firms with separate research facilities are more innovative than others. What type of an organization exists for R&D work at your end?

a) R&D exists as a separate department

b) Teams are formed by the top management for specific R&D projects

c) Design/ Engineering department is responsible for innovation

d) Not clearly defined

33. In order to gain long-term gains, the Japanese firms do risky research? Is such a practice followed in your organization?

a) Absolutely, as there is no survival otherwise

b) Mostly

c) Somewhat

d) Not at all

34. Japanese firms purchase raw technologies developed by others through basic research. These are now developed further into innovative products rapidly through indigenous R&D programs. Thus imported technology is used as a complimentary means for technology development. Does your organization use this strategy i.e. “Imitation for creation” as a means for Technology Development?

a) Not at all

b) Occasionally

c) Usually

d) Always

35. Do the employees in your organization appreciate the importance of developing new process and products through indigenous research to meet the existing cut-throat competition?

a) Not at all

b) Only pretend, due to management pressure

c) Partially to some extent

d) Aggressively

36. Does the organization have adequate scientific and technical manpower to carry out R&D work?

a) Absolutely

b) To a large extent

c) To some extent

d) No

37. Are the employees and workforce level people encouraged to undertake R&D work/innovative work and obtain patents.

a) High encouragement
b) Reasonable
c) Very little encouragement
d) Not at all

38. How many patents have been obtained (applied for) by your organization (in its name) in the last

Period	Number	
	Obtained	Applied for
15 Years		
10 Years		
5 Years		
2 Years		

39. In case, the company makes profits as a result of innovative efforts of employees, how are their contributions recognized?

a) No recognition or reward
b) Share in profits made on account of innovation
c) Fixed monetary reward
d) Increment in salary
e) Promotion in designation
f) Recognition through appreciation letter

40. What type of an action does the management take in case an R&D project failure occurs?

a) Strict action against members of the project team
b) Enquires the reasons for failure and discourages R&D initiatives
c) Advises to learn lessons from current failures to improve for future. Encourages continuing with R&D efforts.
d) Does a thorough analysis, pin points the root causes and plans a future course of action by consensus.

41. The government supports the R&D initiatives of SSMI in the following ways

Type of Support	Mostly	Sometime	Rarely	Not at all
Allocates funds (based on R&D performance of previous years) for development of process and product technologies				
Allocates fixed funds to each industry as a proportion of its annual turnover				
Rewards entrepreneurs for contributions in field of technology development				
Organizes seminars for SSMI to increase awareness about new & raw technologies				
Provides government labs for developmental projects at subsidized rates				
Helps the industry in acquiring imported technologies and leave adoption, adaptation and development to them				
Sponsors employee training programmes				

42. Do you feel that interaction with regional academic institutes would help in solving technology related problems of your organization?

a) Definitely, to a large extent
b) Reasonably
c) To a small extent
d) Not at all

43. Has your organization experienced any industry-institute collaboration on R&D with positive results?

a) Very frequently
b) Quite often
c) Rarely
d) Not at all

44. Can the academic institutes help Small Scale Sector in technological innovations through

Activity	Definitely	To a Large Extent	To a Small Extent	Not at all
Preparation of roadmaps by experts from academia on how to make R&D an integral part of firm’s working				
Expert lectures by academicians on upcoming key technologies				
Training of firm’s employees at academic institutes in specialized fields and skills through short term courses				
Formation of R&D teams comprising of members from both industry and academic institutes to work mutually on R&D projects by sharing their specialized knowledge				
Use of academic institutes labs by industry for conduct of experiments and analysis of results				
Combined supervision of M.E., PhD dissertations by industry-institute personnel on industry oriented problems				

45. If R&D institutes form a network (consortium) to share their infrastructure and knowledge, would they be in better position to help SSMI in the area of Technology development?
a) Absolutely b) To a large extent
c) To some extent d) Not at all

46. Does your organization have contact / collaboration with any of the R&D institutes?
a) For R&D b) For solving most of the day to day problems
c) For solving some day to day problems d) No

47. Do you feel that networking of Small Scale Industries with R&D institutes can lead to greater success of industry in their Technology Development Efforts?
a) Yes to a great extent b) To a reasonable extent
c) To a small extent d) Not at all

48. Do you seek help from external organizations viz SISI, DIC, C-DAC, IIMT, ICAMAT etc for Technology up gradation?
a) Yes b) No

49. Can such organizations help the Small Scale Industry in their Technology Development efforts?
a) Definitely to a great extent b) Reasonably
c) To a small extent d) Not at all

50. What type of support can such organizations provide to the Small Scale Industrial Sector?

ACTIVITIES	Most Beneficial	Beneficial	Less Beneficial	Not at all Beneficial
Awareness on significance of technology development through indigenous research and the means to achieve it.				
Awareness programmes on upcoming key technologies				
Apprenticeship programmes for skill up gradation of work force level employees.				

51. Are the above organizations providing support as mentioned above?
a) Yes to a great extent b) To a reasonable extent
c) To a small extent d) Not at all

52. If you are supplying products to other industries (medium and large scale), do they encourage you to take R&D initiatives? If yes, in what way

a) Whenever they bring changes in the product features or introduce a new product, they train the suppliers for using the new technology

b) Continuously put pressure on the suppliers (SSMI) to upgrade their systems through in-house R&D

c) Encourage the suppliers (SSMI) to use the Companies laboratories and other facilities for any type of research initiative

d) No such encouragement is provided.

53. Please list some of the key features of the organization which have captured a part of your market share in the recent past.

53. In your views if the machine tool industry or cutting tool industry has to be served and made vibrant what should be done by

Industry Itself	
Group of Industries	
Organizations like SISI, DIC, UNIDO, ICAMAT, C-DAC etc	
Government	
Others (Please mention)	

(SIGNATURE OF RESPONDENT & SEAL OF THE ORGANIZATION)

APPENDIX–B

Details of Manufacturing Units included in the Survey

S. No	Name of the Industry	Address	City	Designation of Respondent	Type of Industry	Year of Inception
1	Capital Tool Industries	7 - A, Industrial Estate	Patiala	Proprietor	CTM	1969
2	Chetna Enterprises	Vishwakarma Colony, Focal Point	Ludhiana	Proprietor	CTM	1997
3	DEVE Engineering Works	E - 24, Phase 7	Mohali	Proprietor	CTM	1989
4	Kalgidhar Industrial Company	B - 22, Focal Point, Phase 2	Ludhiana	Partner	CTM	1974
5	King Enterprises	D - 15, GB Phase 6, Industrial Area	Mohali	Proprietor	CTM	1999
6	M/S Murali Engineering Works	Civil Lines	Ludhiana	Proprietor	CTM	1988
7	M/S Orient Ltd.	SP - 148 A, RIICO, Industrial Area	Bhiwadi	Proprietor	CTM	1977
8	Patiala Tools Corporation	1 - A , Industrial Estate, Sirhind Road	Patiala	Partner	CTM	1961
9	M/S Sehgal Ltd.	Focal Point	Ludhiana	Partner	CTM	1976
10	S.S. Tools	Sirhind Road	Patiala	Proprietor	CTM	1978
11	M/S Star Track Engineers	D-156/B, Industrial Area phase 7, SAS Nagar	Mohali	Proprietor	CTM	1994
12	Super Hobs and Broaches Pvt. Ltd.	B - 22, Focal Point	Patiala	Director	CTM	1999
13	Techcellence	C - 17, Focal Point	Patiala	Proprietor	CTM	1999
14	Versa Agro Industries	33 - D, Focal Point	Patiala	Managing Partner	CTM	1995
15	Vishal Tools Corporation	D - 83, Focal Point	Patiala	Proprietor	CTM	2005
16	iM Tools	D - 112, Focal Point	Patiala	Proprietor	CTM	2001
17	M/S R.J. Tools	D - 8, Focal Point, Industrial Estate	Patiala	Partner	CTM	2003
18	Aro Industries	D - 9, Focal Point	Patiala	Proprietor	CTM	1998
19	Humma Tools	9/A	Jalandhar	Proprietor	CTM	1971
20	Amar Tool Corporation	D - 88, Focal Point	Patiala	Proprietor	CTM	2000
21	Super Capital Tools	D - 101, Focal Point	Patiala	Proprietor	CTM	1992
22	Shakti Industries	D - 141, Focal Point	Patiala	Partner	CTM	2002
23	Perfect Engg. Tools	D - 116, Focal Point	Patiala	Proprietor	CTM	1999
24	Jeevandeep Tools	D - 110, Focal Point	Patiala	Proprietor	CTM	1995
25	Kapson India	D - 99, Focal Point	Patiala	Partner	CTM	1995
26	Jindal Tool Industries	Gaushala Road	Patiala	Proprietor	CTM	1979
27	B.S. Enterprises	103 R, Industrial Area B, Basant Road	Ludhiana	Proprietor	MTM	2000
28	Bhagwan Engineering and Foundary Works	103 R, Industrial Area B, Basant Road	Ludhiana	Proprietor	MTM	1970
29	M/S Dattana Industries	182/21 Industrial Area, Phase 1	Chandigarh	Proprietor	MTM	1985
30	Gemo Exports	G.T. Road	Ludhiana	Partner	MTM	1999
31	Gurdeep Industrial Corporation	4049, Street no. 6, Shimla Puri Daba Road	Ludhiana	Proprietor	MTM	2002
32	H.S. Industries	E - 40 Industrial Area Phase 8	SAS Nagar	Managing Partner	MTM	1982
33	M/S Khalsa M/C Tools	Focal Point, C 119 Phase 5	Ludhiana	Proprietor	MTM	1975
34	M.S. Machine Tools	Basant Road, Bhagwan Chownk, Plot No. 10906	Ludhiana	Partner	MTM	1965
35	Mankoo India Pvt. Ltd.	29/535, GT Road, Phandari Kalan	Ludhiana	Director	MTM	1973
36	Pye Tools Pvt. Ltd.	C - 67, Focal Point, Phase 3	Ludhiana	G.M.	MTM	1983
37	Sant Machine Tools Corporation	2. Street Kalsi Nagar Dholewal	Ludhiana	Managing Partner	MTM	1960
38	Sehgal Steel Company	Gill Road, Near Sandhu Automobile	Ludhiana	Managing Partner	MTM	1985
39	Shakti Engineering Works	3 - A, Upkar Nagar, Factory Area	Patiala	Proprietor	MTM	1974
40	Simran Engineering Works	D - 18, Focal Point	Patiala	Proprietor	MTM	2002
41	Tajindra Trading Company	4049, Street No. 6, Shimlapuri, Gill Road	Ludhiana	Proprietor	MTM	2004
42	Ubhi Tools (Registered)	12080, Street No. 26, Backside Sangeet Cinema	Ludhiana	Proprietor	MTM	1992
43	Gripwell Tools Industries	C - 104, Focal Point Extension	Jalandhar	Vice President	MTM	1995
44	TMT Machine Tools	C - 70, Focal Point	Jalandhar	Partner	MTM	1965
45	K.S. Jandu and Brothers	Dhanaula Road	Barnala	Proprietor	MTM	1977
46	Sohal Engg. Works	Court Road	Barnala	Proprietor	MTM	1970
47	Sonalika Agro Industrial Corporation	Industrial Estate, Jalandhar Road	Hoshiarpur	Manager	MTM	2000
48	Eastman Cast and Forge Ltd.	G.T. Road, Near Air Port	Ludhiana	Proprietor	MTM	....
49	Prince Industries	D - 95, Industrial Focal Point	Patiala	Proprietor	MTM	2002
50	Versa Agro Industries	33 - D, Focal Point	Patiala	Partner	MTM	1999
51	Rine Machine Tools	B-61, Phase - 7, Industrial Area, SAS Nagar	Mohali	Quality Control Mgr.	MTM	1968
52	B.T. Industries	Plot No. 1323, Street No. 6, Shimlapuri	Ludhiana	Proprietor	ACM	1993
53	Bamrah Engineering Works	D - 91Industrial Area Phase 7	Mohali	Proprietor	ACM	1992
54	M/S Dattana International	Plot No. 86, Industrial Area, Phase 9	Mohali	Proprietor	ACM	1997
55	G.S. Mankoo and Company	77 - R, Industrial Area B	Ludhiana	Partner	ACM	1974
56	M/S Guru Nanak Engineering Works	Shineer Puri Jauta Nagar	Ludhiana	Proprietor	ACM	1985
57	M/S Happy Ltd.	B29, 2254/1, Kanganwal Road	Ludhiana	CEO	ACM	1979
58	M/S Hari Krishan Industries	# 931, Muradpur	Ludhiana	Proprietor	ACM	1990
59	Hunny Slotting	1324/2 Street No. 6, Shimlapuri	Ludhiana	Proprietor	ACM	1987
60	M/S Jassons Techniks	D-91, Phase 7	Mohali	Chief Executive	ACM	2000
61	M/S Lal Industries	Daba Road Shimla Puri	Ludhiana	Proprietor	ACM	1985
62	M/S Maanik Industries	Plot No. 232, Phase 8, Focal Point	Ludhiana	Proprietor	ACM	2000
63	M/S Mandeep Industries	New Janta Nagar	Ludhiana	Proprietor	ACM	1993
64	Mankoo Engineers	84 R, Industrial Area B	Ludhiana	Partner	ACM	1972
65	Micro Enterprises	D-91, Phase 7, Industrial Area	Mohali	Proprietor	ACM	2004
66	Moonlight Auto Pvt. Ltd.	C-102/105, Phase 5, Focal Point	Ludhiana	Mgmt. Representative	ACM	1989
67	Moonlight Tools Pvt. Ltd.	V.P.O. Jaspalo	Do Raha	Mgmt. Representative	ACM	2003
68	M/S Murali Auto Components	Civil Lines	Ludhiana	Proprietor	ACM	1987
69	M/S Parveen Enterprises	D - 84, Phase 4, Focal Point	Ludhiana	Proprietor	ACM	1999
70	Perfect Auto Liner's	C - 1, Focal Point	Patiala	M.D.	ACM	1999
71	M/S Prima Industries	605 - A, Preet Nagar, Dugri	Ludhiana	Proprietor	ACM	1994
72	M/S R.K. Industries	Industrial Area - A	Ludhiana	Proprietor	ACM	1983
73	M/S S.K. Products	G.T. Road, Sherpur Kalan	Ludhiana	Proprietor	ACM	1997
74	M/S S.S. Industries	H.No. 6502, Street No. 4, New Faitiah Nagar	Ludhiana	Proprietor	ACM	1987
75	Sibros Engineering Pvt. Ltd.	C - 83/7 , Industrial Area	Mohali	Director	ACM	2003
76	Precision Machines	D - 331, Focal Point	Patiala	Proprietor	ACM	2003
77	A.A. Industries	D - 57, Focal Point, Industrial Estate	Patiala	Chief Executive	ACM	2004
78	Super Auto Manufacturers	A - 26, Industrial Estate, Sirhind Road	Patiala	Partner	ACM	1980
79	Krit Fab Industries	104, Industrial Area Phase 2	Chandigarh	Proprietor	ACM	1976
80	Metal Fab India	E - 181, Phase 7, Industrial Area	Mohali	Proprietor	ACM	1995
81	Continental Engineering Works	D - 156, Phase 7, Industrial Area	Mohali	Managing Partner	ACM	1981
82	Amit Engineers Ltd.	B - 61, Phase - 7	Mohali	QC Engineer	ACM	1986
83	Silence Auto	#158, Industrial Area 1	Chandigarh	Partner	ACM	1985

APPENDIX -C

DESCRIPTIVE STATISTICS OF MANPOWER COMPETENCE

S. No.	M1	M2	M3	M4	M5	M6
1	0.75	1.00	0.25	0.75	0.75	0.75
2	1.00	1.00	0.25	0.50	0.75	0.75
3	1.00	1.00	1.00	0.25	0.75	0.75
4	1.00	0.75	0.25	0.75	0.75	0.75
5	0.50	1.00	0.75	0.25	0.75	0.75
6	0.50	0.75	0.75	0.25	0.75	0.75
7	0.50	0.75	1.00	0.75	0.75	0.75
8	0.75	0.75	0.25	0.25	0.25	0.75
9	0.50	0.50	1.00	0.25	0.75	0.75
10	0.75	1.00	0.25	0.75	0.75	0.75
11	0.50	1.00	0.75	0.25	0.75	0.75
12	1.00	0.75	0.25	0.25	0.75	1.00
13	0.25	0.25	0.25	0.25	0.75	1.00
14	0.50	0.50	0.25	0.25	0.75	0.75
15	0.50	1.00	0.25	0.25	0.75	0.75
16	0.50	1.00	0.25	0.50	1.00	1.00
17	0.75	0.50	0.25	0.50	0.75	1.00
18	1.00	1.00	0.25	1.00	0.75	0.75
19	0.75	0.75	0.25	0.50	0.75	0.75
20	0.75	0.75	0.25	0.50	0.75	0.75
21	1.00	0.75	0.25	0.50	0.75	0.75
22	0.75	0.75	0.25	0.50	0.75	0.75
23	0.50	0.50	0.25	0.50	0.75	1.00
24	0.50	0.75	0.25	0.25	0.75	1.00
25	0.75	0.75	0.25	0.50	0.75	1.00
26	0.75	0.75	0.25	0.25	0.75	0.75
27	0.50	0.25	0.25	0.25	0.75	0.75
28	0.50	0.25	0.25	0.25	0.75	0.75
29	0.50	0.75	0.75	0.75	0.75	0.75
30	0.75	1.00	0.25	0.50	0.75	0.25
31	0.75	1.00	0.75	0.25	0.75	0.75
32	1.00	0.50	0.75	0.75	0.75	0.75
33	1.00	1.00	0.25	0.25	0.75	0.75
34	0.75	0.50	0.25	0.50	0.75	0.75
35	0.50	0.25	0.25	0.50	0.75	0.75
36	0.50	0.25	0.25	0.25	0.75	0.75
37	0.25	1.00	0.25	0.25	0.75	0.75
38	0.50	0.75	0.25	0.50	0.75	0.75
39	1.00	0.75	0.25	0.25	0.75	0.75
40	1.00	0.75	0.25	0.50	0.75	1.00

(Continued…...)

S. No.	M1	M2	M3	M4	M5	M6
41	0.75	1.00	0.75	0.25	0.75	0.75
42	0.50	0.50	0.25	1.00	1.00	0.75
43	1.00	1.00	1.00	1.00	0.75	1.00
44	0.75	0.75	0.25	0.50	0.50	1.00
45	0.50	0.50	0.25	0.25	0.75	0.75
46	0.75	0.75	0.25	0.50	0.75	0.75
47	0.00	0.00	0.75	0.75	0.75	0.75
48	0.50	0.50	0.75	0.25	0.75	0.25
49	0.50	0.25	0.75	0.25	0.75	0.25
50	0.50	0.75	0.75	0.75	0.75	0.75
51	0.75	1.00	0.25	0.50	0.75	0.25
52	0.75	1.00	0.75	0.25	0.75	0.75
53	1.00	0.25	0.75	0.25	0.75	0.75
54	0.50	0.75	0.75	0.25	0.75	0.75
55	0.25	0.25	0.75	0.25	0.75	0.75
56	0.75	0.50	0.75	0.75	0.50	1.00
57	0.75	0.75	0.75	0.50	0.75	0.75
58	1.00	1.00	0.25	0.75	0.75	0.75
59	0.75	1.00	0.25	0.50	0.75	0.75
60	0.75	1.00	0.25	0.50	0.75	0.25
61	1.00	1.00	0.25	0.25	0.75	0.75
62	1.00	0.50	0.75	0.50	1.00	0.75
63	1.00	0.50	0.75	0.50	1.00	0.75
64	1.00	1.00	0.25	0.25	0.75	0.75
65	1.00	1.00	0.25	0.25	0.75	0.75
66	0.75	0.25	0.75	0.25	0.75	0.25
67	1.00	1.00	0.25	0.50	0.75	0.75
68	1.00	1.00	0.25	0.50	0.75	0.75
69	1.00	1.00	0.25	0.25	0.75	0.75
70	1.00	1.00	0.25	0.75	0.75	0.75
71	1.00	0.75	0.25	0.25	0.75	1.00
72	1.00	0.25	0.25	1.00	0.75	1.00
73	0.25	0.50	0.25	0.50	0.75	1.00
74	1.00	0.25	0.25	1.00	0.75	1.00
75	0.50	0.50	0.25	0.50	0.75	0.75
76	0.50	0.75	0.25	0.25	0.75	0.75
77	0.00	0.00	0.25	1.00	0.75	0.75
78	0.75	0.75	0.25	0.75	0.75	0.75
79	1.00	1.00	0.25	0.75	0.75	0.75
80	0.00	0.00	0.75	0.75	0.75	0.75
81	1.00	0.50	0.75	1.00	0.75	0.75
82	0.00	0.00	0.75	0.75	0.75	0.75
83	0.75	0.75	0.75	0.50	0.75	0.75

APPENDIX-D

DESCRIPTIVE STATISTICS OF TECHNOLOGY INFRASTRUCTURE

S. No.	T1	T2	T3	T4		S. No.	T1	T2	T3	T4
1	0.25	0.25	0.25	0.25		43	1.00	1.00	0.75	0.75
2	0.25	0.25	0.25	0.25		44	0.00	0.50	0.75	0.50
3	1.00	0.25	0.25	0.25		45	0.50	0.25	0.25	0.50
4	1.00	0.75	0.25	0.25		46	0.50	0.25	0.25	0.50
5	1.00	0.25	0.25	0.25		47	0.00	0.25	0.25	0.00
6	0.50	0.25	0.25	0.25		48	1.00	0.25	0.25	0.25
7	0.75	1.00	1.00	0.50		49	0.50	0.25	0.25	0.25
8	0.75	0.25	0.25	0.25		50	0.25	0.25	0.25	0.50
9	0.50	0.25	0.75	1.00		51	0.25	0.25	0.25	0.25
10	0.25	0.50	0.25	0.25		52	0.75	0.25	0.25	0.25
11	0.50	0.25	0.25	0.25		53	0.50	0.25	0.50	0.25
12	1.00	0.25	0.25	0.25		54	0.75	0.25	0.25	0.25
13	0.25	0.75	1.00	0.25		55	0.25	0.25	0.25	0.25
14	0.50	0.25	0.75	0.50		56	0.75	0.50	0.50	0.50
15	0.25	0.25	0.25	0.25		57	0.25	0.25	0.25	0.25
16	0.75	0.25	0.25	0.25		58	0.75	0.25	0.25	0.25
17	0.50	0.25	0.25	0.25		59	0.50	0.25	0.25	0.25
18	1.00	0.50	0.50	0.25		60	0.25	0.25	0.25	0.25
19	0.75	0.50	0.50	0.25		61	1.00	0.25	0.25	0.75
20	0.25	0.25	0.25	0.25		62	0.50	0.75	1.00	0.50
21	0.75	0.25	0.25	0.75		63	0.50	0.75	1.00	0.50
22	0.50	0.25	0.25	0.75		64	0.25	0.25	0.25	0.25
23	0.50	0.25	0.75	0.50		65	0.50	0.25	0.25	0.25
24	0.50	0.25	0.25	0.25		66	0.75	0.25	0.25	0.25
25	0.75	0.25	0.25	0.75		67	0.25	0.25	0.25	0.25
26	0.50	0.25	0.25	0.75		68	0.50	0.25	0.25	0.25
27	0.50	0.50	0.25	0.50		69	0.50	0.25	0.25	0.25
28	0.50	0.50	0.25	0.25		70	0.50	0.25	0.25	0.25
29	0.25	0.25	0.25	0.25		71	0.75	0.25	0.25	0.25
30	0.25	0.25	0.25	0.25		72	1.00	0.25	0.25	0.25
31	0.50	0.25	0.25	0.25		73	0.50	0.50	0.75	0.25
32	0.25	0.25	0.25	0.25		74	1.00	0.25	0.25	0.25
33	0.75	0.25	0.25	0.25		75	0.50	0.00	0.75	0.50
34	0.50	0.25	0.25	0.50		76	0.75	0.25	0.25	0.25
35	0.50	0.25	0.50	0.50		77	0.00	0.75	1.00	0.50
36	0.25	0.50	0.25	0.50		78	0.50	0.25	0.25	0.50
37	0.75	0.25	0.25	0.25		79	1.00	0.25	0.25	0.25
38	0.50	0.25	0.25	0.25		80	0.00	0.25	0.25	0.00
39	0.75	0.25	0.75	0.50		81	1.00	0.00	0.25	1.00
40	1.00	0.25	0.25	0.25		82	0.00	0.25	0.25	0.00
41	0.50	0.25	0.25	0.25		83	0.75	0.25	0.25	1.00
42	0.50	0.75	0.25	0.25						

APPENDIX-E

DESCRIPTIVE STATISTICS OF REGULATORY SUPPORT

S. No.	G1	G2	G3	G4		S. No.	G1	G2	G3	G4
1	0.25	0.25	0.75	0.68		43	0.25	0.25	0.75	0.25
2	0.25	0.25	0.50	1.00		44	0.75	0.75	1.00	0.54
3	0.50	0.75	0.25	0.25		45	0.75	0.25	0.50	0.50
4	0.25	0.25	1.00	0.75		46	0.75	0.50	0.00	0.39
5	0.50	0.50	0.25	1.00		47	0.00	0.00	0.00	1.00
6	0.50	0.50	0.25	1.00		48	0.50	0.50	0.25	0.68
7	0.75	1.00	1.00	0.86		49	0.75	0.50	0.25	0.86
8	1.00	0.75	0.25	0.29		50	1.00	0.75	0.25	1.00
9	0.50	0.50	1.00	1.00		51	1.00	1.00	0.50	1.00
10	0.25	0.25	0.75	0.68		52	0.25	0.50	0.25	1.00
11	0.50	0.50	0.25	1.00		53	0.25	0.75	0.25	0.50
12	0.75	0.25	0.75	0.29		54	0.50	1.00	0.75	0.75
13	0.25	0.25	0.25	0.46		55	0.25	0.25	0.25	1.00
14	0.75	0.50	0.75	0.64		56	0.25	0.75	0.25	0.39
15	0.75	0.75	0.50	1.00		57	0.50	0.50	0.50	0.75
16	0.50	1.00	0.50	0.96		58	0.25	1.00	0.25	0.79
17	0.50	0.25	0.50	0.29		59	0.25	0.25	0.25	1.00
18	1.00	0.25	1.00	1.00		60	1.00	1.00	0.50	1.00
19	1.00	0.75	0.50	0.46		61	0.25	1.00	0.25	0.25
20	0.50	0.25	0.50	0.54		62	0.50	0.75	0.50	1.00
21	0.75	0.25	0.75	0.54		63	0.50	0.75	0.50	1.00
22	0.75	0.25	0.50	0.50		64	0.75	0.75	0.25	1.00
23	0.75	1.00	0.25	0.57		65	0.50	0.50	0.25	1.00
24	0.50	0.50	0.75	0.61		66	1.00	0.25	0.25	0.36
25	0.75	0.25	0.75	0.39		67	0.25	0.25	0.25	0.75
26	0.50	0.75	0.75	0.43		68	0.25	0.25	0.25	1.00
27	0.25	0.25	0.25	0.79		69	0.50	0.50	0.50	1.00
28	0.25	0.25	0.25	0.79		70	1.00	0.75	0.50	0.89
29	1.00	0.75	0.25	1.00		71	0.75	0.75	0.75	0.75
30	1.00	1.00	0.50	1.00		72	0.50	0.50	0.25	0.25
31	0.50	0.50	1.00	1.00		73	0.75	0.50	0.25	0.96
32	0.50	1.00	0.50	1.00		74	0.50	0.50	0.25	0.25
33	0.25	0.25	0.25	1.00		75	0.75	0.50	0.50	0.82
34	0.50	0.75	0.25	1.00		76	0.25	0.25	0.25	0.25
35	0.50	0.25	0.25	0.96		77	0.00	0.00	0.00	0.25
36	0.50	0.50	1.00	1.00		78	0.75	0.50	0.50	0.50
37	0.75	0.50	0.75	0.75		79	1.00	1.00	1.00	0.83
38	0.25	0.25	0.75	1.00		80	0.00	0.00	0.00	1.00
39	0.75	0.25	0.50	0.57		81	0.50	0.50	0.25	1.00
40	1.00	0.50	0.75	0.39		82	0.00	0.00	0.00	1.00
41	0.50	0.50	1.00	1.00		83	0.75	0.75	0.75	0.92
42	0.50	0.50	0.25	1.00						

APPENDIX-F

DESCRIPTIVE STATISTICS OF INTERACTION WITH OTHERS

S. No.	I1	I2	I3	I4		S. No.	I1	I2	I3	I4
1	1.00	0.25	0.25	0.25		43	0.25	0.25	0.25	0.25
2	1.00	0.25	0.75	0.25		44	0.75	0.25	0.25	1.00
3	1.00	0.25	0.25	0.25		45	0.25	0.25	0.50	0.25
4	0.75	0.25	0.25	0.25		46	1.00	0.25	0.25	0.25
5	1.00	0.25	1.00	0.25		47	1.00	0.25	1.00	0.25
6	0.75	0.75	0.25	0.25		48	1.00	0.25	0.25	1.00
7	0.50	0.25	0.25	0.25		49	1.00	0.25	0.25	1.00
8	1.00	0.25	0.25	0.25		50	1.00	0.25	1.00	0.25
9	1.00	0.25	0.25	0.25		51	0.25	0.25	1.00	1.00
10	1.00	0.50	0.25	0.25		52	1.00	0.25	0.25	0.25
11	1.00	0.25	1.00	0.25		53	0.75	0.25	0.50	1.00
12	0.75	0.25	0.25	0.25		54	1.00	0.25	0.25	0.25
13	0.25	0.25	0.50	1.00		55	1.00	0.25	0.25	1.00
14	1.00	0.25	0.25	1.00		56	0.75	0.75	0.25	1.00
15	1.00	0.25	0.25	0.25		57	1.00	0.25	0.25	0.25
16	0.25	0.25	1.00	1.00		58	1.00	0.50	0.25	0.25
17	1.00	1.00	0.25	0.25		59	1.00	0.25	0.25	0.25
18	1.00	0.25	0.25	0.25		60	0.25	0.25	1.00	1.00
19	1.00	0.25	0.25	0.25		61	0.50	0.25	0.25	0.25
20	1.00	0.25	0.25	1.00		62	0.75	0.25	0.75	1.00
21	1.00	0.75	0.25	1.00		63	0.75	0.25	0.75	1.00
22	1.00	0.25	0.50	1.00		64	1.00	0.25	0.25	0.25
23	1.00	0.25	0.25	1.00		65	1.00	0.25	0.50	0.25
24	1.00	0.25	0.25	1.00		66	0.25	0.25	0.75	0.25
25	1.00	0.50	0.50	0.25		67	1.00	0.25	0.50	0.25
26	1.00	0.25	0.25	1.00		68	1.00	0.25	0.50	0.25
27	1.00	0.25	0.25	1.00		69	1.00	0.25	0.25	0.25
28	1.00	0.25	0.25	1.00		70	1.00	0.25	0.25	0.25
29	1.00	0.25	1.00	0.25		71	0.75	0.25	0.25	0.25
30	0.25	0.25	1.00	1.00		72	1.00	0.75	0.50	1.00
31	1.00	0.25	0.25	0.25		73	0.50	0.25	0.25	0.25
32	0.25	0.25	0.25	0.25		74	1.00	0.75	0.50	1.00
33	1.00	0.25	0.50	0.25		75	0.25	0.25	0.25	1.00
34	0.25	0.25	0.25	0.25		76	1.00	0.75	0.25	0.25
35	0.75	0.50	1.00	1.00		77	1.00	0.25	0.25	0.25
36	1.00	0.25	0.25	1.00		78	1.00	0.25	0.25	0.25
37	1.00	0.25	0.75	0.25		79	1.00	0.25	0.25	0.25
38	1.00	0.25	0.50	0.25		80	1.00	0.25	1.00	0.25
39	1.00	0.50	0.25	1.00		81	1.00	0.25	0.25	1.00
40	1.00	0.25	0.25	0.25		82	1.00	0.25	1.00	0.25
41	1.00	0.25	0.25	0.25		83	1.00	0.50	1.00	0.25
42	1.00	0.25	0.25	0.25						

APPENDIX-G

SPSS OUTPUT OF CANONICAL FACTOR LOADING ANALYSIS

(Contributions of Interaction Issues towards various Development Indicators)

```
Run MATRIX procedure:
>Error encountered in source line #   452

>Error # 12587
>The argument of the MDIAG function is not a vector.
>This command not executed.

Correlations for Set-1
        Y1
Y1  1.0000


Correlations for Set-2
        I1      I2      I3      I4
I1  1.0000   .0144   .0335  -.0501
I2   .0144  1.0000  -.0521   .0925
I3   .0335  -.0521  1.0000   .1224
I4  -.0501   .0925   .1224  1.0000


Correlations Between Set-1 and Set-2
        I1      I2      I3      I4
Y1  -.2749   .1399  -.1646  -.1473


Canonical Correlations
1       .378


Test that remaining correlations are zero:
      Wilk's   Chi-SQ       DF     Sig.
1       .857   11.577    4.000     .021


Standardized Canonical Coefficients for Set-1
          1
Y1    1.000


Raw Canonical Coefficients for Set-1
          1
Y1    1.001

Standardized Canonical Coefficients for Set-2

          1
I1    -.742
I2     .402
```

```
I3    -.338
I4    -.423
Raw Canonical Coefficients for Set-2
          1
I1   -1.136
I2     .615
I3    -.318
I4    -.290


Canonical Loadings for Set-1
          1
Y1    1.000


Cross Loadings for Set-1
          1
Y1     .378


Canonical Loadings for Set-2
          1
I1    -.727
I2     .370
I3    -.435
I4    -.390


Cross Loadings for Set-2
          1
I1    -.275
I2     .140
I3    -.165
I4    -.147

            Redundancy Analysis:

Proportion of Variance of Set-1 Explained by Its Own Can. Var.
               Prop Var
CV1-1             1.000


Proportion of Variance of Set-1 Explained by Opposite Can.Var.
               Prop Var
CV2-1              .143

Proportion of Variance of Set-2 Explained by Its Own Can. Var.
               Prop Var
CV2-1              .252

Proportion of Variance of Set-2 Explained by Opposite Can. Var.
               Prop Var
CV1-1              .036
```

------ END MATRIX -----

```
Run MATRIX procedure:
>Error encountered in source line #   452

>Error # 12587
>The argument of the MDIAG function is not a vector.
>This command not executed.

Correlations for Set-1
        Y2
Y2  1.0000


Correlations for Set-2
        I1      I2      I3      I4
I1  1.0000   .0144   .0335  -.0501
I2   .0144  1.0000  -.0521   .0925
I3   .0335  -.0521  1.0000   .1224
I4  -.0501   .0925   .1224  1.0000


Correlations Between Set-1 and Set-2
        I1      I2      I3      I4
Y2   .1373  -.1403   .2892  -.1566


Canonical Correlations
1       .383


Test that remaining correlations are zero:
      Wilk's   Chi-SQ       DF     Sig.
1       .853   11.900    4.000     .018


Standardized Canonical Coefficients for Set-1
          1
Y2    1.000


Raw Canonical Coefficients for Set-1
          1
Y2    1.598


Standardized Canonical Coefficients for Set-2

          1
I1     .313
I2    -.287
I3     .786
I4    -.463



Raw Canonical Coefficients for Set-2
          1
I1     .479
```

```
I2    -.438
I3     .741
I4    -.318


Canonical Loadings for Set-1
          1
Y2    1.000


Cross Loadings for Set-1
          1
Y2     .383


Canonical Loadings for Set-2
          1
I1     .358
I2    -.366
I3     .755
I4    -.409

Cross Loadings for Set-2
          1
I1     .137
I2    -.140
I3     .289
I4    -.157

            Redundancy Analysis:


Proportion of Variance of Set-1 Explained by Its Own Can. Var.
               Prop Var
CV1-1             1.000


Proportion of Variance of Set-1 Explained by Opposite Can.Var.
               Prop Var
CV2-1              .147

Proportion of Variance of Set-2 Explained by Its Own Can. Var.
               Prop Var
CV2-1              .250


Proportion of Variance of Set-2 Explained by Opposite Can. Var.
               Prop Var
CV1-1              .037
```

------ END MATRIX -----

```
Run MATRIX procedure:
>Error encountered in source line #   452

>Error # 12587
>The argument of the MDIAG function is not a vector.
>This command not executed.

Correlations for Set-1
        Y3
Y3  1.0000


Correlations for Set-2
        I1      I2      I3      I4
I1  1.0000   .0144   .0335  -.0501
I2   .0144  1.0000  -.0521   .0925
I3   .0335  -.0521  1.0000   .1224
I4  -.0501   .0925   .1224  1.0000


Correlations Between Set-1 and Set-2
        I1      I2      I3      I4
Y3   .2766   .1467   .3152   .2298


Canonical Correlations
1       .482


Test that remaining correlations are zero:
      Wilk's   Chi-SQ       DF     Sig.
1       .767   19.850    4.000     .001


Standardized Canonical Coefficients for Set-1
          1
Y3    1.000


Raw Canonical Coefficients for Set-1
          1
Y3    1.274


Standardized Canonical Coefficients for Set-2

          1
I1     .570
I2     .290
I3     .600
I4     .405



Raw Canonical Coefficients for Set-2
          1
I1     .871
```

```
I2     .443
I3     .566
I4     .278


Canonical Loadings for Set-1
          1
Y3    1.000


Cross Loadings for Set-1
          1
Y3     .482


Canonical Loadings for Set-2
          1
I1     .574
I2     .304
I3     .654
I4     .476


Cross Loadings for Set-2
          1
I1     .277
I2     .147
I3     .315
I4     .230

            Redundancy Analysis:


Proportion of Variance of Set-1 Explained by Its Own Can. Var.
               Prop Var
CV1-1             1.000


Proportion of Variance of Set-1 Explained by Opposite Can.Var.
               Prop Var
CV2-1              .233


Proportion of Variance of Set-2 Explained by Its Own Can. Var.
               Prop Var
CV2-1              .269


Proportion of Variance of Set-2 Explained by Opposite Can. Var.
               Prop Var
CV1-1              .063
```

------ END MATRIX -----

```
Run MATRIX procedure:
>Error encountered in source line #   452

>Error # 12587
>The argument of the MDIAG function is not a vector.
>This command not executed.


Correlations for Set-1
        Y4
Y4  1.0000


Correlations for Set-2
        I1      I2      I3      I4
I1  1.0000   .0144   .0335  -.0501
I2   .0144  1.0000  -.0521   .0925
I3   .0335  -.0521  1.0000   .1224
I4  -.0501   .0925   .1224  1.0000


Correlations Between Set-1 and Set-2
        I1      I2      I3      I4
Y4  -.2121   .1620  -.1308  -.1928


Canonical Correlations
1       .358


Test that remaining correlations are zero:
      Wilk's   Chi-SQ       DF     Sig.
1       .872   10.299    4.000     .036


Standardized Canonical Coefficients for Set-1
          1
Y4    1.000


Raw Canonical Coefficients for Set-1
          1
Y4    1.054


Standardized Canonical Coefficients for Set-2
          1
I1    -.621
I2     .502
I3    -.246
I4    -.586

Raw Canonical Coefficients for Set-2
          1
I1    -.949
I2     .768
I3    -.232
```

```
I4    -.403


Canonical Loadings for Set-1
          1
Y4    1.000


Cross Loadings for Set-1
          1
Y4     .358


Canonical Loadings for Set-2
          1
I1    -.592
I2     .452
I3    -.365
I4    -.538


Cross Loadings for Set-2
          1
I1    -.212
I2     .162
I3    -.131
I4    -.193


            Redundancy Analysis:


Proportion of Variance of Set-1 Explained by Its Own Can. Var.
               Prop Var
CV1-1             1.000


Proportion of Variance of Set-1 Explained by Opposite Can.Var.
               Prop Var
CV2-1              .128


Proportion of Variance of Set-2 Explained by Its Own Can. Var.
               Prop Var
CV2-1              .245


Proportion of Variance of Set-2 Explained by Opposite Can. Var.
               Prop Var
CV1-1              .031
```

------ END MATRIX -----

APPENDIX-H

OPTIONS GENERATED TO MEET DIMENSIONS OF RESEARCH PROBLEM

1. Promote knowledge based entrepreneurial skills.
2. Find out opportunities and threats of globalization.
3. Set up short term and long term organizational goals.
4. Bring innovativeness in design to develop new products.
5. Make sustained and regular efforts to improve education levels and technical skills of employees.
6. Increase investments in CAD/ CAM and software packages for improved product designing and modeling.
7. Monitor external technology events through participation in conferences and symposia etc.
8. Examine latest technology trends through publications in magazines, newspapers and research literature.
9. Acquire technology only when indigenous development costs are forbidding.
10. Implement quality system procedures.
11. Produce wide variety of product mix simultaneously.
12. Learn to adapt quickly to customer needs and requirements.
13. Build longstanding strategic partnerships with key technology providers.
14. Facilitate employee empowerment for creative output.
15. Reduce contract based employment and provide job security to employees.
16. Take short term risks (‘risky research’ strategy) for long term pay-offs.
17. Reduce manufacturing costs by using value analysis techniques and reducing overheads.
18. Facilitate open communication for better flow of ideas across the unit.
19. Congregate knowledge of market conditions.
20. Establish and maintain long term contractual relations with customers.
21. Use latest technology in products and processes to compete effectively.

22. Implement a unified law (integrated tax structure) to reduce multiplicity and high level of taxes.
23. Develop multi-skilled workforce through job rotation programs to perform varied tasks.
24. Educate employees to accept the changes willingly.
25. Incorporate skill based learning and principles of market economy in education cycle to develop entrepreneurial skills.
26. Provide formal training to employees to eliminate latent skill deficiencies.
27. Maintain adequate strength of R&D staff to undertake technology development projects.
28. Increase pressure on employees for technology development through in-house research.
29. Attend workshops/ short term courses on IPRs to increase awareness of employees regarding use of patents.
30. Adopt patenting as a means to protect ideas and product innovations from being copied by competitors.
31. Introduce well structured reward schemes based on intrinsic motivation tools.
32. Motivate employees to take risks and experiment for developing new product ideas and novel products.
33. Encourage individual capabilities by allowing employees to work on projects of their interest.
34. Form cross-functional teams to work on projects.
35. Create a tolerant atmosphere to accept a few mistakes as part of taking the initiative for product innovations.
36. Store the results of project failures for possible adoption at a later stage.
37. Establish formal research groups or allocate specific individuals to work exclusively on developing innovations.
38. Provide adequate level of resources for research projects to convert innovative ideas into successful commercial products.
39. Promote higher R&D spending for specialized scientific and technical expertise.

40. Adopt a defined financial strategy and allocate specific proportion of annual budget for research projects.
41. Provide good quality and reliable physical infrastructure at reasonable prices.
42. Develop a ‘Central Distribution System’ for raw material availability at reasonable prices.
43. Ensure continuous and reliable supply of electricity at reasonable prices.
44. Reduce burden of administrative regulations and delays to improve business environment.
45. Bring in goal stretching programs to create innovation context.
46. Identify specific sectors with high export potential and develop a well planned strategy for them to enter international markets.
47. Ensure efficient monitoring of support infrastructure facilities.
48. Allow units to come up only in designated industrial areas in a planned and controlled manner.
49. Obtain marketing oriented financial assistance for advertising, product promotion and appraisal of projects from State Financial Corporations.
50. Ensure coordination between centre and state governments for policy issues and fiscal concessions.
51. Involve private sector in development and management of infrastructure and allow access to services on payment.
52. Strengthen the technological capabilities of government supported R&D institutes.
53. Maintain competencies only in core technologies and obtain additional capabilities through alliances with others.
54. Collaborate with larger firms for finance, expertise and international opportunities.
55. Educate employees to learn across different organizational cultures for effective industrial collaborations.
56. Build credibility with other small units to discuss common problem and share specialized knowledge.
57. Develop an information rich environment and physical infrastructure to promote inter-firm communication.
58. Forge a mutually reinforcing relationship with premier technical institutes.

59. Arrange expert lectures of academic professionals at small units on upcoming key technologies.
60. Train employees in specialized skills through short term courses and apprenticeship programs at technical institutes.
61. Form project teams with members both from industry and technical institutions to work on research projects.
62. Add features to the current product range regularly.
63. Create a mechanism to evaluate cost of investments in R&D.
64. Utilize the research function for process improvements/ product innovations and not for production-maintenance problems.
65. Provide access to well researched databases pertaining to market intelligence and upcoming technologies through a dynamic portal.
66. Formulate and practice specific product innovation strategies to increase effectiveness of research function.
67. Establish research department as a separate division with well defined R&D policy and procedures.
68. Provide financial assistance (soft loans, grants) and professional support to units attempting commercialization of indigenous technologies.
69. Define range of technology options for competitive advantage.
70. Make the developed technology highly marketable.
71. Ensure economic justification of the developed technology.
72. Participate actively in international events (trade fairs etc) for identifying technology gaps and developing business contacts.
73. Develop flexible manufacturing facility to adapt to changing market dynamics.
74. Update product designs constantly using computer aided designing (CAD) and finite element analysis (FEA).
75. Improve access to capital subsidy schemes of government.
76. Improve project management/ production skills for faster technology commercialization.
77. Promote a change culture to make access to new technology less alarming.

78. Develop a market niche through creation of innovative products having distinct features.
79. Provide financial assistance to units for obtaining quality system certification.
80. Arrange study visits of entrepreneurs to technically advanced industrial units to increase awareness regarding latest production technologies.
81. Provide consultancy to units regarding formulation of marketing plans.
82. Bring industry and research institutes closer for mutually beneficial collaborations for technology transfers.
83. Encourage low cost automations through indigenous efforts for process improvements.
84. Broaden the financial infrastructure and simplify procedures for finance availability.
85. Increase the number of Regional Testing Centers (RTC), Field Testing Stations (FTS) and Tool Rooms (TRs).
86. Promote subcontracting relations with large firms through 'Sub-Contracting Exchanges' (SCXs) scheme of government.
87. Safeguard intellectual property of industrial units by effectively administering patent legislation.
88. Technical institutes to undertake projects (from DST etc.) for providing institutional framework to small units for R&D work.
89. Adopt the 'Credit Rating Scheme' to identify strengths, weaknesses etc. and for hassle free flow of credit.
90. Grant custom duty exemption on capital equipment/ materials for R&D projects.
91. Learn and imbibe the process of innovation in day to day working.
92. Develop professional expertise in technology transfer in the university sector.
93. Provide well structured mechanisms/ intermediary agents for effective interaction between SMEs and research institutions.
94. Provide prompt information through regular advertisements regarding various government schemes for supporting small sector.
95. Identify sectors with high export potential and develop a planned strategy for them to enter international markets.

96. Formulate ‘Vision and Mission’ statements for long term strategic decision making.
97. Solicit the academic institutes to focus on applied education and R&D, linked to current and potential future needs of industry.
98. Encourage universities to reshape curriculum for fostering creativity, team working and perseverance.
99. Make access to finance from banks and other financial corporations easy by reducing interest rates.
100. Encourage employees to work in various divisions to gain experience and appreciate problems of different parts of the unit.
101. Recruit qualified professionals in product designing and overseas marketing.
102. Adopt effective career planning measures for employees.
103. Define the level of risks that employees can take safely.
104. Improve knowledge of employees regarding capital grant schemes of government and submit proposals to obtain funds.
105. Bring large scale manufacturing sector to the region to provide operational support to small units.
106. Develop a unified labor law with simple provisions to reduce constrained relations between employer and employees.
107. Restrict frequent changes in steel prices to allow units to finalize long term contracts for exports.
108. Increase the focus of industrial policy on promotion of technological innovations and not just removal of technological obsolescence through technology transfers.
109. Technical institutes to market their resources and areas of expertise.
110. Collaborate with R&D establishments for technological innovations and not for fire fighting of production problems.
111. Develop and introduce knowledge driven products through in-house technological innovations.
112. Adopt a systematic project based approach for product innovations.
113. Utilize the research function for increasing product mix and adding features to the current product range of the unit.
114. Broaden the sales and service network for penetrating into new markets.

APPENDIX-I

AHP WEIGHTS MATRICES

Position Matrix: Respondent – Researcher

A) Pairwise Comparison Matrix

Criteria (Alternative)	A	B	C	D	E
A	**1**	**1/3**	**1/5**	**5**	**3**
B	**3**	**1**	**1/3**	**7**	**5**
C	**5**	**3**	**1**	**9**	**7**
D	**1/5**	**1/7**	**1/9**	**1**	**1/3**
E	**1/3**	**1/5**	**1/7**	**3**	**1**
Sum of Column	9.53	4.68	1.79	25.00	16.33

B) Normalized Comparison Matrix

Criteria (Alternative)	A	B	C	D	E	WEIGHTS
A	0.10	0.07	0.11	0.20	0.18	**0.13**
B	0.31	0.21	0.19	0.28	0.31	**0.26**
C	0.52	0.64	0.56	0.36	0.43	**0.50**
D	0.02	0.03	0.06	0.04	0.02	**0.03**
E	0.03	0.04	0.08	0.12	0.06	**0.07**

C) Consistency Ratio

Maximum Eigen Vector **(X_{max})** = 5.37

Consistency Index **(C.I)** = 0.09

Consistency Ratio **(C.R)** = **8.35 %**

Position Matrix: Respondent – Industry Expert

A) Pairwise Comparison Matrix

Criteria (Alternative)	A	B	C	D	E
A	**1**	**1/2**	**1/3**	**3**	**2**
B	**2**	**1**	**1/2**	**4**	**3**
C	**3**	**2**	**1**	**5**	**4**
D	**1/3**	**1/4**	**1/5**	**1**	**1/2**
E	**½**	**1/3**	**1/4**	**2**	**1**
Sum of Column	6.83	4.08	2.28	15.00	10.50

B) Normalized Comparison Matrix

Criteria (Alternative)	A	B	C	D	E	**WEIGHTS**
A	0.15	0.12	0.15	0.20	0.19	**0.16**
B	0.29	0.24	0.22	0.27	0.29	**0.26**
C	0.44	0.49	0.44	0.33	0.38	**0.42**
D	0.05	0.06	0.09	0.07	0.05	**0.06**
E	0.07	0.08	0.11	0.13	0.10	**0.10**

C) Consistency Ratio

Maximum Eigen Vector **(X_{max})** = 5.09

Consistency Index **(C.I)** = 0.02

Consistency Ratio **(C.R)** = **2.02 %**

Position Matrix: Respondent – Academic Expert

A) Pairwise Comparison Matrix

Criteria (Alternative)	A	B	C	D	E
A	**1**	**1/2**	**1/4**	**4**	**2**
B	**2**	**1**	**1/3**	**5**	**4**
C	**4**	**3**	**1**	**7**	**5**
D	**¼**	**1/5**	**1/7**	**1**	**1/3**
E	**½**	**1/4**	**1/5**	**3**	**1**
Sum of Column	7.75	4.95	1.93	20.00	12.33

B) Normalized Comparison Matrix

Criteria (Alternative)	A	B	C	D	E	WEIGHTS
A	0.13	0.10	0.13	0.20	0.16	**0.14**
B	0.26	0.20	0.17	0.25	0.32	**0.24**
C	0.52	0.61	0.52	0.35	0.41	**0.48**
D	0.03	0.04	0.07	0.05	0.03	**0.04**
E	0.06	0.05	0.10	0.15	0.08	**0.09**

C) Consistency Ratio

Maximum Eigen Vector **(X_{max})** = 5.24

Consistency Index **(C.I)** = 0.06

Consistency Ratio **(C.R)** = **5.43 %**

APPENDIX-J

POSITION MATRICES

Position Matrix: Respondent - Researcher

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach	Weight/ (as determined by AHP)
Goal **A**	0.5	0.3	0.7	0.3	0.5	0.13
Goal **B**	0.9	0.3	0.3	0.3	0.5	0.26
Goal **C**	0.9	0.7	0.3	0.3	0.5	0.50
Goal **D**	0.3	0.3	0.5	0.5	0.5	0.03
Goal **E**	0.5	0.3	0.9	0.3	0.5	0.07

Position Matrix: Respondent - Industrial Expert

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach	Weight/ (as determined by AHP)
Goal **A**	0.3	0.3	0.7	0.5	0.5	0.16
Goal **B**	0.9	0.7	0.5	0.5	0.7	0.26
Goal **C**	0.9	0.7	0.3	0.3	0.5	0.42
Goal **D**	0.3	0.5	0.9	0.7	0.7	0.06
Goal **E**	0.5	0.3	0.9	0.3	0.5	0.10

Position Matrix: Respondent - Academic Expert

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach	Weight/ (as determined by AHP)
Goal **A**	0.5	0.3	0.7	0.7	0.7	0.14
Goal **B**	0.7	0.5	0.3	0.5	0.5	0.24
Goal **C**	0.9	0.7	0.3	0.3	0.5	0.48
Goal **D**	0.3	0.3	0.9	0.7	0.5	0.04
Goal **E**	0.3	0.3	0.9	0.5	0.5	0.09

APPENDIX-K

WEIGHTED POSITION MATRICES

Weighted Position Matrix: Respondent - Researcher

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal **A**	0.065	0.039	0.091	0.039	0.065
Goal **B**	0.234	0.078	0.078	0.078	0.130
Goal **C**	0.450	0.350	0.150	0.150	0.250
Goal **D**	0.009	0.009	0.015	0.015	0.015
Goal **E**	0.035	0.021	0.063	0.021	0.035

Weighted Position Matrix: Respondent - Industrial Expert

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal A	0.048	0.048	0.112	0.080	0.080
Goal B	0.234	0.182	0.130	0.130	0.182
Goal C	0.378	0.294	0.126	0.126	0.210
Goal D	0.018	0.030	0.054	0.042	0.042
Goal E	0.050	0.030	0.090	0.030	0.050

Weighted Position Matrix: Respondent - Academic Expert

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal **A**	0.070	0.042	0.098	0.098	0.098
Goal **B**	0.168	0.120	0.072	0.120	0.120
Goal **C**	0.432	0.336	0.144	0.144	0.240
Goal **D**	0.012	0.012	0.036	0.028	0.020
Goal **E**	0.027	0.027	0.081	0.045	0.045

APPENDIX – L

HADLEY'S MATRICES OF CAUTIOUS OPTIMISM

Hadley's Matrix - 80% Optimism

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal **A**	0.066	0.046	0.011	0.087	0.091
Goal **B**	0.221	0.161	0.118	0.120	0.170
Goal **C**	0.436	0.339	0.145	0.145	0.242
Goal **D**	0.016	0.026	0.046	0.037	0.037
Goal **E**	0.045	0.028	0.085	0.040	0.047

Hadley's Matrix - 60% Optimism

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal **A**	0.061	0.044	0.104	0.074	0.084
Goal **B**	0.208	0.140	0.107	0.109	0.157
Goal **C**	0.421	0.328	0.140	0.140	0.234
Goal **D**	0.014	0.022	0.038	0.031	0.031
Goal **E**	0.040	0.026	0.079	0.035	0.044

Hadley's Matrix - 40% Optimism

Profile ⇨ Objectives ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
Goal **A**	0.057	0.043	0.099	0.063	0.078
Goal **B**	0.194	0.120	0.095	0.099	0.145
Goal **C**	0.407	0.316	0.136	0.136	0.226
Goal **D**	0.012	0.017	0.031	0.026	0.026
Goal **E**	0.036	0.025	0.074	0.031	0.041

Hadley's Matrix - 20% Optimism

Profile ⇨ Objectives ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
Goal **A**	0.052	0.041	0.095	0.051	0.072
Goal **B**	0.181	0.099	0.084	0.088	0.132
Goal **C**	0.392	0.305	0.131	0.131	0.218
Goal **D**	0.011	0.013	0.023	0.020	0.020
Goal **E**	0.032	0.023	0.068	0.026	0.038

APPENDIX-M

HADLEY'S DOMINANCE MATRICES

Dominance Matrix: Hadley's 80% Optimism

Profiles ⇨ ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
S_{ba}	--	1	2	2	3
T_{ba}	4	--	2	3	4
R_{ba}	3	3	--	2	3
N_{ba}	3	2	2	--	4
M_{a}	2	1	2	0	--
Column Sum	12	7	8	7	14
RANK	**II**	**V**	**III**	**V**	**I**

Dominance Matrix: Hadley's 60% Optimism

Profiles ⇨ ⇩	**Strategic Stimulation based Approach**	**Technology based Approach**	**Regulatory Environment based Approach**	**Nucleus based Approach**	**Mixed Approach**
S_{ba}	--	1	3	2	3
T_{ba}	4	--	3	3	4
R_{ba}	2	2	--	1	2
N_{ba}	3	2	3	--	4
M_{a}	2	1	3	0	--
Column Sum	11	6	12	6	13
RANK	**III**	**V**	**II**	**V**	**I**

Dominance Matrix: Hadley's 40% Optimism

Profiles ⇨ ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
S_{ba}	--	1	3	2	3
T_{ba}	4	--	3	3	4
R_{ba}	2	2	--	1	2
N_{ba}	3	2	3	--	4
M_a	2	1	3	0	--
Column Sum	11	6	12	6	13
RANK	**III**	**V**	**II**	**V**	**I**

Dominance Matrix: Hadley's 20% Optimism

Profiles ⇨ ⇩	Strategic Stimulation based Approach	Technology based Approach	Regulatory Environment based Approach	Nucleus based Approach	Mixed Approach
S_{ba}	--	1	3	1	3
T_{ba}	4	--	3	3	4
R_{ba}	2	2	--	1	2
N_{ba}	4	2	3	--	4
M_a	2	1	3	0	--
Column Sum	12	6	12	5	13
RANK	**II**	**IV**	**II**	**V**	**I**

Employee Involvement and Learning

- Incorporate skill based learning and principles of market economy in education cycle to develop entrepreneurial skills
- Provide formal training to employees to eliminate latent skill deficiencies
- Educate employees to accept the changes willingly
- Increase pressure on employees for technology development through in-house research
- Motivate employees to take risks and experiment to develop new product ideas and novel products
- Encourage individual capabilities by allowing employees to work on projects of their interest
- Work on projects through cross-functional teams
- Facilitate employee empowerment for creative output
- Adopt effective career planning measures for employees
- Improve knowledge of employees regarding capital grant schemes of government and submit proposals to obtain funds

COURSES OF ACTIONS (PROFILES)

- Strategic Stimulation based Approach
- Technology based Approach
- Regulatory Environment based Approach
- Nucleus based Approach
- Mixed Approach

Market Responsiveness

- Develop high value customized products for new market creation
- Bring innovativeness in design to develop new products
- Produce wide variety of product mix simultaneously
- Add features to the current product range regularly
- Use latest technology in products and processes to compete effectively
- Establish and maintain long term contractual relations with customers
- Learn to adapt quickly to customer needs and requirements
- Define range of technology options for competitive advantage
- Make the developed technology highly marketable
- Utilize the research function for increasing product mix and adding features to the current product range of the unit
- Broaden the sales and service network

Continuous Improvement and Development

- Find out opportunities and threats of globalization
- Make sustained and regular efforts to improve education levels and technical skills of employees
- Recruit qualified professionals in product designing and overseas marketing
- Encourage employees to work in various divisions to gain experience and appreciate problems of different parts of the unit
- Monitor external technology events through participation in conferences and symposia etc.
- Examine latest technology trends through publications in magazines, newspapers and research literature
- Bring in goal stretching programs to create innovation context
- Update product designs constantly using computer aided designing and finite element analysis
- Promote a change culture to make access to new technology less alarming.
- Encourage low cost automations through indigenous efforts for process improvements
- Learn and imbibe the process of innovation in day to day working
- Participate actively in international events (trade fairs etc) to identify technology gaps and develop business contacts
- Store results of project failures for possible adoption at a later stage
- Facilitate open communication for better flow of ideas across the unit

Policies and Directives

- Ensure efficient monitoring of support infrastructural facilities
- Arrange study visits of entrepreneurs to technically advanced industrial units to increase awareness regarding latest production technologies
- Identify sectors with high export potential and develop a well planned strategy for them to enter international markets
- Provide consultancy to units regarding formulation of marketing plans
- Provide access to well researched databases pertaining to market intelligence and upcoming technologies through a dynamic portal
- Set up facilities for small units to conduct experiment and testing work for in-house research
- Reduce burden of administrative regulations and delays to improve business environment
- Ensure coordination between centre and state governments for policy issues and fiscal concessions
- Safeguard intellectual property by effectively administering patent legislation
- Provide well structured mechanisms/ intermediary agents for effective interaction between units and research institutions
- Strengthen the technological capabilities of government supported R&D institutes
- Increase the number of RTC, FTS and TRs.
- Develop professional expertise in technology transfer in the university sector
- Increase focus of industrial policy on promotion of technological innovations and not just removal of technological obsolescence through technology transfers

Tie line

Business Strategy for Competitive Excellence

- Develop and introduce knowledge driven products through in-house technological innovations
- Promote knowledge based entrepreneurial skills
- Set up short term and long term organizational goals
- Develop a market niche through creation of innovative products having distinct features
- Improve project management/ production skills for faster technology commercialization
- Adopt a defined financial strategy and allocate specific proportion of annual budget for research projects
- Reduce manufacturing costs by decreasing overheads and using value analysis techniques
- Take short term risks (Risky Research Strategy) for long term pay-offs
- Adopt patenting as a means to protect ideas and product innovations from being copied by competitors

COURSES OF ACTIONS (PROFILES)

- **Strategic Stimulation based Approach**
- **Technology based Approach**
- **Regulatory Environment based Approach**
- **Nucleus based Approach**
- **Mixed Approach**

Organizational Support

- Reduce contract based employment and provide job security to employees
- Maintain adequate strength of R&D staff to undertake technology development projects
- Introduce well structured reward schemes based on intrinsic motivation tools to recognize employee contributions
- Incorporate skill based learning and principles of market economy in education cycle to develop entrepreneurial skills
- Create a tolerant atmosphere in which mistakes are accepted as part of taking the initiative for product innovations
- Provide adequate level of resources (finance, time etc) for research projects to convert innovative ideas into successful commercial products
- Develop flexible manufacturing facility to adapt to changing market dynamics
- Increase investments in CAD/ CAM and software packages for improved product designing and modelling
- Encourage low cost automations for process improvements through indigenous efforts
- Implement quality system procedures
- Create a mechanism to evaluate cost of investments in R&D
- Obtain credit rating of the unit through 'Credit Rating Scheme' (to identify strengths, weaknesses etc.) for hassle free flow of credit
- Define the level of risks that employees can take safely

Product Innovation Strategies

- Use latest technology in products and processes to compete effectively
- Establish a separate research department with well defined R&D policy and procedures
- Utilize research function for innovations and not for production-maintenance problems
- Establish formal research groups or allocate specific individuals to work exclusively on developing innovations
- Formulate and practice specific product innovation strategies to increase effectiveness of research function
- Adopt a systematic project based approach for product innovations
- Acquire technology only when indigenous development costs are forbidding
- Maintain competencies only in core technologies and obtain additional capabilities through alliances with others
- Promote higher R&D spending for specialized scientific and technical expertise
- Attend workshops/ short term courses on IPRs to increase awareness of employees regarding patents
- Formulate 'Vision and Mission' statements for long term strategic decision making
- Ensure economic justification of the developed technology

Networking and Joining Hands

- Build longstanding strategic partnerships with key technology providers
- Bring large scale manufacturing sector to the region to provide operational support to small units
- Collaborate with larger firms for finance, expertise and international opportunities
- Establish mutual trust and credibility with other small units to discuss common problem and share specialized knowledge
- Educate employees to learn across different organizational cultures for effective industrial collaborations
- Develop an information rich environment and physical infrastructure to promote inter-firm communication
- Promote subcontracting relations with large firms through Sub-Contracting Exchanges (SCXs) scheme of government
- Forge a mutually reinforcing relationship with premier technical institutes
- Train employees in specialized skills through short term courses and apprenticeship programs at institutes
- Form project teams with members both from industry and technical institutes to work on research projects
- Encourage universities to reshape curriculum for fostering creativity, team working and perseverance
- Undertake projects to receive financial grants (from DST etc.) for providing institutional framework for R&D to small units
- Arrange expert lectures of academic professionals at small units on upcoming key technologies

Policies and Directives

- Implement a unified law (integrated tax structure) to reduce multiplicity and high level of taxes
- Broaden the financial infrastructure and simplify the procedures for finance availability
- Provide prompt information regarding various financial schemes through regular advertisements
- Make access to finance from banks and financial corporations easy by reducing interest rates
- Provide financial assistance (soft loans, grants) and professional support to units attempting commercialization of indigenous technologies
- Improve access to capital subsidy schemes of government
- Provide financial assistance to units for obtaining quality system certification
- Grant custom duty exemption on capital equipment/ materials for R&D projects
- Develop a unified labour law with simple provisions to reduce constrained relations between employer and employees
- Develop a 'Central Distribution System' for raw material availability at reasonable prices
- Restrict frequent changes in steel prices to allow units to finalize long term contract for exports
- Allow units to come up only in designated industrial areas in a planned and controlled manner
- Provide good quality and reliable physical infrastructure at reasonable prices
- Ensure continuous and reliable supply of electricity at reasonable prices

Tie line

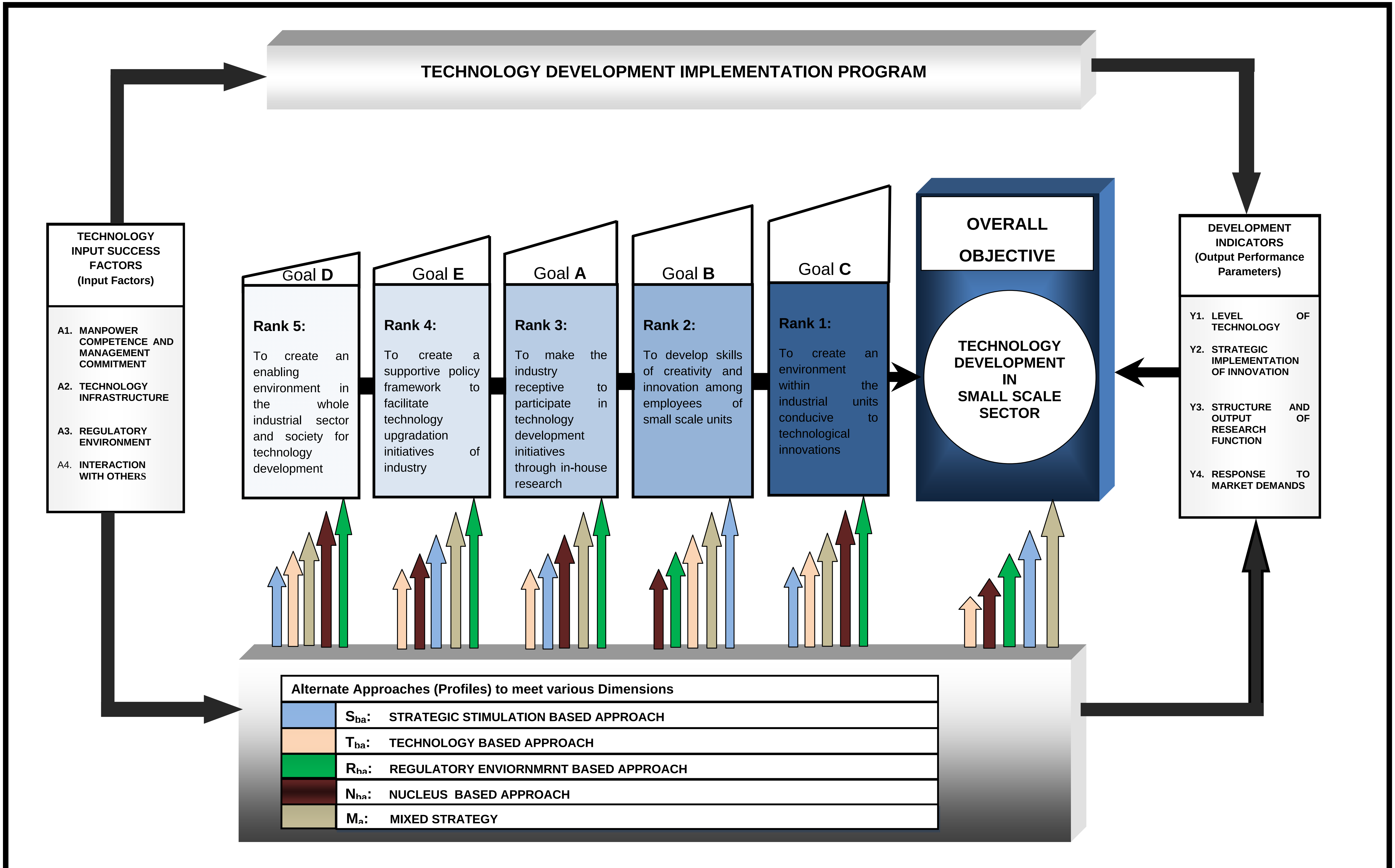

Figure 6.4 Technology Development Program for Small Scale Sector