Evaluation of contributions of Technology Upgradation initiatives towards Performance Enhancements in Small Scale Manufacturing Sector

A thesis submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF ENGINEERING
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By

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CERTIFICATE

This is to certify that the work presented in dissertation entitled **'Evaluation of contributions of Technology Upgradation initiatives towards Performance Enhancements in Small Scale Manufacturing Sector'** in partial fulfillment of the requirement for the award of degree of **Master of Engineering** in **Production and Industrial Engineering** in **Mechanical Engineering Department**, **Thapar University, Patiala** is an authentic record of the work carried out by me under the supervision and guidance of **Mr. Tarun Nanda, Assistant Professor, Mechanical Engineering Department, TU, Patiala**. The matter embodied in this seminar report has not been submitted anywhere else for the award of any other degree.

Dated: 15/07/2010

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i

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CONTENTS

ABSTRACT

As global competition is increasing rapidly with changing technology and shortening of product life cycles, corporations have become more vulnerable to failure than at any time in the past. These formidable changes have left the organizations with no choice but to upgrade the existing systems, products and technologies for their survival. The external acquisition of technology in the initial stages may be desirable or even necessary in the high technology areas, but no industry can prosper in the long run unless it builds up a self reliant base for carrying out indigenization of process and product technologies. In most developing countries like India, small scale industry is still relying heavily on external acquisition of technology. The over dependence of the Indian firms on external technology acquisition have rendered their available technologies and skills inefficient and outdated. They should start managing innovation in research and development activities to develop cutting edge technologies and products.

The objective of the present work is to assess the technology development capabilities of small scale manufacturing industry especially the cutting tool industry in the region. The research explores the present status of technology development capabilities of the tool industry with regards to organizational culture, policies, infrastructural facilities, investments in research initiatives, support from government and interaction with external agencies for technology upgradation. The reasons for low performance of small scale sector in the area of technological innovations have been explored. Further, the units are classified into various categories and analysis is carried out to evaluate the significance of various determinants of technology development program in improving the performance of industrial sector

LIST OF TABLES

LIST OF FIGURES

1.1 General

The economic activities are moving in the direction of globalization. It is creating new structures and new relationships, with the result that business decisions and actions in one part of the world are having significant consequences in other places. Underlying and reinforcing these globalization trends is the rapidly changing technological environment (Muhammad *et al.,* 2010). Increasing global competition coupled with rapidly changing technology, and shortening of product life cycles, have made corporations vulnerable to failure more than any time in the past (Jalan and Kleiner, 1995).

Global competition, technological change, and demanding customers are creating a more knowledge intensive, turbulent, complex and uncertain environment. Creating new forms of competitive advantage has become major area of concern for management in such an uncertain and competitive environment (Singh *et al.,* 2008). Firm's competitiveness is dependent on its ability to provide goods and services more efficiently than others involved in the market place. Today's intense competition requires that firms excel simultaneously in several areas without tradeoff, including innovativeness and responsiveness to their customers. Therefore, organizations should develop core competencies, which will give them a competitive advantage over their competitors in meeting fast changing market requirements. Organizations, which are able to continually build new strategic assets faster and cheaper than those of their competitors, will create long-term competitive advantages (Ajitabh and Momaya, 2004). For the industry to stay "alive" and remain competitive, it must innovate. Innovation is therefore portrayed as the backbone of any industry (Mafunda *et al.,* 2005). In today's business world successful product or process innovation provides companies with major opportunities and advantages. Successful innovation is increasingly important in the globally competitive economy (Regan *et al.,* 2006).

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 organization survival, growth and excellence. Thus the organizations are left with no choice but to upgrade the existing systems, products and technologies for their survival (Martins and Terblanche, 2003; Yang, 2007).

1.2 Technology

Technology means the systematic application of scientific or other organized knowledge to practical task. The word 'technology' comes from two Greek words *'Techne'* and *'Logos'*. *'Techne'* means the skill or craft needed to make something and *'Logos'* mean discussion or knowledge of something. Technology is defined as the practical knowledge, know-how, skill and artifacts that can be used to develop a new product or service and/or a new production/delivery system (Moriarity, 1990). Technology refers to a system of components which act on or change an object from one state to another. Technology is purposeful application of knowledge developed in various areas that include hardware or software, general or firm specific, and alternative, intermediate or appropriate. In a broad sense, technology denotes the broad area of purposeful application of the contents of the physical life and behavioral sciences. It comprises the entire notion of techniques as well as the medical, agriculture, management and other fields with their total hardware and software contents (Zhao and Reisman, 1992)

1.3 Technology Upgradation

In this modern age, technology is the most important resource to any nation. It is the main driver of a nation's economic development. The need of the hour is to deliver high quality products through continuous improvements in product features, bring new products to the market faster, make product changes faster and more manageable, improve forecasting accuracy of the product demands, reduce costs, improve employee training, skills and education levels, improve information systems and networks, achieve greater flexibility of manufacturing functions (Singh *et al.,* 2010).

In this rapid paced environment, the organizations are faced with challenge of bringing forth a steady stream of new products and technologies. Thus the organizations have to learn to stretch themselves in order to create new products and technologies and challenge before the organizations is how they can create their own successful future. Thus continuous upgradation of technology has become essential for survival of any manufacturing unit.

It is high time that the industries wake up and gear up for R&D initiatives to develop cutting edge technologies for sustained competitive advantages in the global market place. Technology upgradation has become mandatory for economic development, industrial growth, enhanced corporate image, more flexible responses, strategic self-reliance and sustained competitiveness of an enterprise. Thus 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 up-gradation is research and development (Choi, 1989).

1.3.1 Means of Technology Upgradation

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 productive 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" (Conceica *et al.,* 2002). For "competition through innovation", there are two options:

- Technology Acquisition or Innovation from Outside
- Technology Development or Innovation from Within

1.3.1.1 Technology Acquisition

'Technology acquisition' or 'Innovation from Outside' is the process of acquiring technology developed by a source external to the company and implementing it in the company. Technology acquisition can be viewed as a process during which technology is carried across the boundary of two entities. These entities can be two companies or countries. Technology acquisition is helpful for the organization and countries, which don't have capabilities to develop technologies of their own. Borrowing technology from outside the firm helps industries accomplish technology accumulation in a short period of time, introduce new products or improve the quality of existing ones at low risks (Van Gundy, 1998).

1.3.1.2 Technology Development

The process of developing technology by a company on its own using its R&D and internal resources is called 'Technology Development' or 'Innovation from Within'. This is the best option for technological growth of the company but, is quite expensive both in terms of time and money. It requires extensive technical/scientific manpower and R&D infrastructure. In addition to this, the shortening of technological life cycle also makes it extremely difficult to make heavy investments in R&D.

1.3.2 Significance of Innovation from Within

The external acquisition of technology in the initial stages may be desirable or even necessary in the high technology areas, but no industry can prosper in the long run unless it builds up a self reliant base for carrying out indigenization of process and product technologies. It is high time that organizations learn to embrace change, as development of advanced technologies help in improving the competitive position of the organization and the full advantage of such technologies can not be purchased off the shelf. Also it is not possible for the organizations to acquire state-of-the-art technologies from external sources due to the basic reason that no entrepreneur ever offers state-of-the-art technology at terms that are suited to encourage the growth and development of the organization and that might lead to the capability building of the purchasing organization. Moreover in many situations, even if state-of-the-art technology is made available to the organizations, it is usually not affordable to effectively and economically adopt/absorb the same into its operations. Also in technology acquisition, a large amount of recurring expenses are involved (Pegels, 1996; Myhrvold, 1997).

1.4 Change in Industrial Scenario

The uncertainties due to globalization of the Indian market after economic reforms have led to drastic changes in the approach of manufacturing organizations for developing various competencies to get competitive advantage. The new competition is in terms of reduced cost, improved quality, products with higher performance, a wider range of products with better service, and all delivered simultaneously (Nanda and Singh, 2008).

The industrial scenario in India has undergone a sea-change consequent to the globalization and liberalization of economy. This competition is marked by rapid technological developments and unprecedented obsolescence rates. Today, the biggest challenge before the 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. The over dependence of the Indian firms on external technology acquisition have rendered their available technologies and skills obsolete, inefficient and outdated. They should move away from their complacent technology development and innovation initiatives and start managing innovation in research and development activities to develop cutting edge technologies and products.

In most developing countries, small and medium enterprises constitute the bulk of the industrial base and contribute significantly to exports as well as to GDP. For instance, in India SMEs, which account for almost 50 per cent of industrial output and 42 per cent of India's total exports. It is the most important employment-generating sector and is an effective tool for promotion of balanced regional development. These account for 50% of private sector employment and 30-40% of value-addition in manufacturing.

According to the Global Competitiveness Report, 2009-2010, published by Harvard Institute, India ranks fourth in the world on the factor of availability of scientists and engineers, yet it ranks at 43 out of 133 nations on overall technological sophistication. The paradox is very stark. On one hand India has developed, nuclear capabilities and has shown lot of strength in the areas of satellite communication, missile technology but on the other performs badly in the export of capital equipment.

The pattern of technology funding by Indian government, does not reflect priorities inferred from economic development and growth objectives. An analysis of R&D expenditure in India shows that funding for technology in specific sectors is not in consonance with the size of domestic or global markets. In India, too much of research and development effort is expended in the public sector. Over 80% of the funding for R&D comes from the government and almost all of this is spent in government run organizations. India stands at number 36 on private sector spending on R&D among 133 developed and emerging economies.

The country ranks 46 on research collaborations between the universities and industry. All high technology businesses across the globe have academic ties wherever they are located. This type of industry - institute interaction lacks in India with a ranking of 46 out of 133 countries (Global Competitiveness Report, 2009-2010).

The status of Indian manufacturing industry in various areas which affect technology innovation capabilities is presented in Table 1.1.

Table 1.1: Technology Innovation Capability of Indian Industry

S.No.	Parameter	India's Rank (133 Countries)
1	Transparency of government policy making	43
2	Burden of government regulations	95
3	Wastefulness of government spending	55
4	Quality of electricity supply	106
5	Quality of overall infrastructure (Transport & Communication)	89
6	Local availability of specialized research and training services	32
7	Extent of staff training	34
8	Availability of latest technologies	31
9	Hiring and firing practices for labor	103
10	Quality of educational system	37
11	Number of procedures required to start a business	111
12	Production process sophistication	43
13	Patents and use of IPR	58
14	Availability of scientific and technical manpower	04
15	Private sector spending on R&D	36
16	University-industry research collaboration	46
17	Overall Technology Sophistication	43

1.5 Research Problem

Successful innovation occurs when an invention, related to a product, service or process in some part of the organization's value chain, is joined with a business design, which in turn is implemented with discipline and skill through innovation management. Successful innovation management requires developing a strategic approach to innovation. The research work is carried out in cutting tool sector in the region. It aims to detect technological innovation processes in the small scale industry and inputs and outputs of the process.

Thus the research problem for the study is stated as:

"What are the main technology development initiatives which influence performance output of the industry"

The present work is an attempt to identify the main factors for affecting technological improvements in the industry. The work would identify the status of key parameters and their relative contributions in performance improvements in the industrial sector.

1.6 Organization of the Thesis

The write up of the thesis is divided into five chapters as discussed as follows. Overall structure of thesis is presented in Figure 1.1.

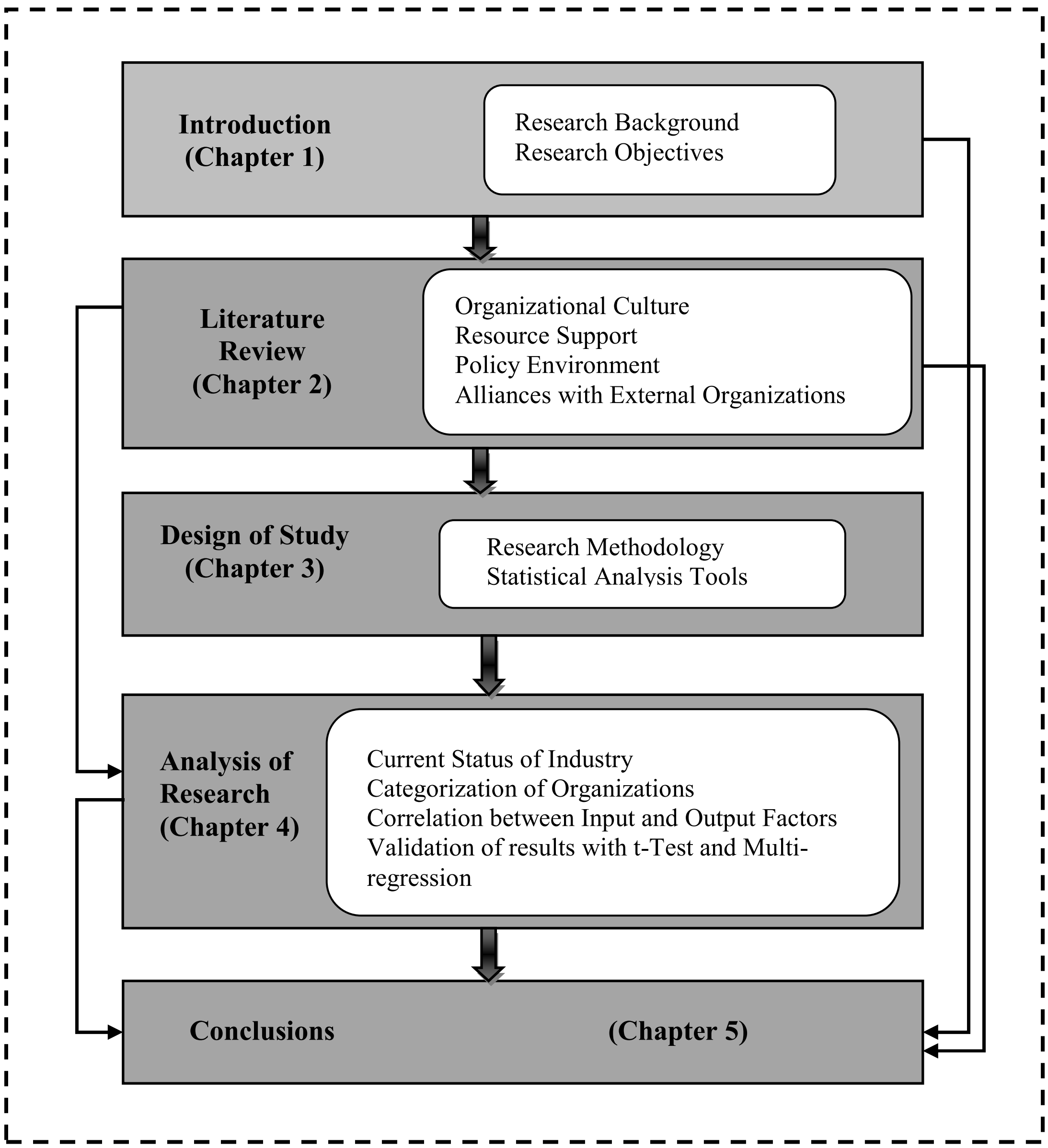

Figure 1.1 Thesis Structure

- **Chapter I** highlights the need for technology upgradation in the manufacturing industry. It defines the research problem and covers the organization of research work.
- **Chapter II** reviews in detail the previous studies to identify the factors which facilitate the technological innovations in manufacturing enterprises. The broad areas identified are organizational culture, resource support, policy environment and alliance with external organizations. The chapter also discusses the research hypothesis.
- **Chapter III** introduces overall design of the study, which includes phases of research and methodology adopted for carrying out the research work. The details of work done in each phase, tools, techniques and models used in the dissertation have also been presented in this chapter.
- **Chapter IV** presents the results of detailed survey conducted in various manufacturing enterprises. Descriptive and empirical analyses of data collected through the survey have been carried out to assess the status of present level of different dimensions of technology development program.
- **Chapter V** covers the summary of research work, its results, conclusions, and the recommendations. Further, the limitations along with scope for future work have been covered in subsequent sections of this chapter.

1.8 Concluding Remarks

An organized attempt has been made to make this study exhaustive, intensive and broad based as possible, for investigating the role of innovation and other development initiatives in technology upgradation.

As global competition is increasing rapidly with changing technology and shortening of product life cycles, corporations have become more vulnerable to failure than any time in the past. These formidable changes have left the organizations with no choice but to upgrade the existing systems, products and technologies for their survival. The external acquisition of technology in the initial stages may be desirable or even necessary in the high technology areas, but no industry can prosper in the long run unless it builds up a self reliant base for carrying out indigenization of process and product technologies.

In most developing countries like India, small and medium enterprises (SMEs) are still relying heavily on external acquisition of technology. The over dependence of the Indian firms on external technology acquisition have rendered their available technologies and skills inefficient and outdated. They should start managing innovation in research and development activities to develop cutting edge technologies and products.

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

2.1 Introduction

This chapter is an attempt to record in brief what has been reported in research literature on various aspects of technology development initiatives required to become competitive. The review has been carried out to assess the requirements of manufacturing industry with regards to existence of facilities and programs for technology development through indigenous research and development (TD) program.

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

- Organizational Culture
- Resource Support
- Policy Environment
- Alliance with External Organizations

2.2 Organizational Culture

Organizational culture and climate is an integral component of any technology development program. Management support and competent workforce are critical to the success of indigenous technology development initiatives. The important issues under this component are discussed as follows:

In the implementation of innovation, firms have to create an organizational culture and climate that fosters innovation by ensuring employee skills, providing incentives and removing obstacles (Aderemi, 2009). Innovative organizations in today's business environment are those who manage their human resources well along with their technological resources. It includes effective manpower planning, recruitment and selection process, realistic performance plans and development oriented performance appraisal, effective learning system providing ample learning opportunities with the help of training, performance guidance and other mechanism such as mentoring. It also consists of mechanism to inculcate sense of pride in work, high degree of organization commitment etc. (Hassan *et al.,* 2006).

Competent workforce is an important element of technology development initiatives of an organization. In innovative organizations, employees directly contribute to the innovation content and assist in improving the process of innovation; such organizations have a significant approach towards manpower development in order to achieve long term organizational goals (Kim and Choi, 1997; Sugasawa and Liyanage, 1999). Innovative organizations believe that the bottom line difference between success and failure is finding, developing and nurturing the right people (Singh *et al.,* 2009).

Skilled workforce can contribute to the performance, effectiveness, competitiveness and sustainable growth of an organization. As a result the recruitment, retention and development of skilled people in the workforce, has become a keen issue for consideration (Klein and Sorra, 1996; Taxell, 2009).

Firms who are adopting and using advanced technologies, continually working to improve the quality of their products, and striving to be first-to-market with new products require a workforce that is adaptable, skilled, and educated (Baldwin *et al.,* 1996; Baldwin and Da Pont, 2008). Innovative organizations have adequate strength of multi-skilled workforce. Strategies are made for identification of areas of skills in which shortfalls either occur or can occur and efforts are made to generate those skills (Visalakshi, 2001). 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).

Lack of availability of multi-skilled or trained personnel is a major business problem in small scale manufacturing organizations. Further, small scale 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 (Abor and Quartey, 2010).

In tomorrow's business world success will be critically influenced by the degree to which firms utilize new knowledge to support innovation (Singh *et al.,* 2008; Yang *et al.,* 2009). For this, 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 (Lange *et al.,* 2000; Leede *et al.,* 2002; Indarti and Langenberg, 2004).

Organizations perform better when they are making investment in training their employees and broaden their skills. The pace at which training system transmits knowledge and skills of the requisite quality directly affects the pace of development (Oyelaran, 2010). Innovators and advanced technology users are more likely to train their workers in response to skill shortages and to the introduction of new techniques, than firms that do neither (Chunyan, 2009)

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). 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 in formal means (Meredith and Burkle, 2008).

Availability of scientific and technical manpower in adequate strength is critical to the success of technology development implementation program. Specialized knowledge and experience in science and engineering is the condition for technological learning and achievement of innovativeness in organizations. Hence, innovativeness in SMEs requires more than having practical, intermediate-level technical skills (Oluwajoba *et al.,* 2007).

Innovative organizations make strategic choices with regard to their human resources. The performance of business organizations depends on ensuring that all categories of employees possess current and up-to-date knowledge and skills (Roy and Raymond, 2008). When the human resources are competitive, they can push the boundaries of technical competence into the area of the unknown or the new (Mc Fadzean, 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. Successful innovation based organizations know how to manage, motivate and reward employees (Gupta *et al.,* 1991). Recognizing individual and team accomplishment with awards encourages innovation. Employee's creativity and innovation skills can increase only by giving them appropriate recognition and reward for their creative work (Koning, 1998; Kiran and Jain, 2010).

In organizations where innovation is 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 recognition (Gupta and Singhal, 1993).

Table 2.1 Major Findings of Literature on Organization Culture Issues

Factors	Key Issues	Supportive Literature
Manpower Development	Innovative organizations believe that the bottom line difference between success and failure is finding, developing and nurturing the right people. Skilled workforce contributes to performance and sustainable growth. Encourage employees to work in various departments.	*Kim and Choi, 1997; Sugasawa and Liyanage, 1999; Visalakshi, 2001; Singh et al., 2009;*
Learning Environment	High-performing organizations spend more time on education and training not just on technical, task-related skills, but also on communication and team skills. Highly skilled and educated workforce is key to increased competitiveness and sustainable growth	*Keogh and Stewart, 2000; Lange et al., 2000; Leede et al., 2002; Indarti and Langenberg, 2004;*
Training to Employees	Innovative organizations continually educate and train their employees in various skills, matching with organization's needs. Maintaining competitiveness relies not only on job-specific training or on-the-job training, but also on a greater degree of formal training. Organizations perform better when they are making investment in training their employees and broadening their skills.	*Bessant, 1993; Locke and Kirkpatrick, 1995; Lange et al., 2000; Oyelaran, 2010*
Traits for Innovation	Availability of scientific and technical manpower in adequate strength is critical to the success of technology development implementation programs. When the human resources are competitive, they can push the boundaries of technical competence into the area of the unknown or the new.	Mc Fadzean, 1998; Pihkala *et al.*, 2002; Oluwajoba *et al.*, 2007
Intrinsic-Extrinsic Motivation	Employee reward systems include such practices as providing freedom for creativity, financial rewards, promotions, and other recognition. Innovative organizations rely heavily on personalized intrinsic rewards whereas less innovative organizations tend to place almost exclusive emphasis on extrinsic awards	*Gupta et al., 1991; Gupta and Singhal, 1993; Koning, 1998;; Martin and Terblanche, 2003; Morris, 2005; Kiran and Jain, 2010*
Risk-Taking and Strategic Direction	Creativity and innovation are truly enhanced when the entire organization supports them. Freedom to experiment, to do things and fail, to challenge the status quo, discussion of dumb ideas, and no punishment for mistakes are cultural traits for innovative organizations.. An organizational culture in which personnel are encouraged to generate new ideas, without being harmed, and where the focus is on what is supported instead of what is not viable, encourage creativity	*Morgan 1991; Amabile et al., 1996; Filipczak, 1997; Mishra and Srinivasan, 2008*

Extrinsic rewards include pay hikes, bonuses, shares and stock options. Intrinsic rewards are based on internal feelings of accomplishment by the recipient and include increased autonomy and improved opportunities for personal and professional growth. Innovative organizations rely heavily on personalized intrinsic rewards whereas less innovative organizations tend to place almost exclusive emphasis on extrinsic awards (Martin and Terblanche, 2003; Morris, 2005).

Developing new products requires teamwork. Innovative organizations strike a fine balance between rewarding a team as a whole and rewarding individual members for their contributions to the team (Mosey *et al.,* 2002; Mosey, 2005).

Creativity and innovation are truly enhanced when the entire organization is supportive (Mishra and Srinivasan, 2008). Senior management support is very important for creativity and innovation (Anderson *et al.,* 1992, McFadzean, 1997). Experimenting and taking risks are behaviors associated with creative persons. 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 (Ahmed, 1998b).

An organizational culture in which personnel are encouraged to generate new ideas, without being harmed, and where the focus is on what is supported instead of what is not viable, encourage creativity (Filipczak, 1997). 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 (Amabile, 1988; Brand, 1998). Successful organizations reward success and acknowledge and celebrate failures, for example, by creating opportunities to openly discuss and learn from mistakes (Ryan, 1996; Kiran and Jain, 2010). Innovation based organizations hold a remarkably constructive attitude towards failure. If a project fails, the employees are not punished but encouraged to continue with the next project (Roberts, 1980).

2.3 Resource Support

To support technology development programs, organization must provide resources in the form of adequate physical infrastructure (like dedicated laboratories for experimentation, advanced production systems and softwares for modeling and analysis) and sufficient financial support. Important issues under this component are discussed as follows:

Infrastructure becomes critically important in a world characterized by an abundance of emerging technologies. All major technology breakthroughs require a surrounding infrastructure (Best and May, 1997). 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 less innovative organizations (Laffort and Tann, 2006). Organizational structure should be such that there are adequate funds, materials, production facilities and information support system to sustain innovation (Amabile *et al.,* 1996; Ghosbani and Bagheri, 2008). Capability base of the firm is enhanced through internal learning, involving investments in formal R&D, experimentations, making minor adaptations to products, processes and organizations, in-house staff training, among others. Organizations, which are able to continually build new strategic assets faster and cheaper than those of their competitors, will create long-term competitive advantages (Ajitabh and Momaya, 2004).

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).

Project resources include an array of elements: people with necessary expertise, sufficient funds, material resources, systems and processes for work, relevant information and availability of training (Amabile *et al.,* 1996; Williams, 2001; Pihkala *et al.,* 2002). For better technological advances, new infrastructures (mainly telecommunication), information technology, modern production systems and new strategic thinking practices are needed (Sheel, 2002; Vargas and Rangel, 2007). Developing an adequate financial programme 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).

In order to enhance efficiency and productivity, organizations are encouraged to undertake measures to modernize and upgrade machinery, equipment and operation (Char *et al.,* 2010; Muhammad *et al.,* 2010)

Table 2.2 Major Findings of Literature on Resource Support Issues

Factors	Key Issues	Supportive Literature
Physical Environment	Absence of adequate infrastructure services is one of the main problems that hinder efforts to develop technology Project resources include an array of elements: people with necessary expertise, sufficient funds, material resources, systems and processes for work, relevant information and availability of training For better technological advances, new infrastructures (mainly telecommunication), information technology, modern production systems and new strategic thinking practices are needed Building a physical infrastructure for enhancing organizational capabilities and developing an adequate financial programme that supports training and educational activities for innovation are the key success factors for highly innovative companies	*Smilor et al., 1988; Amabile et al., 1996; Williams, 2001; Pihkala et al., 2002; Sheel, 2002; Odette et al., 2006; Ridley et al., 2006; Ghorbani and Bagheri, 2008; Char et al., 2010; Muhammad et al., 2010*
Capital Support	Innovation budget is one of the factors that distinguish innovative firms from their less innovative counterparts. Management must clearly earmark funds for R&D activities aimed at innovations for new product and process developments Higher R&D spending heightens the level of research activity and builds specialized scientific and technical expertise as a result. The tangible outcome of this is the ability to develop several significant product technologies	*Chandrashekhar, 1995; Amabile, 1998; Parthasarthy and Hammond, 2002; Souitaris, 2002; Huang, 2008; Abor and Quartey, 2010*

Innovation budget is one of the factors that distinguish innovative firms from their less innovative counterparts (Souitaris, 2002). Management must clearly earmark funds for R&D activities aimed at innovations for new product and process developments (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 (Parthasarthy and Hammond, 2002; Huang, 2008). Manufacturing organizations in developed countries spend substantial fraction of annual turnover on technology development (Chandrashekhar, 1995).

The role of finance has been viewed as a critical element for the development of SMEs. Lack of adequate financial resources places significant constraints on SME development. A large portion of the SME sector does not have access to adequate and appropriate forms of financial services (Cook and Nixson, 2000; Abor and Quartey, 2010).

2.4 Policy Environment

Government can create the right economic, fiscal and regulatory framework within which innovation 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 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 (Henrik *et al.,* 2009; Zeng *et al.,* 2010).

Public policies focusing on increasing 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; Avnimelech and Teubal, 2008).

Policy restrictions and complex procedures greatly hinder the growth of small firms. Reforming policies and simplifying regulations are thus preconditions for boosting the growth of industry. Policy makers need to understand much better the motivations and requirements that shape and drive an innovative firm (Beaver and Prince, 2002; Hyland and Beckett, 2005).

Governments should develop policies for technological innovations, both on a global and local scale, using especially tools geared towards improving the links between firms and research. These tools involve creation of infrastructures for assistance and technological transferal. 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 firms (Cariola, 2009; Henrik *et al.,* 2009).

Government provides a range of programmes to help businesses to 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 include: 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; Sheel, 2002; Hyland, 2004). Facilitating access to credit and business development services and promoting formalization, all increase firm's growth (Brown *et al.,* 2005; Shi *et al.,* 2008; Fajnzylber *et al.,* 2009).

Table 2.3 Major Findings of Literature on Policy Environment Issues

Factors	Key Issues	Supportive Literature
Government Policies on R&D for Small Scale Sector	Policy restrictions and complex procedures greatly hinder the growth of small firms Government can create the right economic, fiscal and regulatory framework within which innovation can flourish. Government assistance can basically be divided into two sub-groups: financial and technical.	*Beaver and Prince, 2002; Hyland and Beckett, 2005; Cariola, 2009; Henrik et al., 2009; Zeng et al., 2010*
Support Mechanisms	Government can support programs to build infrastructure as well as incentives (such as tax incentives) Government provides a range of programmes which include financial and credit assistance; technical and training assistance; extension and advisory services; marketing and market research; and infrastructure support	*Abdullah, 1999; Paul and Robson, 2000; Rolfo and Calabrese, 2003; Brown et al., 2005; Shi et al., 2008; Tambunan, 2008; Fajnzylber et al., 2009*
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. Government support for small-scale sector is provided in the form of direct grants, subsidies or other forms of financial support. Increase in technological innovation demands that government should enhance the extent of investment on R&D and training of employees through targeted expenditure and collaborative research programs.	*Liyanage, 2003; Regan et al., 2006; Soderbom et al., 2006; Elaine et al., 2007; Massa and Testa, 2008; Fajnzylber et al., 2009;Zhang,2009;Jaehoon,2010*

Government can provide a supportive environment conducive for growth. Business environment is assessed by the extent of delay in obtaining government permissions and clearances like 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. These interactions are costly in terms of time, labour and money. Any delay in getting clearances from the administrative regulations adds to these costs. A congenial business environment should aim at minimizing these costs of interactions (Paul and Robson, 2000; Rolfo and Calabrese, 2003).

Government can also play an important role in enabling industry to be creative through correction of market failures. It can encourage networking, promote growth ambitions and encourage new product development. 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).

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. Despite of these obstacles, which are mostly interdependent, the general opinion on which SSI supporting policies are based, stems in the fact that lack of finance makes up the principal restraint in their growth and intensification (Soderbom *et al.,* 2006; Elaine *et al.,* 2007; Jaehoon,2010).

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. 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 (Massa and Testa, 2008; Zhang and Dai, 2009).

Increase in technological innovation demands that government should enhance the extent of investment on R&D and training of employees through targeted expenditure and collaborative research programs (Liyanage, 2003; Regan *et al.,* 2006; Fajnzylber *et al.,* 2009).

2.5 Alliance with External Organizations

Organizations are feeling the pressure of shifting markets because of globalization and have to operate in a competitive environment. Their need for support and information is high and they must make improvements in internal strategies to start interacting with external organizations (Wani *et al.,* 2004).

Organizations need a culture that supports collaboration and a systematic approach for managing innovation. Knowledge is generated not only by individuals and organizations, but also by their complex pattern of interaction (Roy, 2000; Hyland and Beckett, 2005; Santos, 2006).

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 (Faem *et al.,* 2005). Further, collaborations with customers and suppliers contribute most effectively to the exploitation of results (Christensen, and Overdorf, 2000; Frishammar, and Horte, 2005), while collaborations with universities rather address the explorative capabilities (George *et al.,* 2002).

Forming networks with other organizations in the search for information is a mechanism, by which small firms can emeliorate the problem of extending their knowledge base and strengthen their market standing. To develop new-to-market products, firms must continually build new networks of customers and suppliers by using a trial and error approach. This results in gain of requisite new markets and technological knowledge (Mosey, 2005; Ha-Brookshire, 2009). Strong ties can offer steady flows of new ideas, technological innovations, and operational support (Nanda and Singh, 2009).

Research highlights the importance of adopting the strategy of networking or the formation of a consortium among the various actors in the innovation process in its different stages (Roy, 2000). 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).

Partnerships between SMEs and large firm partners help SMEs 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 (Indergaard, 1996; 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 (Mooreman *et al.,* 1992; Rycroft and Kaash, 2002; Singh *et al.,* 2008).

University-Industry Collaborations are especially appealing for companies that aim to stay up-to-date concerning the latest technological developments and to foster innovation capabilities (Hall *et al.,* 2003; Siegel *et al.,* 2003; Hurmelinna, 2004; Prichard *et al.,* 2008).

By collaborating with universities, firms may reduce uncertainty inherent from the innovation process, as well as expand their markets, access to new or complementary resources and skills, keep up with evolution of scientific knowledge, and create new technological learning options on future technologies (Thomas, 1993; Hagedoorn *et al.,* 2000).

Industrial academic collaboration is an efficient way to accelerate and diversify the progression of novel technological solutions, educate new multidisciplinary professionals, and incubate new business (Katz 2006; Nelson 2008).

Institutes are not making sincere efforts to properly develop and maintain their resources, and to ensure that they are capable to cater to the contemporary needs of industry. Further institutions are showing neither interest nor inclination to market their resources, and industry is mostly unaware of what institutions can deliver and how they can be helpful to it (Jaffe, 2003).

The main reasons for establishing industrial academic collaboration with an industrial R&D consortium are accelerating the built-up of competence, intensifying knowledge transfer, creating a new value network, sharing costs and risks, and educating multidisciplinary professionals (Becker and Gassmann, 2006; Hanel and Pierre, 2006).

As most SMEs lack financial resources, the best way 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 centres for technological transfer and foster firms in making use of the scientific and technical services offered by these centres and institutes (Justman and Teubal 1996; Kharbanda, 2001)

Table 2.4 Major Findings of Literature on Alliance with External Organizations Issues

Factors	Key Issues	Supportive Literature
Industrial Collaborations	Strong ties can offer steady flows of new ideas, technological innovations, and operational support Collaboration with much larger organizations can provide resources, in the form finance and expertise, as well as future sales and international opportunities	*Mooreman et al., 1992; Indergaard, 1996; Mitra, 2000; Rycroft and Kaash, 2002; Terziovski, 2003 ; Capaldo, 2007; Li and Qian, 2007; Singh et al., 2008; Xu et al., 2008;*
Networking as a Strategy in SMEs	Forming networks with other organizations in the search for information is a mechanism, by which small firms can ameliorate the problem of extending their knowledge base and strengthen their market standing. Business networks play an important role in activating innovation in SMEs. Networks can provide a valuable source of support, information and a means of sharing resources.	*Rothwell, 1991; Barnir and Smith, 2002; Beaver and Prince, 2002; Love and Thomas, 2004; Xu et al., 2008; Nanda and Singh, 2009*
Industry-Institute Bonding	University-Industry Collaborations are especially appealing for companies that aim to stay up-to-date concerning the latest technological developments and to foster innovation capabilities. By collaborating with universities, firms may reduce uncertainty inherent from the innovation process, as well as expand their markets, access to new or complementary resources and skills, keep up with evolution of scientific knowledge, and create new technological learning options on future technologies.	*Thomas, 1993; Hagedoorn et al., 2001; Hall et al., 2003; Siegel et al., 2003; Hurmelinna, 2004; Prichard et al., 2008*
Other Alliances	As most SMEs lack financial resources, the best way is to enter into linkages and partnerships with other enterprises, academia and/or R&D institutions. Service institutes and private research laboratories which are engaged in the supply of scientific, technological and market knowledge can be sources of taking competitive advantage	Malerba, 1992;Thomas, 1993; Justman and Teubal 1996; Gibb, 1997; Maniukiewicz *et al.,* 1999;

Service institutes and private research laboratories which are engaged in the supply of scientific, technological and market knowledge can be sources of taking competitive advantage (Thomas, 1993; Gibb, 1997; Maniukiewicz *et al.,* 1999).

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 from both internal sources of knowledge such as through R&D activity and from a wide variety of external sources (Malerba, 1992). These external sources are represented by many organizations such as universities and research institutions, government laboratories and agencies, competitors, suppliers and customers (Dosi, 1988). Firms' collaboration with external organizations allows the expansion of their range of expertise and can support the development of new products.

2.6 Theoretical Models

Some of the important theoretical models in the context of technological innovations in SMEs are presented as follows:

Plunkett (1990) analyzed the effect reward mechanisms on innovation potential of firms. The study revealed that extrinsic rewards have to be present at a base level to ensure that individuals are at least comfortable with their salary. Beyond these threshold levels, innovation is primarily driven by self esteem and intrinsic motivation tools and not by extrinsic rewards.

Gupta and Singhal (1993) analyzed that innovative organizations have adequate strength of multi-skilled workforce. These 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.

Amabile (1996) proposes that to enhance employee's creativity, organization structure should be such that it should have adequate funds, materials, facilities, and information support system to support innovation and technological advancement.

Judge et al. (1997) suggested that too many management controls inhibit risk taking and consequently creativity. 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. 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 and regarding mistakes as learning experiences.

Losey (1999) reports that organizations always seek help from the workforce and must build effective training programs for improving employee's skills in order to develop employee competencies and to enable them to respond quickly and flexibly to business needs. The research reports that formal training contributes more to technological improvements compared to on-the-job training or other forms of informal training.

Lange et al. (2000) identified and clarified the barriers to skills development in SMEs and sub-divided these barriers into four simplified categories. These include ‘Cultural barriers’, ‘Financial barriers’, ‘Access and Provision barriers’ and ‘Awareness barriers’.

Sheel (2002) states that for technological advances new infrastructures, mainly telecommunication, information technology, new strategic thinking practices are needed for hypercompetitive environment.

Beaver and Prince (2002) have investigated that government and policy makers need to understand much better the motivations and requirements that shape and drive an innovative firm. Main outcome of their study suggests that government can help raise the awareness of the benefits of innovation, of adopting progressive strategic management practice and provide sufficient financial resources for efficient business support services.

Leede, et al. (2002) has suggested that high-performing organizations spend more time on education and training not just on technical, task-related skills, but also on communication and team skills.

Love and Thomas (2004) discovered the extent of the effect of business networks on SMEs. This research study showed that networks, if they are to be successful, have to provide a wide range of advice, support, opportunities for networking, joint marketing and promotion, information as well as sharing skills and resources. The study also proved that networks for small manufacturing firms can be a very cost effective way of improving their performance.

Narayana (2004) focused on analysis of quality and cost of infrastructure facilities and business environment, and their impact on competitiveness of India’s Small-Scale Industries (SSIs). Infrastructure facilities include transport, market information, credit, power, water, telecom, technology upgradation and quality certification. Quality of business environment is indicated by duration of delay in obtaining government’s permissions and clearances.

Zhongming W. (2005) suggests that employee training has a direct and positive effect upon technological innovation in firms. In order to achieve long term gains, a variety of practices are required for facilitating employee's high performance, intrinsic motivation, teamwork and attitude.

Kelly (2007) have found that relationship benefits sought by small firms collaborating with larger partners can be classified as cost, service, image and flexibility benefits and suggest that their transfer can facilitate improved small firm competitiveness by building capabilities and resources.

Li and Qian (2007) have suggested that SMEs engaged in technology industries are different from traditional industries in three significant ways. Innovation is much more frequent in technology industries, frequent innovations lead to short product life cycles and economics of scale is not necessarily important competitive advantage.

Singh et al. (2008) have showed that SMEs face many constraints due to lack of resources and poor innovative capabilities. For sustaining their competitiveness, they have to benchmark their assets, processes and performance with respect to best in the industry. There is also need for developing a framework for quantifying the competitiveness by adopting a holistic approach. Major problems are related with knowledge loss, product design and development capability, training infrastructure and networking.

Xu et al. (2008) have found that 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. Partnerships between SMEs and large firm partners help SMEs 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.

Zhang (2008) states that scientific and technological innovation is a key factor that promotes economic growth. Governments are required to offer policies and funds to support scientific and technological innovation to solve the problem that the market is unable to dispose the scientific and technological innovation resources effectively.

Marques and Ferreira (2009) have identified factors that contribute to the building of a firm's innovative capacity. A conceptual model is proposed consisting of dimensions namely: the firm;

the entrepreneur; the external business environment; the firm's innovative capacity; and the firm's performance. The results provided evidence regarding the factors influencing the innovative capacity of firms.

Henrik et al. (2009) analyzed the role of direct government assistance during start-up and other forms of interaction with the state sector. The results indicate that the government support has influenced long-run performance of small and medium-sized manufacturing enterprises.

Nanda and Singh (2009) investigated that as to what makes certain organizations more innovative than others. The means of encouraging creativity and innovation in working environments and the key factors that influence organizational creativity have been investigated. Three major factors that enhance creativity and innovation in the workplace: organizational culture and climate, individual characteristics and the support system. The paper explains how companies can use each of these determinants to enhance innovation within workplace environments.

Kiran and Jain (2010) undertook a research study with the objective to study the technology management strategies used by manufacturing units in the state of Punjab. The study is an attempt to highlight the extent of use of Intellectual Property Rights by Punjab Manufacturing sector and to recommend the factors for developing an IPR culture in the region.

2.7 Conceptual Model

Based upon the examination of the literature review and scope of the present research, a conceptual model has been derived and presented in figure 2.1. The issues which have come into picture from the literature review are broadly classified into four areas which include 'organizational culture', 'Resource support', 'Policy environment' and 'Alliances with external organizations'. It is proposed to focus on these four dimensions of technology development program in an industry. It is hypothesized that *'organizational culture', 'resource support', 'policy environment'* and *'alliances with external organizations'* will positively influence the performance of industry.

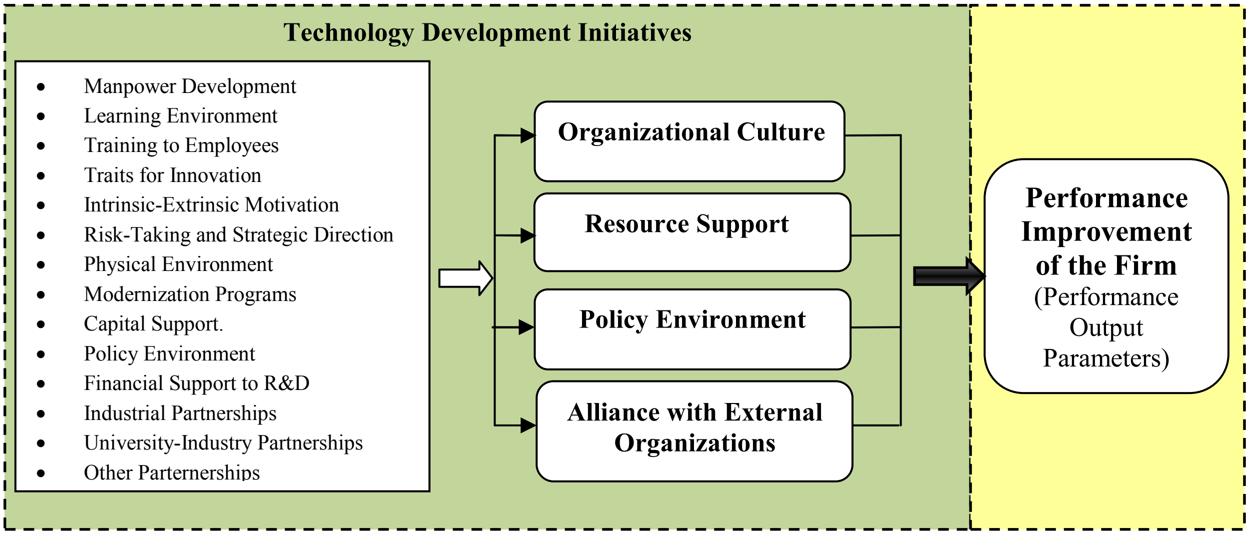

Figure 2.1 Conceptual Model of Research Work

2.8 Research Hypothesis

Enormous research has taken place to explain why certain individuals, teams or organizations are more creative and innovative than others.

Through this literature survey, an attempt has been made to identify the factors which facilitate the technological innovations in manufacturing enterprises. The broad areas identified are organizational culture, resource support, policy environment and alliance with external organizations which have been considered to be the main predictors of technology development.

In order to answer the research problem following hypotheses has been stated on the basis of inter-linkages depicted in conceptual model:

H1: Firm's organizational culture has a significant impact on the output performance parameters.

H2: Firm's resource support to R&D function influences the output performance parameters.

H3: Favorable government policy environment significantly contributes towards firm's output performance parameters.

H4: Firm's alliances with external organizations have significant impact on output performance parameters.

3.1 Introduction

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

3.2 Objective and Issues

The study has been carried out with the purpose of analyzing the technology upgradation initiatives of the tool sector in the region to improve the output performance. The study tends to explore the status of each critical issue of various components of a technology development program. Performance of industrial units is measured in each component of technology development program and then industrial units are classified into various categories. Further, the association of various technology development input factors with output performance parameters has been established from the analysis of survey.

3.3 Research Methodology

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 is considered appropriate to carry out the research work under the methodology as discussed in the following sections.

3.3.1 Questionnaire Development

In order to carry out the research, a survey of various manufacturing organizations involved in technology development at the strategic level has been carried out by a specially designed questionnaire to ascertain the status of various technology development implementation factors and development indicators. A detailed questionnaire called, 'TD Questionnaire' has been used to seek information on the status of various components and issues of technology development initiatives in cutting tool engineering industry in the region (Nanda and Singh, 2009).

3.3.2 Sampling and Data Collection

The questionnaire along with a postpaid reply envelope was mailed to small scale manufacturing units chosen at random from list of industries provided by District Industrial Center (DIC), Patiala. The survey has been conducted through mails, personal visits and other communication means.

The questionnaire is divided into two sections. Section I seeks information on general aspects of the industrial organizations (product range, annual turnover, year of inception etc). Section II seeks information on the status of technological innovations, in general, and also specific information on various factors related to technology development in the industry.

Section II is devoted to multiple choice questions with a scale of 4 provided for each response. 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 (Nanda and Singh, 2009).

3.4 Analysis of Survey

The present work considers five broad areas (components) for overall assessment of technology development initiatives in the industry. These include '*Organizational Culture', 'Resource Support', 'Policy Environment', 'Alliances with External Organizations'* as the input factors and fifth area is, *'Output Performance Parameters'* accrued as a result of innovation initiatives. These broad areas comprise of several key issues, details of which are available in Appendix-II and Appendix-III.

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

- To assess the main factors and problems affecting the performance of small scale manufacturing industry.
- To assess the status of each component (aspect) of technology development program in the industry.
- To assess the overall standing of each manufacturing organization in different key components, leading to classification of companies into various categories ranging from very good to very poor.
- To evaluate contributions of technology development initiatives towards achieving manufacturing performance improvements.

3.4.1 Statistical Tools

The various statistical tools and techniques employed in the research work are discussed as follows:

Firstly, in the analysis of questionnaire, the status of all the issues under each component (or aspect) of technology development in the manufacturing sector is assessed. A set of questions (from the questionnaire) which reflect different issues under each component is selected. For each question, total points score (T.P.S) and percent points scored (P.P.S) are calculated. These measures reflect as to how well the area (issue) represented by that question is being looked after in the industry.

Secondly, the status of manufacturing units in different components of Technology Development (TD) program is evaluated and the manufacturing units are classified into different categories. The score of each unit (in terms of Percent Points Scored, PPS) in individual components has been calculated from the raw score of issues under each component. The criterion reported in earlier research studies has been is used to classify the industries into different categories (Singh, 1993; Nanda and Singh, 2009).

Thirdly, the contributions of TD initiatives in the industry for accruing core competencies for meeting the challenges posed by global competition are assessed. 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 *'TD Input Factors'* (I1, I2, I3, I4) and four output parameters called *'Output Performance Parameters'* (Z1, Z2, Z3, Z4) have been identified as significant in analyzing the impact of development initiatives towards achieving performance improvements in organizations. The detailed description of issues (statements/ items) related to these parameters is listed in Appendix II and Appendix III.

On the basis of the responses received from the industry, an assessment of association of various input factors with output parameters has been presented in the study. The score of each output parameter has been calculated from the average of scores of the items comprising it.

Cronbach's Alpha Coefficient: 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 a construct (internal consistency validity). The internal reliability of the items (inter-item analysis) under each output parameter has been assessed by using Cronbach's alpha coefficient. 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. The coefficient ranges in value from 0 to 1 and higher the score, the more reliable the generated scale is **(…………………).**

t-Test Analysis: To find the relationship between various key inputs and key outputs, Pearson's correlation coefficient values (r values) between various issues of inputs and the output parameters has been calculated. The correlation values obtained has been further validated and authenticated using t-test. Pearson's correlation values and t-values (obtained from t-test) has 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 – 3.1.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \geq t_{n-2} \text{ (from 't' Tables)} \qquad \text{------------------ Equation 3.1}$$

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.

Multiple Regression Analysis: For closer examination of relationships between individual dimensions of dependent variable with the independent variables, the multiple regression analysis has been done. Multiple regression analysis is a statistical technique that is used to analyze the relationship between a single dependent variable and several independent variables.
The notations employed in this test include: β= Regression Coefficient (Beta Coefficient), R= Multiple Correlation Coefficient.

3.5 Discussion of Results

Finally the inferences drawn from the survey have been used to evolve guidelines for effective strategic measures to be taken to overcome the barriers in technology development implementation programs in the cutting tool manufacturing industry in the region.

4.1 General

This chapter presents the analysis and major findings of survey based research data. The survey explores the status of technology development capabilities of cutting tool industry in the region. The main factors affecting the performance of small units have been evaluated. The analysis also establishes the relationship of various technology development input factors with output performance parameters.

4.2 Survey Methodology

For conducting the survey, the questionnaire based technique has been used. A relevant and comprehensive questionnaire (from an earlier research finding) has been utilized to seek information on various aspects of technology development through in-house research in small scale manufacturing industry (Nanda and Singh, 2009).

The present work considers five key areas (components) for overall assessment of technology development initiatives in small scale cutting tool sector. These include

- Organizational Culture
- Resource Support
- Policy Environment
- Alliance with External Organizations
- Output Performance Parameters

4.2.1 Industrial Units Surveyed

Small scale cutting tool manufacturing organizations in Patiala (Punjab, India) have been included in the survey. The main products of cutting tool industry in the region include metal slitting saws, slotting cutters, side and face cutters, shank type milling cutters, reamers, gear hobs, milling cutters, broaches, harvester blades, jack plane blades etc.

A total of 75 cutting tool units were selected from the list of registered units provided by the office of District Industrial Centre, Patiala. In the first place, the questionnaire was mailed to all these 75 units along with a covering letter stating the objectives of the study and its usefulness to the industry. Information from some of the organizations was received in this way. Most of the information, however, has been collected by making personal visits to the industrial units and having discussions with proprietors and senior executives. A total of 46 units responded to the questionnaire.

4.3 Analysis of Questionnaire

The analysis of questionnaire has been carried out to assess the following:

1. Main factors affecting performance of cutting tool manufacturing industry in the region.
2. Status of each component (aspect) of Technology Development program (TD Program) in the industrial sector.
3. Classification of industrial units in various TD components.
4. Contributions of TD initiatives (Technology Implementation Success Factors) towards achieving Manufacturing Performance Improvements (Development Indicators).

4.4 Main Factors Affecting Performance

A section of the questionnaire (Question Number 16) seeks information on factors affecting performance of cutting tool industry in the region. The results are presented in Table 4.1 and depicted in Figure 4.1.

The results indicate that three factors have been most significant (PPS>70) in deteriorating the performance of industry. These include shortage and high cost of electric power (PPS=82.60), absence of large scale manufacturing industry in region (PPS=73.37) and old process technology being used in the units (PPS=71.11).

Another four factors have secured a reasonably high rating (PPS~ 65-70). These include lack of financial support for technology development projects (PPS=69.57); increase in competition because of globalization and liberalization (PPS=66.85); high prices of raw material (PPS=66.11) and shortage of multi-skilled workforce (PPS=65.76).

Absence of modernization programs (PPS=63.89); low level of labor education (PPS=61.96); unavailability of raw materials (PPS=60.33) and poor physical (roads and rails) infrastructure (PPS=55.43) are factors in the next range (PPS~ 55-65) of scores and need attention. However, the remaining issues have a relatively low scoring (PPS<55) and are not considered significant by the industry in lowering their performance. These include marketing management strategies adopted by small scale units (PPS=54.34); underutilized capacity of units (PPS=47.83) and geographical location of the Patiala city (PPS=47.28).

Table 4.1 Main Factors Affecting Performance

S. No	Question Number	Topics in Component	No. of Responses (N)	No. of Units Scoring				Total Point Score (TPS)^	Percent Point Score (PPS) $\frac{TPS}{4*N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	16n	Poor Marketing Management	46	12	19	10	5	100	**54.34**
2	16m	Geographical Location	46	20	14	9	3	87	**47.28**
3	16l	Poor Physical Infrastructure	46	14	16	8	8	102	**55.43**
4	16k	Increased Competition because of Globalization	46	8	9	19	10	123	**66.85**
5	16j	Absence of Large Scale Industry in Region	46	0	18	13	15	135	**73.37**
6	16i	Absence of Modernization Programs	45	9	13	12	11	115	**63.89**
7	16h	Underutilized Capacity	46	20	12	12	2	88	**47.83**
8	16g	Low Level of Labour Education	46	6	23	6	11	114	**61.96**
9	16f	Scarcity of Financial Support	46	4	17	10	15	128	**69.57**
10	16e	Old Process Technology	45	7	10	11	17	128	**71.11**
11	16d	Shortage of Multi-Skilled Workforce	46	15	9	12	10	121	**65.76**
12	16c	Scarcity of Power	45	3	5	9	28	152	**82.60**
13	16b	High Price of Raw Material	45	6	17	9	13	119	**66.11**
14	16a	Unavailability of Raw Material	46	12	16	5	13	111	**60.33**
^Total Point Score(TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$									

Scarcity of electricity is the prime reason causing poor performance in the small scale industrial units in the region. The units receive electricity only for 6-8 hours (on average) daily. They have to use alternate sources (viz Diesel Generator Sets) of electric power in which the costs involved are very forbidding.

Majority of the units are using processes based on old production technologies. Further, absence of large scale manufacturing industry in the region is also affecting performance. Large organizations, if present, can provide support in the form of finance and expertise, as well as future sales and international opportunities.

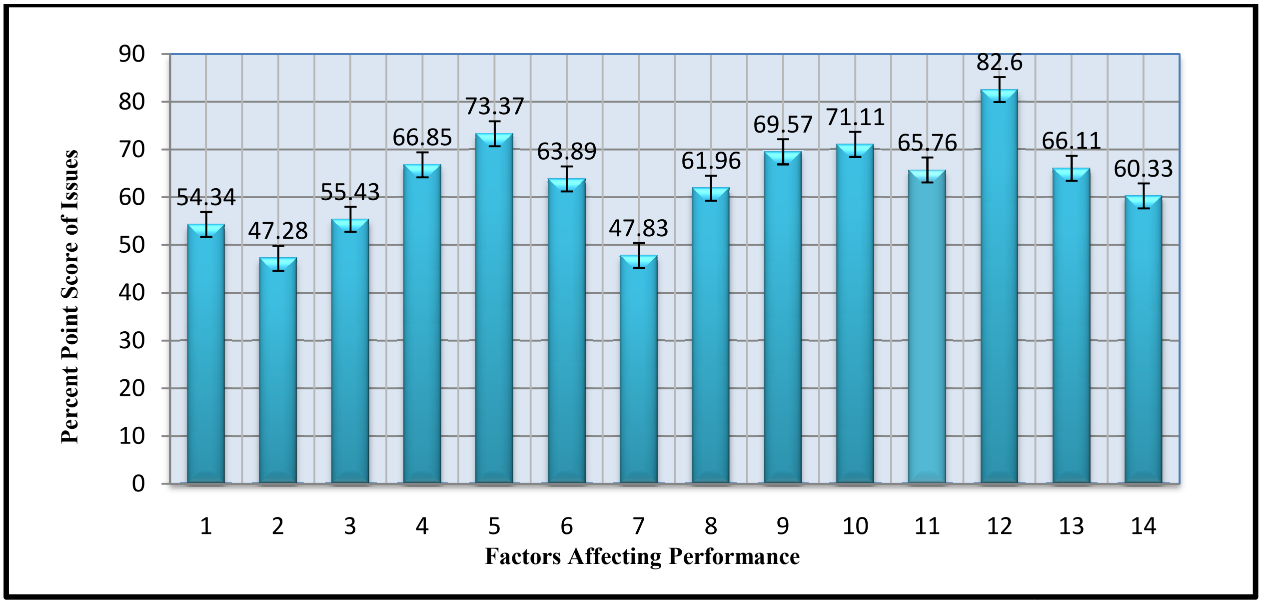

Figure 4.1 Main Factors Affecting Performance

Cutting tool sector is facing cut throat competition because of globalization and liberalization. It is finding it difficult to compete with high quality-innovative cutting tools from countries including Germany, China, Czech Republic, Korea and Taiwan etc.

4.5 Status of components of Technology Development Program

The present work considers five key areas (components) for overall assessment of technology development initiatives in small scale sector. These include '*Organizational Culture'* issues, '*Resource Support'* facilities for research function, '*Policy Environment*' to support development efforts of the industry, '*Alliance with External Organizations'* for technological developments and '*Output Performance Parameters'* issues. This section assesses the status of each of these components in the cutting tool sector in the region.

4.5.1 Organizational Culture

This section discusses the status of *'Organizational Culture'* issues in the manufacturing sector. The questions in questionnaire for this component aim at collecting information on the following:

i) Proficiency and competency of employees to contribute in technology development efforts of the organization.

ii) Commitment of the top management to utilize human resources efficiently and effectively by providing an environment conducive to technology upgradation initiatives.

The response to individual questions (issues) on this component is presented in Table 4.2

Table 4.2 Evaluation of Organizational Culture Issues

S No	Question Number	Topics in the Component	No. of Responses (N)	No. of Units Scoring				Total Point Score (TPS) ^	Percent Point Score (PPS) $\frac{TPS}{4*N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	35	Awareness regarding importance of in-house R&D	46	3	7	20	16	138	**75.00**
2	16g	Level of labor education	46	11	6	23	6	116	**63.04**
3	28	Training provided to employees	46	38	0	6	2	64	**34.78**
4	39	Reward schemes to recognize contributions	45	3	0	42	1	133	**73.89**
5	40	Reaction of top management to project failure	46	1	1	27	17	152	**82.60**
6	36	Availability of scientific and technical manpower	46	12	22	7	5	97	**52.72**
7	37	Undertaking R&D work for technology development	46	13	10	19	4	106	**57.60**
8	16d	Availability of multi-skilled workforce	46	15	9	12	10	109	**59.24**

^ Total Point Score (TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$

The tool sector in the region secures a very good rating (PPS= 75.0) as far as awareness of employees regarding significance of technology development is concerned.

Education level of employees can be helpful in enhancing their creative potential. A little more than one tenth (13%) of the units consider education level of their workforce at a very good level. Nearly two third (63%) of the units report the education level of employees to be between fair and good. However, the remaining 24 % of units consider poor education level of employees to be a serious concern.

Literature reveals that innovative organizations rely heavily on proper training to enhance creativity and innovation skills of employees (Bessant, 1993; Locke and Kirkpatrick, 1995;

Barnett and Storey, 2000; Salavou et al., 2004; Laforet and Tann, 2006). However, the tool industry in the region has shown an unreasonably low rating, in terms of percent points scored in this issue (PPS= 34.78 only). Majority (83%) of the units do not provide any formal training to employees. About one tenth (13%) provide training either during orientation period through senior executives or on-the-job training where employees learn through experience. Only a very few (4%) organizations provide formal training to employees just after induction into the organization.

One of the key strategies to stimulate interest of employees in research initiatives is to suitably reward their contributions. Innovation based organizations know how to manage, motivate and reward employees. The results reveal that employees efforts are adequately recognized (PPS=73.89) in case profits are made because of innovative endeavors. Majority of the units provide either a fixed monetary reward, or an increment in salary or a share in profits made on account of product and process innovations. In a few organizations, the reward structure is intrinsic motivation based. About 2% of the units provide promotion in designation for contributions in area of technology development. In another few (6%), recognition is in the form of an appreciation letter.

Technological innovation is truly enhanced when the entire organization supports it. Senior management support is very important for creativity and innovation (Anderson et al., 1992, Jones and McFadzean, 1997; Mishra and Srinivasan, 2008). Majority of the units (PPS=82.60) conduct a through analysis in situations of project failures to find root causes and plan a future action to reduce such occurrences. A few organizations (2%) take strict action against members of the project team when a failure occurs. Another 2% of the units discourage their employees to undertake projects for innovation if failure occurs.

Industrial units lack in availability (PPS=52.72) of technical and scientific staff (R&D personnel). Majority of the units do not have R&D personnel in required numbers. Only one tenth (11%) of the units have scientific manpower in sufficient strength to undertake development projects.

The level of encouragement to employees by senior management for undertaking R&D work has obtained a moderate score (PPS= 57.60 only). There is only little pressure on employees to put efforts for technology development. Patents can be used as a strategic tool for technological innovations but tool industry in the region does not seem to value this fact. In the last fifteen years, none of the cutting tool units has obtained a patent.

Figure 4.2 Evaluations of Organizational Culture Issues

Innovative organizations have a significant approach towards manpower development (Kim and Choi, 1997). Highly skilled workforce is the key to increased competitiveness and sustainable growth (Keogh and Stewart, 2000; Lange et al., 2000). Manufacturing units in the region are not performing well in availability of multi-skilled workforce (PPS= 59.24). It is only about one fifth of the units that have such workforce in desired numbers.

The analysis of Organizational Culture issues reveal that formal training of employees and availability of R&D staff in adequate strength are critical factors needing attention.

4.5.2 Status of Resource Support

This section presents the status of availability of resources for in-house research initiatives. The questions on *'Resource Support'* contained in the questionnaire aim at collecting information on the availability of following aspects:

i) Financial support to development initiatives.

ii) Infrastructural facilities to carry out technology development work.

The response to individual questions on this component is presented in Table 4.3.

Table 4.3 Evaluation of Resource Support Issues

S. No	Question Number	Topics in the Component	No. of Responses (N)	No. of Units Scoring				Total Point Score (TPS)^	Percent Point Score (PPS) $\frac{TPS}{4*N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	31b	Source of financial support	46	5	11	10	20	137	**74.75**
2	27c	Use of softwares packages	46	17	19	9	1	86	**46.73**
3	27a	Availability of dedicated labs for R&D	46	34	7	4	1	60	**32.60**
4	16f	Financial support to industry	46	15	10	17	4	102	**55.44**
5	30	Proportion of annual turn over as R&D funding	46	29	9	8	0	71	**38.59**
6	16i	Modernization & renovation programs	46	11	12	13	9	110	**59.78**
7	27b	Advanced production facilities	46	29	13	4	0	67	**36.41**
8	29	Allocation of funds	46	27	3	12	4	85	**46.20**

^ Total Point Score (TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$

Innovative organizations have specific funds earmarked for technology development initiatives. Manufacturing units in developed nations spend substantial fraction of their annual turnover on research initiatives. Small units are not financially strong and depend upon government support for research and development funding (Parthasarthy and Hammond, 2002; Souitaris, 2002; Huang, 2008). Despite this fact, in majority (66%) of the organizations in the region, the main source of funds for technology development initiatives is the organization itself and not government or any other agency.

Cutting tool units in the region do not have latest software for drafting, designing and modeling etc. and thus a very poor rating (PPS= 46.73) is shown. More than three fourths (79%) of the units are using softwares only to a very small extent. It is only less than one tenth of the units which possess state of the art software packages.

For technological innovations, dedicated laboratories with facilities for experimentation and subsequent analysis are essential. The industry has shown an extremely poor rating (PPS= 32.60) in this issue. Majority of the units (74 %) do not have these facilities. One tenth (9%) of the units have these facilities to a small extent. There are only 2% units which have proper R&D infrastructure for experimentation, testing etc. Absence of these basic infrastructural facilities has been a major impediment to growth.

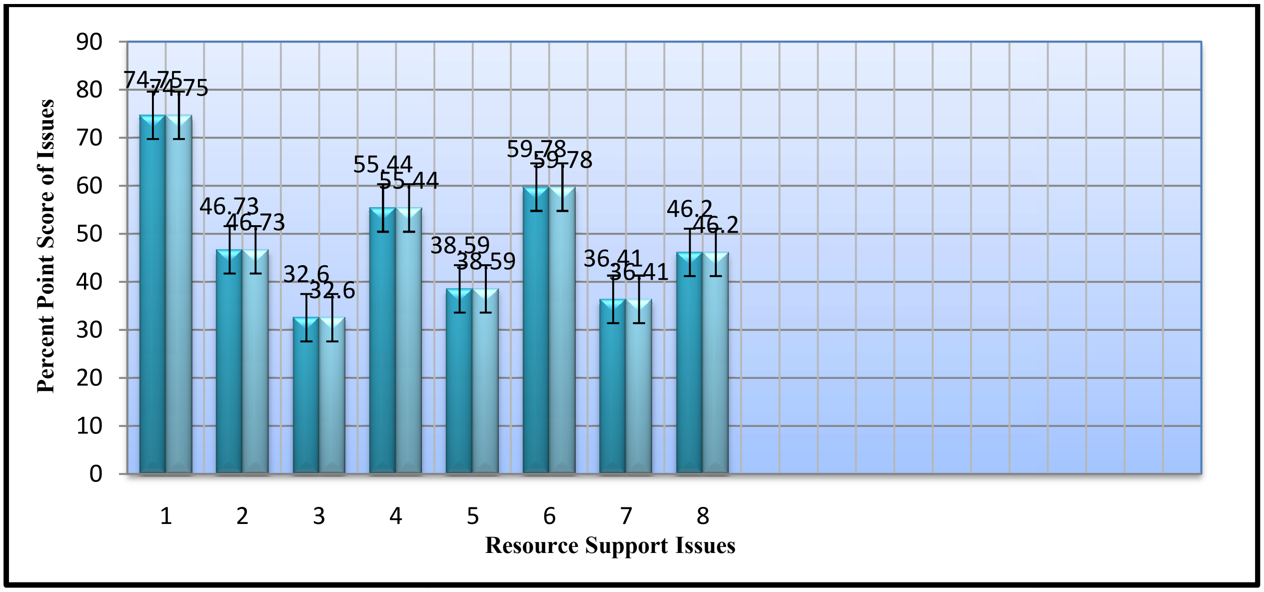

Figure 4.3 Evaluation of Resource Support Issues

Financial support to research initiatives is not very encouraging. About one third of the units have been facing acute shortage of funds for developmental work and consider this factor as most significant in impairing performance. Majority of the organizations (59%) have only little to reasonable support for their development projects.

Manufacturing organizations in developed economies spend a substantial fraction of annual turnover on in-house research projects. Tool industry has obtained an extremely poor rating (PPS= 38.59) in this issue. Nearly two thirds (63%) of the units do not spend even 0.5% of annual turnover on R&D. Another one fifth (20%) spend between 0.5-2.5% of annual turnover on development initiatives. The region does not have any industrial unit whose spending in research initiatives compares global standards.

Absence of modernization and renovation programs is another aspect preventing development in the tool sector. About one fourth (24%) of the units consider this factor as most significant in causing sickness in the small scale industry. Only one fifth (19%) of the units regularly implement modernization and renovation measures.

State of the art production machinery and equipment is not available in majority (63%) of the industrial units and thus a very low (PPS= 36.41) rating has been shown in this issue. Only less than one tenth (9%) of the units have latest production facilities, which is discouraging.

Management must clearly earmark funds for research and development activities aimed at innovations for new product and process developments (Huang, 2008). The industrial sector has obtained a low rating in this issue (PPS=46.20). 59% of the units do not clearly allocate funds for research and development initiatives. About one fourth (26%) club these funds with other developmental activities. There are only a few units (8%) where management clearly assigns funds for research projects.

The critical analysis of various issues related to 'Resource Support' component reveal that lack of adequate financial support to the research function and unavailability of suitable technology infrastructure are important concerns needing attention.

4.5.3 Status of Policy Environment

This section discusses the role of government in providing support to the industrial sector through its policy framework. The questions on 'Policy Environment' aim at collecting information on the following:

i) Policies regarding pricing of raw material, condition of physical infrastructure and subsidy schemes for the sector.

ii) Status of government funding for research initiatives and other business support mechanisms.

The response to individual questions on this component is presented in Table 4.4

Government and policy makers need to understand much better the motivations and requirements that shape and drive an innovative firm (Beaver and Prince, 2002; Hyland and Beckett, 2005). Government can support small scale industrial sector by funding R&D projects, establishing effective reward schemes and providing laboratories for R&D work. It can support programs to build infrastructure as well as incentives (such as tax incentives) and special start up programs to develop private sector. Government also supports R&D through targeted expenditure and collaborative research programs. It also plays an important role in financial markets (Thomas, 1993; Breif and Motowidlo, 1996; Sheel, 2002; Liyanage, 2003; Hyland, 2004, Rhee et al, .2010).

Table 4.4 Evaluation of Policy Environment Issues

S. No	Question Number	Topics in the Component	No. of Responses (N)	No. of Units Scoring				Total Point Score (TPS)^	Percent Point Score (PPS) $\frac{TPS}{4*N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	31a	Funding for R&D activities	46	30	7	3	6	77	**41.85**
2	16b	Cost and availability of raw material	45	13	9	17	6	106	**57.60**
3	16c	Availability of electricity	45	28	9	5	3	73	**40.56**
4	16l	Transportation infrastructure	45	8	8	15	14	125	**69.45**
5	41c	Motivation through reward schemes	46	11	22	7	5	96	**52.17**
6	41g	Funding for employee training programs	46	16	16	7	7	97	**52.72**
7	41e	Availability of labs for R&D work	46	15	13	9	9	104	**56.52**
8	41f	Support in acquiring imported technology	46	11	19	9	7	104	**56.52**
9	41d	Awareness programs for technology upgradation	46	9	18	15	4	106	**57.61**
10	16o	Capital subsidy schemes	45	12	12	17	4	103	**57.22**

^ Total Point Score (TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$)

Government has failed miserably (PPS= 41.85) in providing funds to the industry for technology upgradation initiatives. Majority of the units (66%) do not receive any financial help from the government which is discouraging.

The analysis of data reveals that government policies need to be improved for ensuring availability of raw materials at reasonable prices (PPS= 57.60). 28% of the units consider raw material prices to be exceptionally high and regard this factor as significant in affecting performance of industry in the area of technological innovations. Another one fifth considers raw material prices to be very high. More than one third (37%) of the units consider this factor to be less significant. There are only about one tenth units (13%) which are satisfied with the government policies on raw materials.

Availability and cost of electric power in the region also shows a relatively low rating (PPS= 40.56). Nearly two third (62%) of the units consider this factor as most significant reason for poor performance of industry. Another one fifth (20%) considers it as a significant hurdle in their progress.

However, government is performing reasonably well (PPS= 69.45) as far as rail and road infrastructure in the region is concerned.

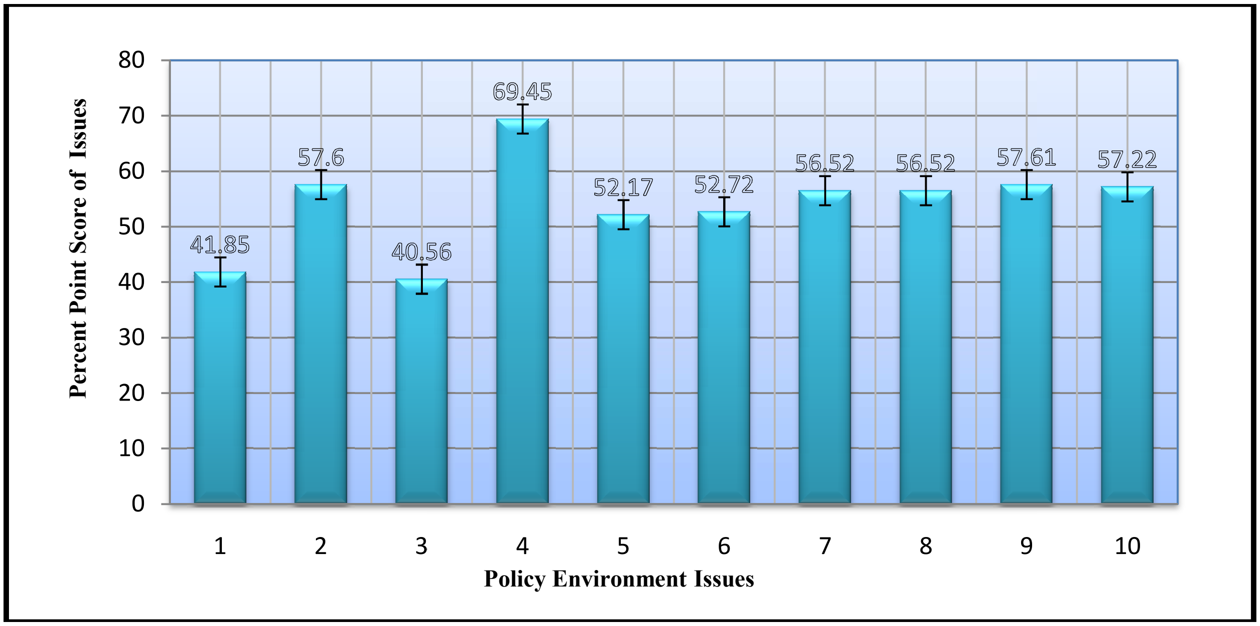

Figure 4.4 Evaluation of Policy Environment Issues

The proprietors and senior executives of the industrial units are of the opinion that government can suitably reward entrepreneurs for their achievements in the field of technological innovations. Further, the government can support tool industry by organizing seminars/workshops on advanced and upcoming technologies. Government help ensuring availability of labs for testing, analysis etc. and funding for employee training programs is also sought by the industry.

The analysis of data reveals that major improvements need to be made regarding effective implementation of various government support mechanisms in the tool industry. Inadequate financial help and lack of availability of electricity are critical factors needing urgent attention.

4.5.4 Status of Alliance with External Organizations

This section presents the status of interaction of industrial units with external organizations.

The questions on this component aim at collecting information on the following:

i) Extent of technology acquired from external sources, technology developed in collaboration with other industries.
ii) Industrial ties with academic institutes for solving technology related problems.
iii) Collaborations with research institutes and other agencies for technology development.

The response to individual questions on this aspect is presented in Table 4.5

Innovative organizations 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 R&D organizations (Larsen, 1998)

Government has set up several service institutes for providing support to small scale sector. These include Small Industries Service Institutes (SISI), District Industrial Centres (DIC), National Small Industries Corporation (NSIC), Small Industries Development Organization (SIDO) to name a few. Tool industry in the region has shown a poor rating (PPS=49.45) in deriving support from these institutes. There are only a very few (4%) industrial units which are seeking active support from these government subsidiaries.

By collaborating with academic institutes, firms can reduce uncertainty inherent from the innovation process, as well as expand their markets, access new or complementary resources and skills, keep up with evolution of scientific knowledge, and create new technological learning options on future technologies (Hagedoorn *et al.,* 2001). Cutting tool industry in the region also considers academic alliances as an important activity (PPS=75.54). More than three fourth (83%) of the units consider that alliance with academic institutions can solve technology related problems to large extent. However, in the actual practice, the results of interaction have not been effective. The industry has obtained an extremely poor rating (PPS=39.13) in this issue. Most of the organizations (89%) have not experienced any affirmative results through these alliances, which is discouraging.

More than half (PPS=60.33%) of the units suggest that faculty from technical institutions can prepare roadmaps for industry to make research an integral function of the working of units.

Expert lectures by academicians on advanced technologies are considered as an effective interaction mode (PPS=70.66) by the industrial units.

Training of employees through short term programs at regional academic institutes seems to be the most preferred interaction mode by the industries. About three fourths (76%) of the units that training of employees in specialized skills would be beneficial to a large extent.

Table 4.5 Evaluation of Alliance with External Organizations Issues

S. No	Question Number	Topics in the Component	No. of Responses (N)	No. of Units scoring				Total point Score (TPS)^	Percent Point Score (PPS) $\frac{TPS}{4 * N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	49	Awareness regarding government subsidiaries	46	2	13	24	7	128	**69.56**
2	51	Assistance from government organizations	45	14	20	9	2	89	**49.45**
3	42	Awareness of industry-institute interaction	46	3	5	26	12	139	**75.54**
4	43	Industry-institute alliance with positive results	46	26	15	4	1	72	**39.13**
5	44a	Academia for preparing road maps	46	10	16	11	9	111	**60.33**
6	44b	Expert lecture by academicians	46	6	11	14	15	130	**70.66**
7	44c	Training through short term courses	46	1	10	17	18	144	**78.26**
8	44d	Combined teams for R&D	46	1	12	16	17	141	**76.63**
9	44e	Institute labs for analysis	46	1	11	23	11	136	**73.91**
10	44f	Collective guidance for thesis	45	11	20	10	4	97	**53.89**
11	21b	Technology from within the country	46	4	8	6	28	150	**81.52**
12	21c	Technology developed through alliances	46	32	12	1	1	63	**34.24**
^ Total Point Score (TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$									

Formation of project teams with members both from industry and technical institutions to work on research projects by sharing specialized knowledge is another preferred option of interaction.

Majority of the units consider this option to be largely helpful (PPS= 76.63) in increasing technological capabilities of industry.

Cutting tool sector in the region lacks in good R&D infrastructure. Three fourths (72%) of the units believe that laboratories and other infrastructural facilities at academic institutes can be helpful in research and development projects to a large extent. Nearly one fourth (24%) believe that this type of interaction with institutes can be of help only to a small extent. Only 2% do not consider this alternative to be of use.

Most of the machinery, tools and other equipments have been procured from large scale (Indian) manufacturing units (PPS=81.52). There are only a few units who have been importing machines and equipment from manufacturers outside the country.

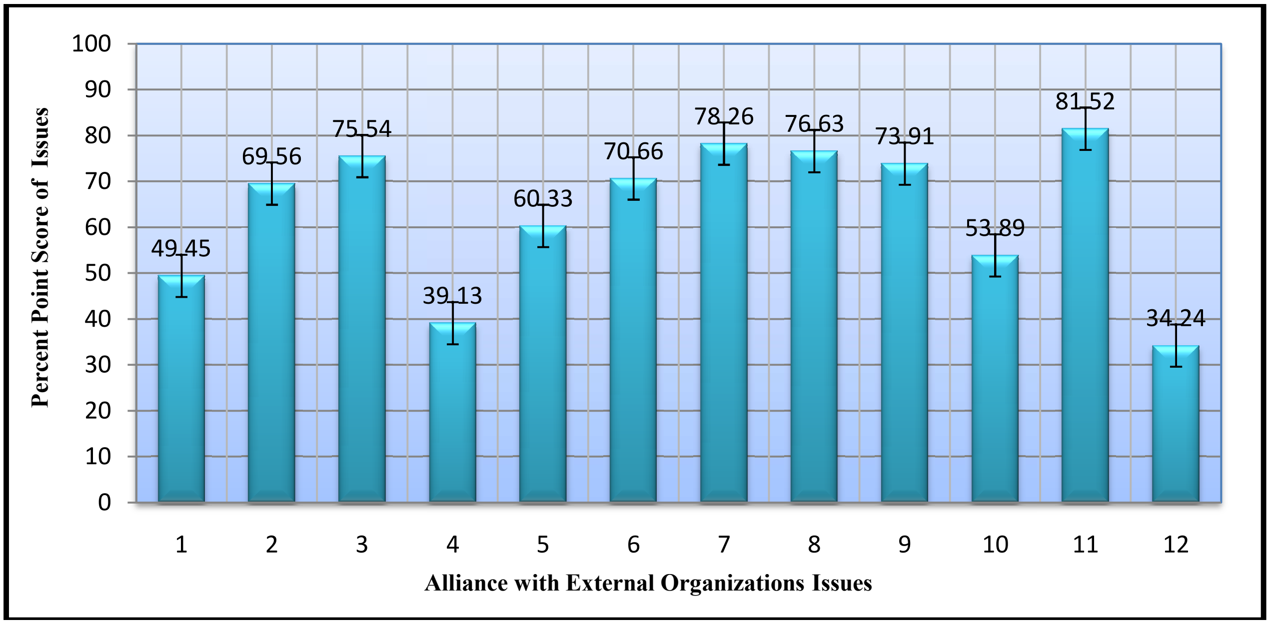

Figure 4.5 Evaluation of alliances Issues

Partnerships between SMEs and large firms help the small units to pioneer innovation. By sharing technological resources, SMEs can develop their core competencies and increase their opportunities to innovate (Li and Qian, 2007). However, the regional industry fails to notice this fact. The industrial units have not developed any technology in collaboration with other industries.

The industrial units have shown an unreasonably low rating (PPS= 34.24 only) in collaborating with external agencies Most of the units in the region have never interacted with external agencies. There are a very few manufacturing organizations (2%) where most of the product and process technologies have been developed through collaborations. Another 19% of the units work with these agencies but only to solve production and maintenance problems

The analysis of data reveals that performance of cutting tool industry in developing technology through interaction with other industries, academic institutes and research institutes is below desired levels.

4.5.5 Status of Output Performance Parameters

This section presents the status of outcome of research initiatives being undertaken by manufacturing units.

The questions aim at collecting information on the following:

i) Response of industrial sector to the changing market demands
ii) Strategic implementation of innovation.
iii) Level of technology employed in the industry.
iv) Structure and output of research function.

The response to individual questions on this aspect is presented in Table 4.6

In order to have long term gains, organizations in developed economies work with specific product innovation strategies like practicing '*Risky Research',* developing a *'Market Niche'*, using *'Imitation for Creation'* etc. The response of industry is low (PPS=46.20) in the *'Risky Research'* strategy. Nearly half of the industrial units (48%) are not using this strategy at all. Another one third uses it only to a small extent. The remaining (21%) units are using *'Risky Research'* strategy to a large extent for product innovations.

Another R&D strategy which is widely used (especially in Japanese manufacturing units) is '*Imitation for Creation'*. In this, firms purchase raw technologies developed by others. These raw technologies are developed into innovative products through indigenous research programs. A relatively low rating (PPS= 38.59) has been shown by the cutting tool sector is in this issue. More than half (54%) of the units have never practiced this strategy. Another 39% use it only occasionally. It is only about 2% of the units which use this strategy more than often for technology development.

Manufacturing firms with separate research facilities are more innovative than their counterparts without these facilities. Only one tenth of the units have their research function as a separate department. In nearly 13% of the units, teams are formed by top management for specific research projects. In 3% of the units, design department is responsible for product innovations. In the remaining, about three fourth of the units, the structure of R&D function is not clearly defined, which is discouraging.

Table 4.6 Evaluation of Research Output Issues

S. No.	Question Number	Topics in the Component	No. of Responses (N)	No. of Units Scoring				Total Point Score (TPS)^	Percent Point Score (PPS) $\frac{TPS}{4*N}100$
				1 (W_1)	2 (W_2)	3 (W_3)	4 (W_4)		
1	33	'Risky Research' practice	46	22	14	5	5	85	**46.20**
2	34	'Imitation for Creation' strategy	46	25	18	2	1	71	**38.59**
3	32	Structure of research function	46	34	1	6	5	74	**40.22**
4	26c	Maintenance related problems through R&D	45	1	22	20	2	113	**62.78**
5	26a	Developing new process through in-house research	46	6	16	13	11	130	**70.65**
6	21d	Technology developed through indigenous R&D	46	18	20	5	3	85	**46.20**
7	26b	R&D for developing new products	46	5	21	12	8	115	**62.50**
8	23	Collecting information for customer needs	46	14	18	6	8	100	**54.35**
9	17	Importance of technology up gradation for growth	46	0	0	16	30	168	**91.30**
10	8	Increase in product mix	46	8	8	21	9	123	**66.85**
11	26d	Improvement in product quality	46	6	17	14	9	118	**64.13**
12	25	Establishment of research policy	46	18	20	5	3	85	**46.20**
13	22	Means of technology up gradation	46	10	8	11	17	127	**69.02**
14	20	Level of process technology in use	46	9	18	16	3	105	**57.06**
15	18	Drawbacks of technology acquisition	46	2	12	28	4	126	**68.48**
16	14	Modifications in product features	44	5	28	10	1	95	**53.98**

^ Total Point Score (TPS) = $1\times W_1+2\times W_2+3\times W_3+4\times W_4$

Innovative organizations generally use their research initiatives for developing new products and/or improving the production processes. However, the situation is different for the tool sector in the region. Nearly half of the industrial units utilize their research efforts in solving maintenance related problems. It is only 18% units which tend to use research function for developing new products and about one fourth utilize it for developing improved processes.

To respond to the changing market demands, data collection on customer needs and perceptions is very important. About one third (30%) of the units perform this job in a structured manner. Out of these, 18% units have a separate marketing department to perform this function and in the remaining, a team of senior executives performs this job. In nearly 40% of the units, information is collected in an informal manner from the existing customers. The remaining, nearly one third (31%) of the units do not make any special efforts to collect information on customer needs.

The actual performance of industry in developing indigenous technology through in-house research is not very encouraging with a low rating (PPS= 46.20). 40% of the units have never developed any process or product technology in-house through indigenous efforts. Nearly half of the industrial units have partially developed some technology. There are only less than one tenth of the units (6%) which meet their technology needs completely through adequate research efforts.

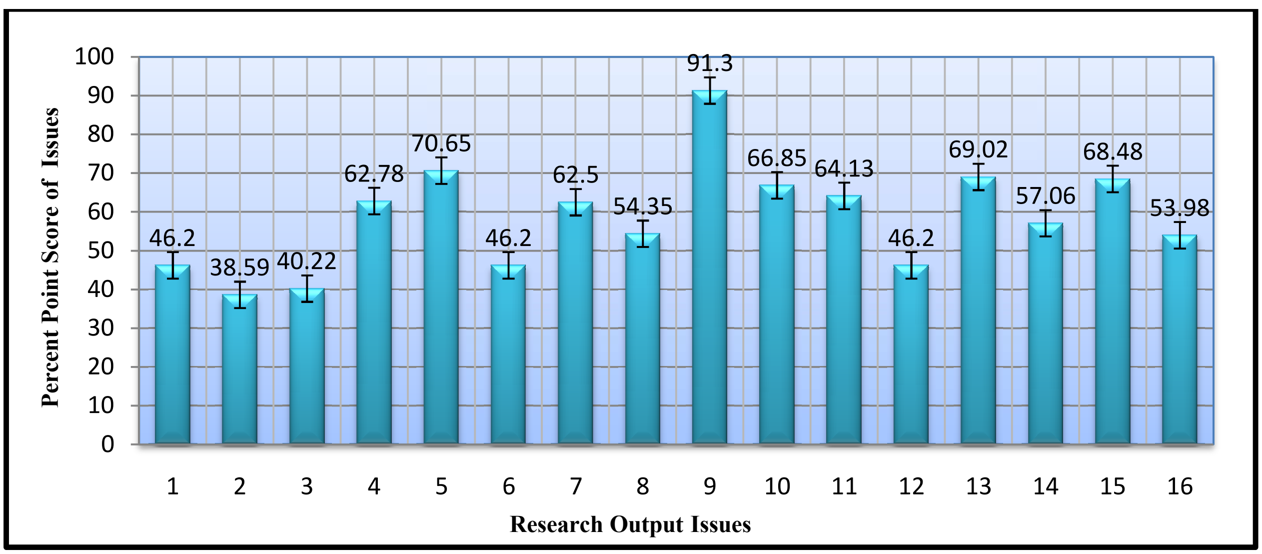

Figure 4.6 Evaluation of Research Output Issues

Cutting tool sector is aware of the benefits (PPS= 91.30) of in-house technology development programs but, a lot needs to be done on the practical front. At present, not even one tenth (6%) of the units are employing latest technology to produce products. More than half (59%) of the units are producing products based on old technology, which is a cause of concern.

The performance of industry has not been very good as far as increase in product mix and adding new features to the products is concerned. Organizations have scored moderately (PPS= 66.85 and PPS= 53.98 respectively) in these issues. There are only 3% units which have increased product features considerably in the last few years.

More than one third (40%) of the units do not work with a well defined R&D policy and majority of these have never developed any technology in-house. 44% of the units have just started formulating their research policy. There are only a few units (6%) which follow and practice a well defined R&D policy.

The critical analysis of this component reveals that a few issues have shown very low ratings. The industrial units should use the research function for technology upgradation activities rather than for solving production and maintenance problems. Further, utilization of well defined R&D policy and effective implementation of strategic approaches for technology development can greatly improve the efficacy of research function in industry.

4.7 Classification of Cutting Tool Units

The objective of this part of analysis is to evaluate the status of manufacturing units in different components of Technology Development (TD) program and to classify the units into different categories. The score of each unit (in terms of Percent Points Scored, PPS) in individual components of '*Organizational Culture', 'Resource Support', 'Policy Environment', 'Alliance with External Organizations', and 'Research Output'* has been calculated from the raw score of issues under each component.

The criterion used to classify the industries into different categories is presented in Table 4.10 (Singh, 1993; Nanda and Singh, 2009). Table 4.11 presents the performance rating of industrial units in various components of technology development.

Table 4.7 Criteria for Classification of Industries

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

Table 4.8 Performance Rating of Units in Various Components of Technology Development Program

Range of PPS → / Aspect ↓	25-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100
	Number of Units in a given PPS Range														
Organizational Culture	--	--	1	--	4	7	9	6	12	5	--	1	1	--	--
Resource Support	4	1	1	7	12	9	4	4	2	1	1	--	--	--	--
Policy Environment	--	2	1	3	13	4	8	5	3	3	2	1	1	--	--
Alliance with External Org	2	--	--	1	6	8	7	7	7	5	3	--	--	--	--
Research Output	--	--	--	4	6	7	12	6	3	3	3	2	--	--	--

The industry wise performance in *'Organizational Culture'* component is presented in Figure 4.10. The classification of units in this component is presented in Figure 4.11.

The performance of organizations in '*Organizational Culture'* component is moderate with an average score of 61.75%. More than one fourth (26%) of the units fall in '*Poor'* category in this component. Only 4% units are at a '*Good'* level. Majority of the units (70%) are at a *'Fair'* level. The manufacturing units can improve performance in this component if management pays proper attention to training of employees and makes adequate investments both in formal as well as in-house training of employees.

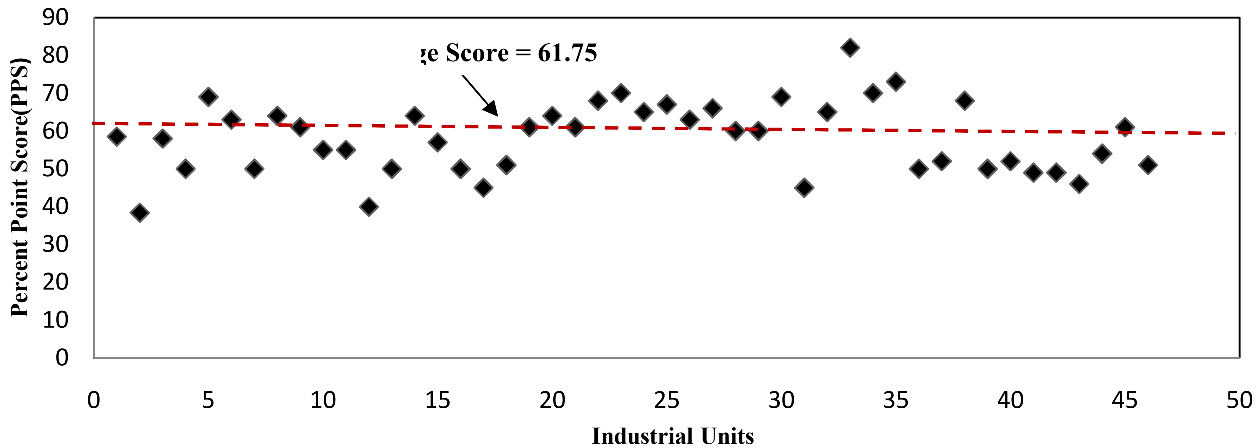

Figure 4.7 Performance of Units in Organizational Culture Component

Percent Points Scored (PPS)	Category	Number of Units in the Range	Proportion of units in the range (%)
25-35	Very Poor	-	-
36-55	Poor	12	**26**
56-75	Fair	32	**70**
76-90	Good	2	**4**
91-100	Very Good	–	–

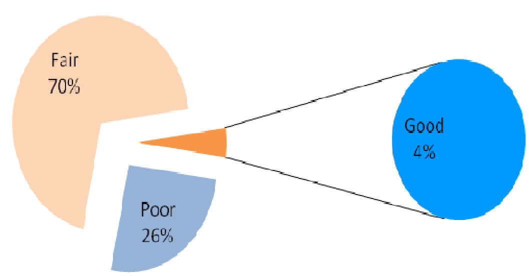

Figure 4.8 Classification of Units in Organizational Culture Component

The performance of industrial units in '*Resource Support'* component is presented in Figure 4.12. The classification of units in this component is presented in Figure 4.13.

This component has shown worst performance with an average score of 50.06%. Around one tenth (11%) of the units are at *'Very Poor'* level and 63% units are at a '*Poor'* level which is disappointing. Around one fourth (24%) of the units are doing '*Fairly Well'* and only 2% are at '*Good*' level.

The industrial units lack in production facilities. Majority of them do not have research infrastructure to conduct project work. Many innovative ideas get languished because of lack of resources and for want of financial support.

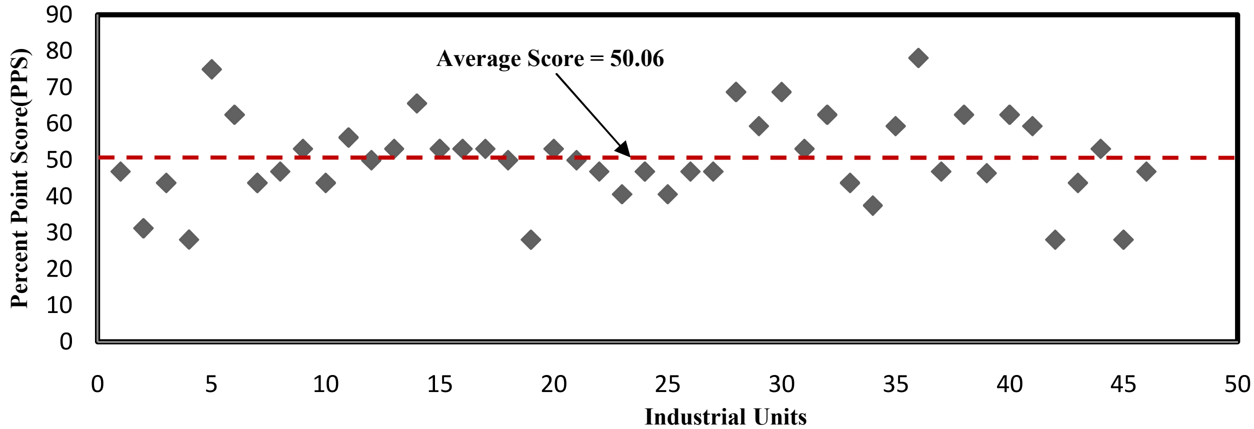

Figure 4.9 Performance of Units in Resource Support Component

Percent Points Scored (PPS)	Category	Number of Units in the Range	Proportion of units in the range (%)
25-35	Very Poor	5	**11**
36-55	Poor	29	**63**
56-75	Fair	11	**24**
76-90	Good	1	**2**
91-100	Very Good	–	–

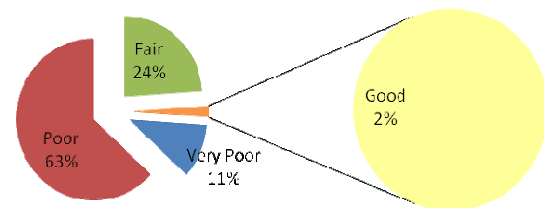

Figure 4.10 Classification of Units in Resource Support

The industry wise performance in '*Policy Environment'* component is presented in Figure 4.14 and classification of units is presented in Figure 4.15.

The average score of units in the component, '*Policy Environment'* is 54.70%. 4% units are at *'Very Poor'* level and around half (46%) are at '*Poor'* level. 41% of the units are doing '*Fairly Well'* and around one tenth (9%) fall in '*Good'* category.

Though government has several schemes for small scale industrial sector but the benefits of these have not reached the industry because of large bureaucratic hurdles and tedious procedures involved in obtaining government support.

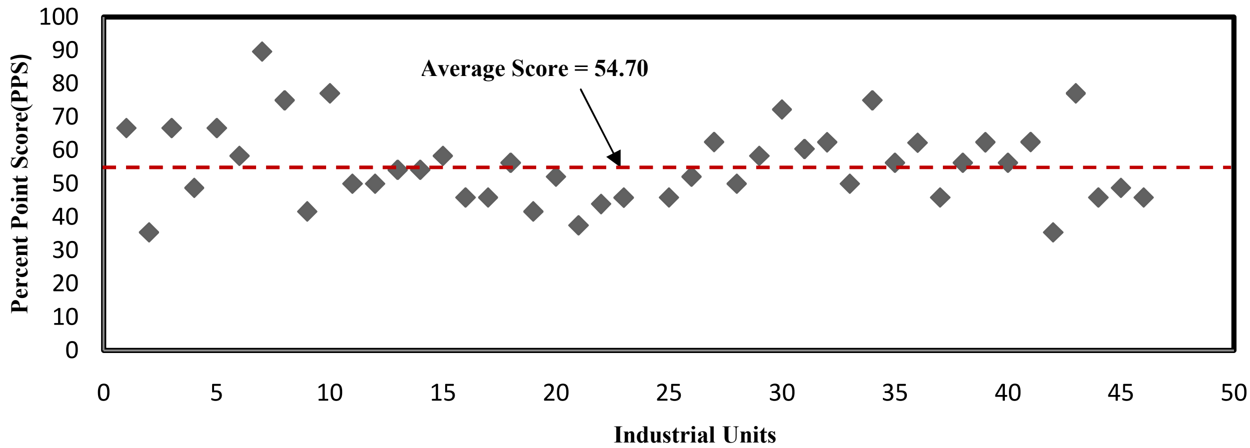

Figure 4.11 Performance of Units in Policy Environment Component

Percent Points Scored (PPS)	Category	Number of Units in the Range	Proportion of units in the range (%)
25-35	Very Poor	2	**4**
36-55	Poor	21	**46**
56-75	Fair	19	**41**
76-90	Good	4	**9**
91-100	Very Good	–	–

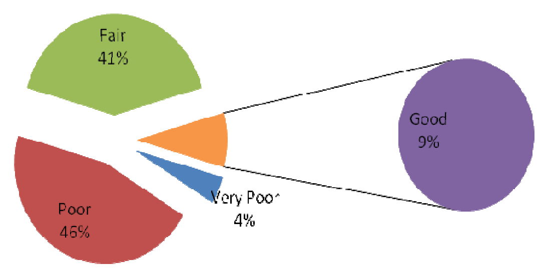

Figure 4.12 Classification of Units in Policy Environment Component

The industry wise performance in '*Alliances with External Organizations'* component is presented in Figure 4.16. The classification of units in this component is presented in Figure 4.17.

The average score of organizations in this component is 58.94%. The results show that 4% of the units are at a *'Very Poor'* level and one third (33%) units are at '*Poor'* level. Most of the units are at *'Fair'* level in this component. There are a few units (7%) which are performing *'Good'* in interacting with external organizations and agencies for technology development.

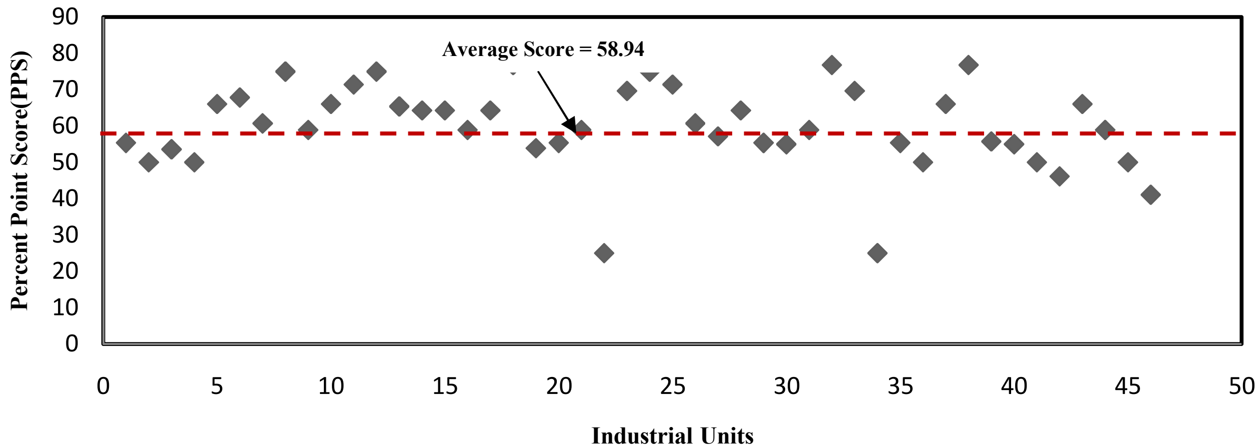

Figure 4.13 Performance of Units in Alliances with External Organizations Component

Percent Points Scored (PPS)	Category	Number of Units in the Range	Proportion of units in the range (%)
25-35	Very Poor	2	**4**
36-55	Poor	15	**33**
56-75	Fair	26	**56**
76-90	Good	3	**7**
91-100	Very Good	–	–

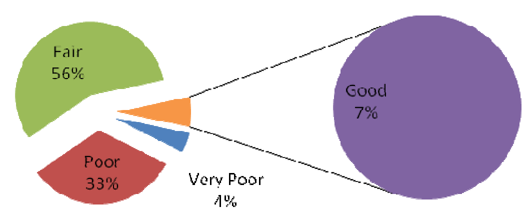

Figure 4.14 Classification of Units in Alliances with External Organizations Component

The industry wise performance in *'Research Output'* component is presented in Figure 4.18. The classification of units in this component is presented in Figure 4.19.

The average score of organizations in '*Research Output'* is 56.08%. More than one third (37%) of the units are at *'Poor'* level as far as managing their research function is concerned. A little more than half (52%) of the units are in '*Fair'* category. There are only one tenth units (11%) which are managing their research function effectively and are at *'Good'* level.

The manufacturing units can enhance their research output by establishing research function as a separate division having clear procedures and well defined policy. Also the research initiatives should be based on specific product innovation strategies.

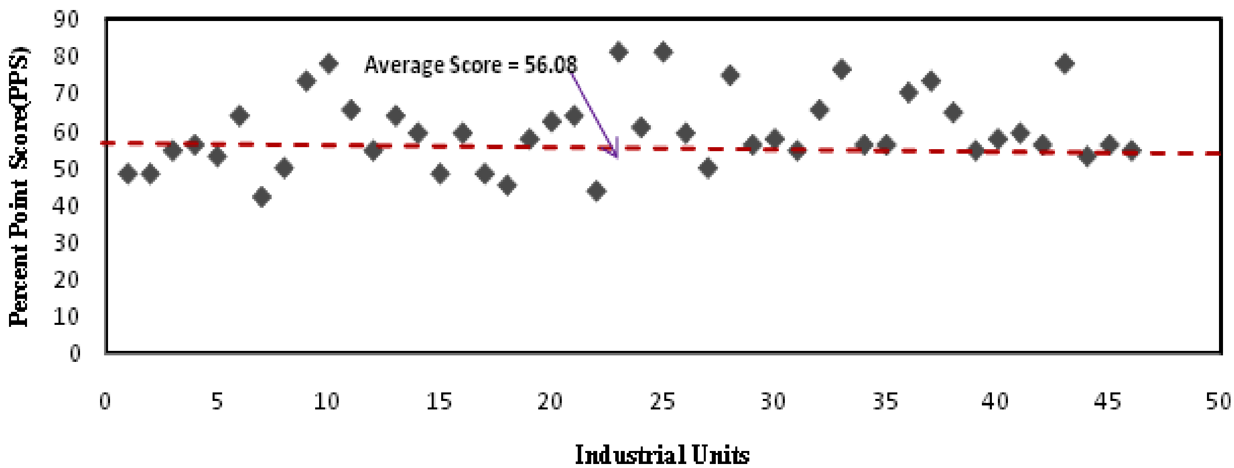

Figure 4.15 Performance of Units in Research Output Component

Percent Points Scored (PPS)	Category	Number of Units in the Range	Proportion of units in the range (%)
25-35	Very Poor	-	-
36-55	Poor	17	**37**
56-75	Fair	24	**52**
76-90	Good	5	**11**
91-100	Very Good	–	–

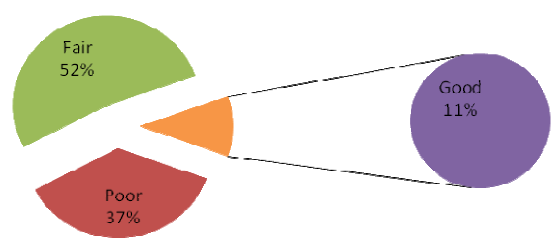

Figure 4.16 Classification of Units in Research Output

Resource Support is the most critical component with the lowest average score. Without state-of-the-art infrastructural facilities and adequate financial and resource support the objective of technology upgradation in small scale sector can not be met.

4.5 Contributions of TD initiatives in achieving Performance Improvements

From the literature findings, four input factors called *'TD Input Factors'* (I1, I2, I3, I4) and four output parameters called *'Output Performance Parameters'* (Z1, Z2, Z3, Z4) have been identified as significant in analyzing the impact of technology development initiatives towards achieving performance improvements in organizations. These input and output parameters are presented in Table 4.5. The output parameters have been obtained from an earlier research study (Nanda and Singh, 2009).

Table 4.9 Input and Output Parameters of TD Program

Technology Development Input Factors	Performance Output Parameters
I1. Organizational Culture	Z1. Level of Technology
I2. Resource Support	Z2. Strategic Implementation of Innovation
I3. Regulatory Framework	Z3. Structure and Output of R&D Function
I4. Alliances with External Organizations	Z4. Response to Market Demands

Research output is divided into four factors which measure the technological capability of the firm and are termed as *'Output Performance Parameters'*. The detailed description of issues related to these factors is listed in Appendix II and Appendix III. The research hypotheses formulated in the present work are described as follows

Thus more hypotheses are added to H1, H2, H3 and H4. These are as follows:

Four hypotheses are added to H1 *(Concerning Organizational Culture)*

H1-a: Firm's organizational culture has a significant impact on level of technology.

H1-b: Firm's organizational culture has a significant impact on strategic implementation of innovation.

H1-c: Firm's organizational culture has a significant impact on structure and output of research function.

H1-d: Firm's organizational culture has a significant impact on response to market demands.

Four hypotheses are added to H2 *(Concerning Resource Support)*

H2-a: Firm's resource support has a significant impact on level of technology.

H2-b: Firm's resource support has a significant impact on strategic implementation of innovation.

H2-c: Firm's resource support has a significant impact on structure and output of research function.

H2-d: Firm's resource support has significant impact on response to market demands.

Four hypotheses are added to H3 *(Concerning Policy Environment)*

H3-a: Policy environment has a significant impact on level of technology.

H3-b: Policy environment has a significant impact on strategic implementation of innovation.

H3-c: Policy environment has a significant impact on structure and output of research function.

H3-d: Policy environment has a significant impact on response to market demands.

Four hypotheses are added to H4 *(Concerning Alliances with External Organizations)*

H4-a: Alliances with external organizations has a significant impact on level of technology.

H4-b: Alliances with external organizations has a significant impact on strategic implementation of innovation.

H4-c: Alliances with external organizations has a significant impact on structure and output of research function.

H4-d: Alliances with external organizations has a significant impact on response to market demands.

On the basis of responses received from the industry, an assessment of association of various input factors with output factors has been made to confirm the above hypotheses. The score of each input and output parameter has been calculated from the average of scores of the items comprising it.

The internal reliability of items (inter-item analysis) under each input and output parameter has been assessed by using Cronbach's Alpha co-efficient, as recommended for empirical research in operations management (Flynn et al., 1990; Hair et al., 1998). Cronbach's Alpha values for various categories are more than 0.5, which indicates high reliability of data collected through the questionnaire. The Cronbach's alpha values are presented in Table 4.6.

Table 4.10 Cronbach's Alpha for Key Parameters

Key Parameter		Cronbach's Alpha Value
Organizational Culture	I1	0.641
Resource Support	I2	0.812
Regulatory Framework	I3	0.614
Alliances with External Organizations	I4	0.885
Level of Technology	Z1	0.740
Strategic Implementation of Innovation	Z2	0.711
Structure and Output of R&D Function	Z3	0.687
Response to Market Demands	Z4	0.830

4.5.1 Association between Input and Output Performance Parameters

The impact of TD input parameters in achieving performance improvements in the industry have been evaluated in this section. For this, Pearson's correlation coefficient values (r values) between each input factor and the output parameters have been calculated. The correlation values obtained have been further validated using statistical tools like t-Test and multiple regression analysis.

Pearson's correlations, t-values and significance levels (p-values) for pairs of interrelationships of various input and output factors are depicted in Table 4.7.

t-values can also be worked out through the empirical expression provided in equation 4.1.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \geq t_{n-2} \text{ (from 't' Tables)} \qquad \text{--------------------- Equation 4.1}$$

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

Table 4.11 Correlation and t-Test Analysis between Input Factors and Output Parameters

OUTPUT PARAMETERS → / INPUT FACTORS ↓			Level of Technology	Strategic Implementation of Innovation	Structure and Output of R&D Function	Response to Market Demands
			Z1	**Z2**	**Z3**	**Z4**
Organizational Culture	**I1**	r	0.41**	-0.28	0.42**	0.32*
		t	2.96	-1.91	3.10	2.23
		p	0.0049	0.0624	0.0033	0.0309
Resource Support	**I2**	r	0.17	0.35*	0.34*	0.23
		t	1.13	2.48	2.41	1.56
		p	0.2628	0.0169	0.0199	0.1242
Regulatory Framework	**I3**	r	0.39**	-0.12	-0.06	0.30*
		t	2.84	-0.78	-0.39	2.07
		p	0.0067	0.4364	0.6911	0.0444
External Alliances	**I4**	r	-0.19	0.31*	0.32*	-0.04
		t	-1.23	2.14	2.23	-0.23
		p	0.2232	0.0376	0.0309	0.8191

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

The results of t-test have been used to identify the input factors which have a significant contribution towards realization of performance improvements in the manufacturing units. The '$t_{critical}$' value for the confidence limits corresponding to 'n-2' (= 44) degrees of freedom and significance level of 95 percent (from statistical t-tables) works out to be 2.0003 (and 2.6603 at 99 percent level of significance). So, pairs with t-value greater than or equal to 2.0003 are considered as having a significant association at 95 percent level of confidence (and those with values greater than 2.6603 are significant at 99 percent level).

Finally, the inter-relationships between significant input factors and output performance parameters have been validated through multiple regression analysis as depicted in Table 4.8.

The results of analysis imply that there is a strong association of several input factors with output parameters which validates the acceptance of research hypotheses.

4.5.2 Discussion of Results

The present research provides an empirical evidence of a significant contribution of several input factors towards output performance parameters.

'Organizational Culture' (I1) is the first key input parameter for strategic implementation of TD program in an organization. The main issues under this component are presented in Appendix- II.

Pearson's correlations and t-test results depict that the adaptation of *Organizational Culture* (I1) initiatives significantly contribute towards the realization of various performance parameters. *The results show that organizational culture issues (I1) are significantly correlated (r= 0.41, p= 0.0049) with the level of technology (Z1). Thus H1-a is accepted.*

Organizational culture affects the extent to which creative solutions are encouraged, supported and implemented. The proportion of educated and technical employees is a significant predictor of technological improvements. Enterprises having adequate strength of R&D staff and multi-skilled workforce have a wider range of required knowledge. This makes it possible for them to innovate with a view to improve technology.

Organizational culture issues (I1) have shown a negative correlation (r= -0.28) with strategic implementation of innovation (Z2). As a result, the hypothesis H1-b is not accepted.

From the results it has been found that organizational culture (I1) significantly influences (r= 0.42; p= 0.0033) the structure and output of research function (Z3). Thus H1-c is accepted.

A positive attitude of top management correlates with continual attention being paid to innovative opportunities and provides employees with support for their innovative behavior. This in turn strongly affects the decision to innovate and the ways in which innovation is carried out in small firms. Well trained and educated workforce is able to work with specific innovation strategies and utilize the research function effectively to improve and develop new processes and products. Effective reward schemes for innovative efforts and a supportive environment which promotes risk taking and accepts mistakes as part of taking the initiative lead to improvement in research output.

Organizational culture (I1) has shown a significant correlation (r= 0.32; p= 0.0309) with response to market needs (Z4). It provides an environment for improved adjustment to customer demands in the market. Thus H1-d is accepted.

An effective organizational culture providing multi-skilling to employees, opportunities to enhance education levels, providing extensive formal training and suitably recognizing employee contributions helps the organizations to continuously increase their production mix and cater to changing needs of the marketplace.

'Resource Support' (I2) is the next key input parameter for successful implementation of technology upgradation initiatives of industry.

The results highlight that 'Resource Support' (I2) has not been contributing towards technological improvements in the industry (Z1). Thus H2-a is rejected.

Absence of adequate infrastructure facilities in industrial units is one of main problem that hinder efforts to develop technology. For technological improvements, adequate infrastructures (mainly telecommunication, information technology, modern production systems) and new strategic thinking practices are needed. Further, investments in research function heighten the level of research activity within firms and builds improved technology as a result. However, for tool industry in the region, investments in R&D have been extremely low. Technology upgradation in industrial sector has remained constrained by limited availability of finance and technology infrastructure to meet variety of operational and investment needs.

A significant correlation (r= 0.35; p= 0.0169) has been exhibited between resource support (I2) issues and strategic implementation of innovation (Z2). Thus H2-b is accepted.

This means that specific product innovation and business strategies like creating a 'market niche', 'imitating for creating', 'risky research' etc. can be implemented effectively if the necessary resource support (viz. state of the production machinery, labs for experimentation, funds for research initiatives) is present.

The results highlight that adequate resource support (I2) effectively contributes (r= 0.34; p= 0.0199) towards an improved structure and output of research function (Z3). Thus H2-c is accepted.

Building physical infrastructure for enhancing organizational capabilities and developing an adequate financial programme that support training and educational activities for innovation are the key success factors for development of new products and processes. Earmarking specific funds for technology development is also an important initiative. This reveals that various R&D activities can be organized and utilized effectively if an explicit financial plan is prepared for each.

The results show an insignificant correlation between resource support (I2) and response to market demands (Z4). Thus H2-d is rejected.

'Policy Environment' (I3) is the third key input factor considered in the present work.

The results show that policy environment (I3) significantly influences(r= 0.39; p= 0.0067) the level of technology (Z1). Thus H3-a is accepted.

Government support in terms of financial and technical assistance helps in upgrading technology levels. Financial assistance includes various forms of investment initiatives and soft policy loans whereas technical assistance includes support in human resource training, export promotion initiatives and quality and technology programs.

Policy Environment (I3) has not exhibited a significant linkage (r= -0.12; p= 0.4364) with implementation of strategic approaches for technology development (Z2).Thus H3-b is rejected.

Policy Environment (I3) as an input to the technology development initiatives has not shown a significant correlation (r= -0.06; p= 0.6911) with structure and output of research function (Z3). Thus H3-c is rejected.

Tool industry in the region is most dissatisfied with the tedious procedures and other bureaucratic hurdles involved in obtaining government support. Taxation policies, getting clearances, registrations are major problems. These administrative regulations add cost and time which hinder the output of research activities in the firm. Further, government has failed miserably in providing support and facilities to the tool sector which are necessary for development of new products and processes.

The results reveal that Policy Environment (I3) issues significantly affect (r= 0.30; p= 0.0444) the response of cutting tool sector to market demands (Z4). Thus H3-c is accepted.

Favorable industrial policy regarding subsidies helps the organizations to respond effectively to the market place. Active government policies play an important role for small scale organizations in selling their products in the local market or within the country and competing with global counterparts. Various support mechanisms also facilitate organizations in responding to the increasing competition.

'External Alliances' (I4) is next input factor for implementation of TD program in an organization.

The results show that Alliances with External Organizations (I4) has not exhibited a significant association with level of technology (Z1) in the cutting tool sector. Thus H4-a is rejected.

Tool sector in the region has not performed well in interacting with external knowledge generators viz other industries, technical institutes, R&D establishments and service institutes set by government to support small units. There are very few units (2%) which have worked in collaboration with technical institutions and universities for upgradation initiatives. Further, interaction with R&D institutes has not contributed in enhancing the level of technology because manufacturing units have been collaborating with these institutes for solutions to production and maintenance problems and not for process or product innovations.

The results show that there is a significant correlation (r=0.31; p= 0.0376) between 'Alliances' issues (I4) and implementation of strategic approaches for technology development (Z2). Thus H4-b is accepted.

Research establishments and other external agencies work with a project based approach and utilize specific strategies for creative outcome. Working in close cooperation with such institutions can lead to greater success in implementing strategic approaches for product innovations.

'Alliances with External Organizations' (I4) has shown significant association (r= 0.32; p= 0.0335) with improvement in structure and output of research activities (Z3). Thus H4-c is accepted.

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 innovative activities. Collaboration with companies and customers provides a firm with greater access to domestic or international markets. This can lead to greater commercial success of the new products and enhances the productivity of innovation through economies of scale. Collaboration with suppliers may lead to lower costs and better quality of the new products.

Results do not show any significant correlation between Alliances with external organizations (A4) and response to market demands (Y4). H4-d is rejected.

Small scale organizations in the region are having more 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, collaboration requires sharing or changing of some established practices and the acceptance of a degree of interdependency on other firms, as well as the development of a common language. Also, small units focus more on solving production and maintenance issues through these alliances and stress less on technological development issues.

The results reveal that small scale sector is yet to learn the art of working in mutual cooperation with external agencies.

4.5.3 Regression Analysis

The results of multi-regression analysis have been presented in Table 4.8. Multiple correlation coefficient (R) has been calculated which uses all independent variables *(Input Factors)* simultaneously and one output variable *(Output Performance Parameters)* as dependent variable. Multiple correlation coefficient (R) for level of technology (Z1) and the independent variables is 0.49 and variance (R^2) is 0.2360, leading to the connotation that 23.60% of the variance in level of technology (Z1) parameter can be predicted from *'organizational culture'* (I1) and *'policy environment'* (I3) issues combined. The results indicate that 'organizational culture' is very significant (at $p<0.01$) and β coefficient (0.9245) for this parameter is highest among other independent variables chosen for regression analysis. Thus organizational culture issues play a major role in making technological improvements

Table 4.12 Multiple Regression Analysis between 'Input Factors' and 'Output Performance Parameters'

Development Indicators	Significance Factors	Beta Value (β)	t Value	Significance Value (p)	R Value	R^2 Value
Z1	**I1**	0.9245	2.7267	0.0092	0.49	0.2360
	I3	0.4848	1.9122	0.0626		
Z2	**I1**	-0.2995	-1.5405	0.1311	0.38	0.1505
	I2	0.1190	0.9213	0.3622		
	I4	0.1480	1.3455	0.1858		
Z3	**I1**	0.7955	3.4756	0.0012	0.65	0.4236
	I2	0.3869	2.5430	0.0148		
	I4	0.3288	2.5389	0.0150		
Z4	**I1**	0.2257	0.8283	0.4121	0.13	0.0177
	I3	-0.0149	-0.0709	0.9437		

Multiple correlation coefficient (R) for *level of technology* (Z1) and the independent variables is 0.49 and variance (R^2) is 0.2360, leading to the connotation that 23.60% of the variance in *level of technology* (Z1) parameter can be predicted from *'organizational culture'* (I1) and *'policy environment'* (I3) issues combined. The results indicate that 'organizational culture' is very significant (at $p<0.01$) and β coefficient (0.9245) for this parameter is highest among other independent variables chosen for regression analysis. Thus organizational culture issues play a major role in making technological improvements.

Multiple correlation coefficient (R) value for *strategic implementation of innovation* (Z2) and the independent variables is 0.38. This reveals that 15.05% of the variance in this output parameter can be predicted from *'organizational culture'* (I1), *'resource support'* (I2) and *'alliances with external organizations'* (I4) issues combined.

'Structure and output of research function' (Z3) and 'independent variables' show a strong association with regression coefficient of 0.65. The results show that 42.36% of the variance in research output can be predicted from these input parameters. The organizational culture issues have maximum impact on increasing the effectiveness of research function.

Multiple correlation coefficient (R) for *response to market demands* (Z4) and the input variables is 0.13.

The results of multi correlation analysis have corroborated with those obtained through t-test analysis and thus validate the same.

5.1 Introduction

This chapter covers the summary of research work, its results, conclusions, and the recommendations. The chapter also lists various areas, which can be taken up for further research. The summary of research covers the major inferences drawn and learnings. Based on the results and the findings, conclusions have been drawn and recommendations have been made. The limitations along with the scope for future work are covered in the subsequent sections of the chapter.

5.2 Results and Major Findings

The results have been derived from the descriptive and empirical analysis of data collected through questionnaire based survey. The main findings are presented as follows:

General Areas

- The most significant (PPS>70) factors deteriorating the performance of tool sector include absence of large scale manufacturing industry in the region, lack of technological dynamism and shortage and high cost of electricity to run production operations smoothly.
- Increase in competition because of globalization and liberalization, scarcity of funds for development projects, shortage of multi-skilled workforce and high price of raw material are also significant (PPS~ 65-70).

Organizational Culture Issues

- Education level in majority (63 percent) of the units is between fair to good. However, one fourth (24 percent) of units have considered poor education level of employees to be a serious concern.
- Most of the units (83 percent) do not provide any formal training to employees. Only a few (4 percent) organizations provide formal training to employees just after induction into the organization.
- Majority of the organizations (92 percent) either give a fixed monetary reward, an increment in salary or a share in the profits made on account of innovation. Thus reward schemes have been largely based on extrinsic motivation tools only.

- In majority of the units the role of top management has been supportive in situations of project failures. However, a few organizations (4 percent) take strict action against members of project team or discourage employees to undertake projects for innovation if failure occurs.
- Industrial units lack in availability of technical and scientific staff (R&D personnel). Majority of the units do not have R&D personnel in required numbers.
- The level of encouragement to employees by senior management is moderate (PPS= 57.60) for undertaking R&D work. There is only little to reasonable pressure on employees to put efforts for technology development.
- Cutting tool sector in the region is not performing well in availability of multi-skilled workforce. It is only about one fifth of the units that have such workforce in desired numbers.

Resource Support Issues

- Industry, in general, has lacked in adequate financial support for technology upgradation. One third of the units face acute shortage of funds. 59 percent units have only little to reasonable support for their development projects.
- State of the art production machinery and equipment is not available in majority (63 percent) of the industrial units. Only less than one tenth (9 percent) of the units have latest production facilities.
- Cutting tool units in the region do not have latest software for drafting, designing and modeling etc. 79 percent of the units are using softwares only to a very small extent.
- The tool sector lacks in availability of dedicated laboratories with facilities for experimentation and analysis. Majority of the units (74 %) do not have these facilities.
- As far as earmarking of funds for research and development activities is concerned, the performance of industry is not satisfactory. 59 percent units do not allocate funds for research activities clearly. 26 percent club these funds with other developmental activities.
- Investments in research function by the local industry do not compare global standards by any means. 63 percent units do not spend even 0.5% of annual turnover on R&D.
- Absence of modernization and renovation programs is another aspect preventing development. Only one fifth (19%) of the units regularly implement modernization and renovation measures.

Policy Environment Issues

- Majority of the units (66 percent) do not receive any financial help from government which is discouraging.
- Government has to make improvements (PPS= 57.60) in its policies to ensure availability of raw materials at appropriate prices. Majority of the units have considered raw material prices to be high and significant in impairing their performance.
- Availability and cost of electric power in the region has been considered as a major problem. Nearly two third (62 percent) of the units consider this factor as most significant in restricting growth and competitiveness of industrial units.
- The proprietors and senior executives of industrial units are of the opinion that government can suitably reward entrepreneurs for their achievements in the field of technological innovations, support tool industry by organizing seminars/workshops on advanced and upcoming technologies, provide labs for testing, analysis etc. and provide funding for employee training programs.

Alliance Issues

- Organizations have shown unreasonably low rating (PPS= 34.24 only), in interaction with external agencies (other industries, academic institutes and research institutes). Most of the units have never collaborated with these organizations
- Industry has shown a poor rating (PPS= 49.45) in deriving support from government service institutes. There are only a very few (4 percent) industrial units which have sought active support from these government subsidiaries.
- The industry has obtained an extremely poor rating in interacting with academic institutions. Most of the organizations (89 percent) have not experienced any affirmative results through industry-institute interactions.
- Cutting tool sector in the region lacks in good R&D infrastructure. Majority of the units (72 percent) are of the opinion that institutional infrastructure can be helpful in development initiatives of industry to a large extent.
- Majority of the units (73 percent) have been dependent on large scale manufacturing industry in the country for process technology needs.

Concerning Output Performance Parameters

- The response of industry in utilizing *'Risky Research'* strategy has been low. Nearly half of the industrial units (48 percent) are not using this strategy at all.
- A relatively low rating has been shown in '*Imitation for Creation'* strategy. More than half (54%) of the units have never practiced this strategy.
- Nearly half of the industrial units utilize their research efforts for solving maintenance related problems. It is only 18 percent of the units which tend to use research function for developing new products.
- Only 30 percent of the industrial units collect information on customer requirements in a structured manner. Out of these, 18 percent units have a separate marketing department to perform this function and in the remaining 12 percent units, a team of senior executives performs this job.
- Cutting tool sector is aware of the benefits of in-house technology development programs (PPS= 46.20), but, a lot needs to be done to convert this awareness into actual benefits. At present, not even one tenth (6 percent) of the units are employing latest technology to produce products. 59 percent units employ old technology in their products which is a cause of concern.
- The performance of industry has not been very encouraging as far as increase in product mix and adding new features to the products is concerned (PPS=66.85, PPS=53.93 respectively). Only 3 percent units have increased product features considerably in the last few years.
- There are only a few units (6 percent) which follow and practice a well defined R&D policy. 40 percent units do not have a defined R&D policy. 44 percent of the units have just started formulating the policy and remaining 10 percent have almost decided their R&D policy but are yet to implement it.

Classification of Manufacturing Units

- The performance of organizations in *'Organizational Culture'* issues is moderate. More than 26 percent units fall in *'poor'* category in this component. Majority of the units (70 percent) are at a *'fair'* level. There are only 4 percent units whose performance is *'good'* in this component

- Performance of industry is worst in *'Resource Support'*. Around one tenth (11 percent) units are at *'very poor'* level and 63 percent are at a *'poor'* level.
- In *'Policy Environment'* issues, 4 percent units are at *'very poor'* level and 46 percent are at *'poor'* level.
- As far as industry wise performance in *'Alliances with External Organizations'* is concerned, 4 percent units are at a *'very poor'* level and one third units are at a *'poor'* level. Most of the units are in the *'fair'* category.

Results of Empirical Analysis

- *Organizational culture* (I1) and *policy environment* (I3) issues have significantly influenced the *level of technology* (Z1) in firms. Thus H1-a and H3-a are confirmed.
- *Strategic implementation of innovation* (Z2) can be mainly achieved through availability of suitable *research infrastructure* (I2) and *alliances with external organizations* (I4). Thus H2-b and H4-b are confirmed.
- The *structure and output of research function* (Z3) has depicted significant association with *organizational culture* (I1), *resource support* (I2) and alliances with external organizations (I4). Thus H1-c, H2-c and H4-c are confirmed.
- The firm's ability to *respond to the market needs* (Z4) mainly depends upon *organizational culture* (I1) and *policy environment* (A3). Thus H1-d and H3-d are confirmed.

5.3 Conclusions and Recommendations

The main conclusions to be drawn are as follows:

i. Absence of large scale manufacturing industry in the region and use of old process technology to manufacture products are the prime factors affecting performance of small units. Large scale manufacturing sector, if present, can provide resources in the form of finance and expertise, as well as operational support and international opportunities.
ii. High cost of electricity with restricted and unreliable supply is also affecting the industrial performance.
iii. Becoming innovative, requires an organizational culture that constantly guides employees to strive for innovation and a climate that is conducive to creativity. Small scale sector in the region has to particularly focus on appropriate reward systems and training of

employees to build an organizational culture conducive for process improvements and product innovations.

iv. The performance of industry is worst in resource support component. A restriction of resources limits innovative ability because employees are more occupied with finding additional resources and not with actually developing new products. Resources are important not only for functional support, but also because having an adequate level of resources for a project influences employee's perception that the project is valuable and worthy of organizational support.

v. Government has several schemes for industry but, benefits of the same have not reached the industrial sector because of lack of awareness of proprietors regarding the schemes and ineffectiveness of government subsidiaries in reaching small units and extending support. Government should also ensure good quality and reliable physical infrastructure at reasonable prices.

vi. Small industry has not been interacting much with external organizations for technology upgradation. Industrial units should enter into interactive learning networks with other firms, customers and suppliers, government laboratories, universities and R&D organizations.

5.4 Limitations of the Study

The main limitations of the study are as follows:

- The item measures for various research parameters have been considered to be of equal weightage. Under actual conditions some parameters may be contributing more towards a parameter than the other items.
- No mathematical model (or equations etc.) has been developed to assess the contribution of input factors towards output performance parameters.

5.5 Scope of Future Work

- The study has been limited to small scale manufacturing industry only. It can be extended to medium and large scale as well. Further, the study can be conducted for other type of industry viz. process industry, service industry etc.

- Similar studies can be conducted to analyze the effect of technology upgradation initiative on other competitive priorities like quality or cost individually.

The present research is aimed at developing an insight into the prevalent technology development practices adopted in the manufacturing industry for realizing sustainable growth and development of the industrial sector. It appears that creativity and innovation flourish only under the right circumstances in an organization. Without doubt the most innovative companies of the future will be dominated by those that do not simply focus energies upon product and technical innovation, but those who have managed to build enduring environments of human communities striving towards innovation through the creation of appropriate cultures and climate.

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APPENDIX-I

Details of Respondents to TD Questionnaire

S. No.	Name of Organization	Address	Designation of Respondent	Year of Inception	Main Products
1.	A.A. Industries	D-57, Focal Point, Patiala	Chief Executive R.S. Sehgal, 2232843 (O)	--	*Gear shaper Cutters, Gear Shaving Cutters & all types of Milling Cutters*
2.	Ajit Tool Industry	D-145, Industrial Focal Point, Patiala	Proprietor Harinder Singh 3291027(O)	1999	*Special Purpose Machines, Milling Cutters, Side and Face Cutters*
3.	Aman Tools	D-38, Focal Point, Patiala	Proprietor Devinder Pal Dhall 5181282(O)	1999	*Gear Cutting Tools, Gear Hobs, Worm Gear Hobs*
4.	Amar Tool Corporation	D-88, Focal Point, Patiala	Proprietor Amar Nath Singh 6522808 (O)	2000	*Precision Gear Hobs, Gear Shaving Cutters, Master Gears, Gear Shaper Cutters*
5.	Aro Industries	D-9, Focal Point, Patiala	Proprietor Mitilesh Aggarwal 3291462 (O)	2003	*Master Gears, Gear Shaper Cutters, Straight and Spiral Bevel Cutter Blades*
6.	Canon Tools	D-149, Focal Point, Patiala	Proprietor --	--	*Gear Hobs, Gear Shaper Cutters, Milling Cutters, Dies and Moulds*
7.	Capital Tool industries	7-A, Industrial Estate, Patiala	Proprietor R. K. Gupta. 2351089, 2352326	1966	*Gear Cutting Tools, Gear Hobs, Worm Gear Hobs, Involute Gear Cutters, Gear shaper Cutters, Gear Shaving Cutters & all types of Milling Cutters*
8.	Central Tool Corporation	C-226, Focal Point, Patiala	Proprietor Ravinder Pal Singh 2362349 (O)	1983	*Central Drills, End Mill Cutters, Broaches*
9.	Chief Tool Corporation	D-258, Focal Point	Proprietor Ravinder Singh 9417236855(M)	1991	*Gear Hob Cutters, Gear shaper Cutters*
10.	ESGI Tools Pvt. Ltd.	B-06, Focal Point, Patiala	Partner Naresh Gupta 2233991-4 (O)	1991	*Precision Gear Hobs, Gear Shaving Cutters, Master Gears, Gear Shaper Cutters, Straight and Spiral Bevel Cutter Blades*

11.	Ferro Tech. Tools	C-134, Focal Point, Patiala	Proprietor R.K. Singla 3293454 (O)	2004	*Reamers, End Mill Cutters, Dovetail Cutters, Slitting Saw, Side and Face Cutters*
12.	Global Enterprses	C-6, Focal Point, Patiala	Proprietor Sunil K. Sood 2232856 (O)	1995	*Gear Hobs, Gear Shaper Cutters, Milling Cutters, Dies and Moulds*
13.	Guru Mehar Industries	B-05, Focal Point, Patiala	Proprietor Paramjit Singh 2232810 (O),	2001	*Broaches, Splines,Cutters*
14.	HMB Tools	E-25, Focal Point, Patiala	Proprietor Jasbir Singh 9B554-92150 (M)	2006	*Slotting Cutters, Side and Face Cutters*
15.	IM Tools	D-112, Focal Point, Patiala	Proprietor Devinder Singh 5003767(O),	2001	*Reamers, End Mill Cutters, Dovetail Cutters*
16.	India Tools	7756/5, Factory area, Patiala	Proprietor Harwinder Singh 9417178292(M)	1965	*Reamers, Ball Seat Cutters, Side and Face Cutters*
17.	Jeevandeep Tools	D-110, Focal Point, Patiala	Proprietor Navdeep Gupta 2233915 (O)	1997	*Shank Type Tools,Reamers, End Mill Cutters*
18.	Jindal Tool Industries	Gaushala Road, Patiala	Proprietor --	1979	*Gear Hobs, Gear Shaper Cutters, Milling Cutters*
19.	Kapson India	D-99, Focal Point, Patiala	Partner Sanjay Kapoor 2216950(O)	1995	*Master Gears Worm, Gear Hobs, Involute Gear Hobs, Gear Shaper Cutters, Gear Shaving Cutters, Involute Gear Cutters*
20.	KEM Tools Industries	Near- Verka Milk Plant, Sirhind Road, Patiala	Proprietor Parminder Bhardwaj 2351877(O)	1996	*Gear Hobs, Gear Shaper Cutters, Milling Cutters, Side and Face Cutters*
21.	R.J. Tools	D -8, Focal Point, Patiala	Partner Rajinder Gupta 2232423 (O)	2003	*Reamers, End Mill Cutters, Dovetail Cutters*
22.	Mahindra Precision Tools	C-159-160,Focal Point, Patiala	Proprietor Mohinder Singh 3290203(O)	1994	*CTC Chasers And Cutters,Hob Cutters For Gears,Splines,Sprockets And Serrations*
23.	Marshal Tools	E-27, Focal Point, Patiala	Proprietor	--	*Precision Gear Hobs, Gear Shaving Cutters, Master Gears, Gear Shaper Cutters*

24.	Module Tools	D-268, Focal Point, Patiala	Proprietor Mitilesh Aggarwal 9988319017(M)	2006	*Hobs, Gear Shaving Cutters, Master Gears, Gear Shaper Cutters*
25.	National Tools	D-107, Industrial Focal Point, Patiala	Proprietor Jagdeep Sachdeva 3292323(O)	1998	*Milling Cutters, Side and Face Cutters, Splines*
26.	Patiala Tools Corporation	1 - A , Industrial Estate, Patiala	Partner Prakash C. Goel 2353101(O)	1961	*Gear Hobs, Gear Shaper Cutters, Milling Cutters*
27.	Perfect Engg. Tools	D-116, Focal Point, Patiala	Proprietor Dilbagh Singh, 5001314 (O)	2000	*Reamers, End Mill Cutters, Dovetail Cutters*
28.	Precision Machines	D-331, Focal Point, Patiala	Proprietor Tejinder Jeet 5003287 (O),	2003	*Shank Type Tools, , Involute Gear Cutters, End Mill Cutters*
29.	Punjab tools	D-71, Focal Point, Patiala	Proprietor Navaljit Singh 2233248 (O)	1994	*End Mill Cutters, Side and Face Cutters*
30.	S.K.Tools	D-228, Focal Point, Patiala	Proprietor S.K. Sethi. 3290624 (O)	--	*Gear Hobs, Gear Shaper Cutters, Milling Cutters*
31.	S.Lal & Sons	D-276, Focal Point, Patiala	Proprietor Vijay Singa 2351397(O)	2002	*End Mill Cutters, Side and Face Cutters, Special Tools*
32.	S.S. Tools	Sirhind Road, Patiala	Proprietor Rajan Gupta 2351272(O)	1978	*Master Gears Worm, Gear Hobs, Involute Gear Hobs, Gear Shaper Cutters, CTC Chasers & Cutters, Rolling Dies & Crushers*
33.	Shakti Tool Industries	D-141, Focal Point, Patiala	Partner	2002	*Reamers, End Mill Cutters, Dovetail Cutters*
34.	Simran Engineering Works	D-18, Focal Point, Patiala	Proprietor Tejinder Singh. 5003287 (O),	2002	*Shank Type Tools, Involute Gear Cutters*
35.	Star Industries	C-75, Focal Point, Patiala	Partner Pritpal Dhiman 5000883 (O)	--	*End Mill Cutters, Slot Drills, Counter Bore, Convex cutter, Face cutter, Angle cutter*
36.	Steelmans Cutting Tools	183, Ajit Nagar, Patiala	Proprietor Jasbir Dhingra 2218031	1986	*Core Drill with Taper Shank, Centre Drills, Taps & Dies, Reamers, Slot Drills, Counter Bore, Convex cutter, Face cutter, Angle cutter, End mills cutters*

37.	Sunrise Industries	11-A, Factory area, Patiala	Inderjit Birdi (Proprietor) 2363440	1985	*End Mill Cutters, Side and Face Cutters*
38.	Super Capital Tools	D-101, Focal Point, Patiala	Proprietor Surinder Gupta 3292049 (O)	1992	*Shank Type Tools, Involute Gear Cutters, End Mill Cutters*
39.	Super Hobs and Broaches Pvt. Ltd.	B - 22, Focal Point, Patiala	Director Narain Nath, 2232772 (O)	1999	*End Mill Cutters, Side and Face Cutters, Slotting Saw*
40.	Surindra Tools	E-20, Focal Point, Patiala	Proprietor Surinder Singla 98887-30796 (M)	2001	*circular saw, drills, reamers*
41.	Surya Tools Industries	D-97, Focal Point, Patiala	Proprietor Naresh Goyal 3294307 (O)	1998	*Side and Face Cutters, Slotting Saw, End Mill Cutters*
42.	Techcellence Pvt. Ltd.	C - 17, Focal Point, Patiala	Proprietor D.K. Bansal, 2232100(O)	1999	*Master Gears Worm, Gear Hobs, Involute Gear Hobs, Gear Shaper Cutters, Gear Shaving Cutters, Involute Gear Cutters*
43.	Tiwana tool Industries	C-162, Focal Point, Patiala	Proprietor Jagbeer Tiwana 2360847 (O)	1983	*Broaches*
44.	Tool Masters	C-36, Focal Point, Patiala	Partner Mohit Gupta. 2232808(O)	--	*Rack cutters, timing belt hobs, gear shaper cutters, gear cutting tools, spline broaches, helical shaper cutter, face cutters, gear hobs, slitting saws, timing belt, sprocket milling cutters, gear milling cutters, shaper cutters, keyway broaches, endmills reamers, shaper cutter, side cutters*
45.	United Tool Company	# 1598, Ragho Majra, Patiala	Proprietor	--	*Involute Gear Cutters ,Shank Type Tools, End Mill Cutters,*
46.	Vishal Tools Corporation	D-83' Focal Point, Patiala	Proprietor Vishal Kapoor 2365280 (O),	2005	*Master Gears Worm, Gear Hobs, Involute Gear Hobs, Gear Shaper Cutters, Gear Shaving Cutters, Involute Gear Cutters*

APPENDIX-II

Various TD Input Factors

Organizational Culture (I1)	• *Manpower Development* • *Learning Environment* • *Training to Employees* • *Traits for Innovation* • *Intrinsic-Extrinsic Motivation* • *Risk-Taking and Strategic Direction*
Resource Support (I2)	• *Physical Environment* • *Modernization Programs* • *Capital Support* • *Investments in R&D as a function of annual turnover*
Policy Environment (I3)	• *Raw materials availability and prices.* • *Cost and availability of power in region.* • *Policy Environment* • *Financial Support to R&D*
Alliance with External Organizations (I4)	• *Industrial Partnerships* • *University-Industry Partnerships* • *Other Parternerships*

APPENDIX-III

Various Performance Output Parameters

Level of Technology (Z1)	• ***Level of process technology in use.*** • *Role of old technology in impairing performance.*
Strategic Implementation of Innovation (Z2)	• *External sources for technology needs.* • *In-house R&D for developing new technology products and processes.* • *Technology developed through in-house research.* • *Use of 'Risky Research', as a strategic approach.* • *Use of 'Imitation for creation', as a strategic approach.*
Structure and Output of Research Function (Z3)	• *Collecting customer requirements through a separate marketing department* • *Well defined R&D policy for technology development.* • *New processes developed through in-house research efforts.* • *New products developed through in-house research efforts.* • *Organizational structure for R&D function.*
Response to Market Needs (Z4)	• *Increase in product features to respond to needs of marketplace.* • *Product quality and attributes as compared to competitors.* • *Markets served by the industrial units.* • *Improvement in product-mix offered by the industrial units.*