

**AN ASSESSMENT OF TECHNOLOGY DEVELOPMENT  
INITIATIVES OF TOOL INDUSTRY IN THE REGION**

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

**MASTER OF ENGINEERING  
(PRODUCTION AND INDUSTRIAL ENGINEERING)**

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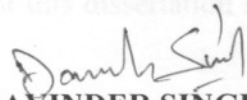
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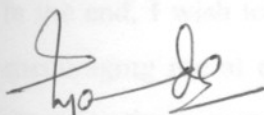
## CERTIFICATE

This is to certify that the work presented in this dissertation entitled '**An Assessment of Technology Development Initiatives of Tool Industry in the Region**' in partial fulfillment of the requirement for the award of degree of **MASTER OF ENGINEERING in Production and Industrial Engineering** in the Mechanical Engineering Department, **THAPAR UNIVERSITY, PATIALA** is an authentic record of the initial work carried out by me under the supervision and guidance of **Mr. TARUN NANDA, Sr. Lecturer, Mechanical Engineering Department, TU, Patiala**. The matter embodied in this dissertation report has not been submitted anywhere else for the award of any other degree.

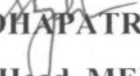
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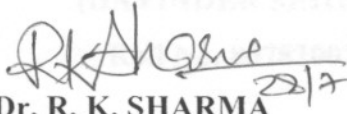
  
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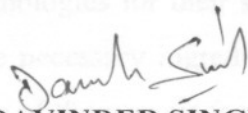
  
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## **ABSTRACT**

In today's competitive business environment, global competition forces companies to perpetually seek ways of improving their products and services. The pressure on organizations to adapt to new technologies and external threats requires resourcefulness, creativity and innovation. The fierce competition situation arising out of globalization and liberalization is forcing the organizations across the globe to realize that their survival is not feasible in the absence of R&D and innovation practices. Markets have become more open, competitive and the customers more demanding. To stay close to the customers is essential for sustained growth and continuity of business. Without continuous technology upgradation, no enterprise can ever remain competitive. The rate of change is accelerating rapidly as new knowledge and global diffusion increase. 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. Organizations that want to survive in today's highly competitive business environment must address the need for high quality, lower costs, and more effective and swifter research and development. 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. The key driver of organization's ability to change is innovation. Thus the organizations are left with no choice but to upgrade the existing systems, products and technologies for their survival. The present work explains that creativity and innovation are the necessary ingredients for developing new technology. The study presents a detailed analysis of the various factors and issues affecting technology development initiatives of tool industry in the region and their relative significance in affecting improvements.

# CHAPTER I

## INTRODUCTION

### 1.1 General

Today the world is moving from an era of separate national economies to a networked global economy. The advent of liberalization, privatization and globalization has brought forth profound economic, social, environmental and technological pressures on the organizations. Markets have become more open, competitive and the customers more demanding. Competition is fierce in all aspects of the business such as technology, cost, product quality and service (Gottardi, 2000).

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). Post industrial organizations are today knowledge based organizations and their success and survival depend upon creativity, innovation, discovery and inventiveness (Read, 1996; Goffin et al, 2000; Scott, 2001; Martins and Terblanche, 2003; Swann and Birke, 2005; Yang, 2007). The competitive business environment is forcing organizations to perpetually seek ways of improving their products and services (Andriopoulos, 2001).

Pressures have increased for both profit and non-profit organizations to become 'innovative organizations'. As competitive pressures mount, firms are attempting to do more with less and far more quickly (Andriopoulos and Lowe, 2000). In the face of global economic competitiveness the idea of innovating has found favor among governments, industry and academia (Chaharbaghi and Newman, 1996). External forces such as increasing international competition and advances in information technology have escalated demands on organizations to be innovative (Williams, 2004).

Innovation process is very critical in order to secure company's future position, or even existence, and thus appropriate time and energy should be given to it (Tushman and Nadler, 1986). It is a fact, that nowadays the choice is between to innovate or to die (Tom, 1991). It is not question where this choice is to be made; every industry has this feature nowadays (Barnholt, 1997). For organizations to become and remain successful and competitive, they must be continually developing and learning (Hitt et al, 1997; Barker and Neailey, 1999; Martensen and Dahlgaard, 1999; Cruz et al., 2009).

Innovation is described as a pervasive attitude that allows business to see beyond the present and create the future. Innovation is the engine of change and in today's fiercely competitive environment resisting change is dangerous. Change, while it brings uncertainty and risk, also creates opportunity. The key driver of organizations ability to change is innovation (Ahmed, 1998b; Jarratt, 1999; Williams, 2001; Wong and He, 2003; Carayannis and Provan, 2008). The rate of change is accelerating rapidly as new knowledge and global diffusion increase. The ability to change has become a crucial factor in the effectiveness of organizations (French and Delahaye, 1996). Successful organizations are those that continually adapt their structures, strategies, systems, products and cultures (Waterman, 1988; Syrett and Lamoniman, 1997).

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 (Barton 1991; Martins and Terblanche, 2003; Yang, 2007).

## **1.2 Need for Technology Upgradation**

The nations are now on the verge of immense technological change and knowledge revolution. In the modern age, technology is the most important resource to any nation. It is the main driver of a nation's economic development. Technology developments, in the areas of both product and process technologies are taking place at a very fast pace. As the organizations around the world are faced with dynamic environments, the technology upgradation has become a key factor for the organization's survival and prosperity on the long term basis. The need of the hour is to achieve more product variety, shorten the delivery times and achieving greater flexibility of manufacturing functions.

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. In order to address the top competitive issues facing the industry, successful firms across the world are continuously making efforts in meeting pace with new technologies. Thus continuous upgradation of technology has become essential for survival of any manufacturing unit (Ha-Brookshire, 2009).

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 Status of Technology Development in India**

According to the Global competitiveness Report, 2007-2008, published by Harvard Institute, India ranks fourth in the world on the factor of availability of scientists and engineers, yet it ranks at 48 out of 131 nations on overall technological sophistication. The paradox is very stark. On one hand India has developed, nuclear capabilities and has shown a lot of strength in the areas of satellite communication, missile technology but on the other performs badly in the export of capital equipment. Also, 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. Only less than 20% of the R&D funding comes from private organizations. According to Global Competitiveness Report 2007-2008, India stands at number 28 on private sector spending on R&D among 131 developed and emerging economies.

India stands at number 33 on the extent of staff training. India as a whole is in an advantageous position by way of having an extraordinary large pool of trained scientific and technological manpower, reputedly the fourth largest in the world, in sheer numbers, though perhaps not in merit.

According to the Global competitiveness report 2007-2008, India stands at number 44 on research collaboration 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 44 out of 131 countries (Global

Competitiveness Report, 2007-08). The status of Indian industry in various areas which affect technology innovation capabilities is presented in Table 1.1.

**Table 1.1: Technology Innovation Capability of Indian Industry**

<b>S.No.</b>	<b>Parameter</b>	<b>India's Rank (131 countries)</b>
1.	Technological readiness (Adoption of existing technologies)	62
2.	Transparency of government policy making	45
3.	Burden of government regulations	79
4.	Wastefulness of government spending	47
5.	Quality of railroad infrastructure	23
6.	Quality of electricity supply	106
7.	Quality of overall infrastructure (Transport & Communication)	79
8.	Local availability of specialized research and training services	31
9.	Extent of staff training	33
10.	Availability of latest technologies	31
11.	Hiring and firing practices for labor	102
12.	Quality of educational system	31
13.	Extent of staff training	33
14.	Number of procedures required to start a business	85
15.	Production process sophistication	41
16.	Utility patents	62
17.	Availability of scientific and technical manpower	04
18.	Private sector on R&D	28
19.	University-industry research collaboration	44
Overall Technology Sophistication		48

#### **1.4 Objectives of the Research work**

The main objective of the present study is to analyze the technology development capabilities of small scale manufacturing industry in the region. The research work will present the broad areas required for overall assessment of technology development initiatives in the industry. A structured approach will be employed for managing the input success factors to enhance the probability of success through such initiatives.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

The industrial scenario in India has undergone a sea change consequent to globalization and liberalization of economy that began in the country in early nineties. After liberalization was initiated in 1991, leading international players targeted India along with China as a key investment opportunity in all areas (Sethi and Sushil, 2000). Fierce competition started coming both from local and global markets. 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. Organizations must move away from their complacent technology development initiatives and start managing innovation in research and development activities to develop cutting edge technologies and products. In the last one decade, leading Indian manufacturing entrepreneurs have taken proactive steps to imbibe technology development initiatives in the organizations to realize enhanced manufacturing performance. The Indian industry is faced with the challenge of adopting technological innovations through in-house R&D as a strategy for staying competitive. In the present context, R&D function must be regarded as an equal partner in the organization, having a huge potential in enhancing the competitive advantage of the organization. The manufacturing organizations in the country have been forced to look out for proactive strategic technology development initiatives, in the recent past, for harnessing their manufacturing competencies for meeting the global competition.

The literature review presented here depicts the results of a detailed survey related to technology upgradation initiatives required to become competitive. The review has been carried out to assess the requirements of industry with regards to existence of facilities and programs for technology development through indigenous research and effectiveness and extent of deployment of various components of technology development (TD) in the industry.

#### **2.2 Management Proficiency**

The literature highlights that top management support and competency of available manpower are critical to the success of technology development initiatives. Thus,

management proficiency is an integral component of any technology development program. The important issues under this component are discussed as follows:

### **2.2.1 Skill Development of Employees**

Competent manpower is an important element of technology development initiatives of an organization. Innovative organizations have a significant approach towards manpower development in order to achieve long term organizational goals (Kim and Choi, 1997). Employees directly contribute to the innovation content and can assist in improving the process of innovation so that fewer resources are wasted. Lack of proper human resources and capital are the major impediments to manufacturing organization's efforts in the development of new industrial technology and such organizations have to increasingly rely on external knowledge sources to build up technological competence (Sugasawa and Liyanage, 1999). Innovative organizations believe that the bottom line difference between success and failure is finding, developing and nurturing the right people (Ahmed, 1998a; Harney and Dundon, 2006; Paauwe and Boselie, 2005; Nunes et al, 2006). Such organizations explicitly strive towards the attraction, development and retention of creative talent. Their strategies include effective manpower planning, realistic performance plans, development oriented performance appraisal, effective learning system, performance guidance and other mechanisms such as mentoring (Cook, 1998; Wang et al, 2007).

Skill development is a crucial element of any strategy which aims at improving competitiveness within a firm. Historically, government strategies have focused on promoting formal skills development to businesses while businesses have often bypassed this by recruiting, or selectively buying in, individuals with the required skills set. Government is chasing businesses to develop their workforce through training yet businesses are seeking to recruit a 'final product' (Lange et al, 2000).

It is commonly acknowledged that an increase in the productivity of labor may result from the acquisition of relevant skills. Basic and strategic management skills are crucial for the success of firms (Keogh and Stewart, 2000; Al-Madhoun and Analoui, 2003; Temtime and Pansiri, 2005). The idea and knowledge of creative employees are considered as prime business assets. Employees' knowledge, intellectual abilities, thinking style preferences, personality and task motivation are important components of creativity (Smolensky and Kleiner, 1995; Lloyd, 1996; Thacker, 1997; Amabile, 1997, 1998). When people acquire

skills, they are able to produce more output for a given amount of time and effort (Sternberg et al., 1997).

Innovative organizations have adequate strength of multi-skilled workforce. Strategies range from identification of areas of skills in which shortfalls either occur or can occur and efforts are made to generate those skills (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).

Pressures faced by new technology-based SMEs come from a number of different sources. The environments in which these companies work are dynamic, and the technology they work with is often transient. Successful exploitation of technology in a dynamic environment depends crucially upon a skill base capable of identifying opportunities for, and managing, technological development (Scott et al., 1996).

Small scale manufacturing enterprises are found unwilling to explore external resources, as they associate with a loss of control or as an embarrassing indictment of the value of their in-house expertise. This suggests deeply rooted obstacles to the further acquisition of technological and organizational expertise in small manufacturing firms. Small firms often rely on their own experiential know-how, and train up their own operative and intermediate level skills. Small firms generally remain insular and autonomous and fail to recognize the underlying or latent skill deficiencies. The increased propensity for jobs to be created and/or maintained via the use of temporary contracts rather than permanent employment affords employers the flexibility they desire. However, the resultant increase in job insecurity may cost them both the skills and knowledge that are gained from longer terms of employment and the likelihood of individuals receiving formal skills development (Lange et al, 2000).

A lack of contact with appropriate facilitators (training organizations). Smaller companies often do not have the capacity to undertake skills forecasting and strategic analysis. While this may well hinder a firm's ability to manage the problems and barriers they face, it has wide-reaching consequences as skill shortages in small firms can have an adverse effect on competitiveness.

### **2.2.2 Education level of the Workforce**

A highly skilled and educated workforce is key to increased competitiveness and sustainable growth (Keogh and Stewart, 2000; Lange et al, 2000). The benefits of education and training, which result in gain in skills by individuals, also have the effect of increasing adaptability. Better educated workers provide the flexibility needed to switch production between sectors and branches, and to restore external balance through innovation, retraining and relocation. This adaptability is essential for keeping labor and capital employed and maintaining competitiveness.

Small scale organizations do not exploit recruitment to the same degree as large firms and tend not to recruit from higher education sector because of financial reasons. As such graduates and post graduates are perceived as more expensive to hire.

### **2.2.3 Employee Training**

Innovative organizations continually educate and train their employees in various skills, matching employee's professional career goals with organization's needs (Locke and Kirkpatrick, 1995; Samaha, 1996; Arad et al, 1997; Goncalo and Staw, 2006). Innovative organizations empower their employees more, study the marketplace regularly and provide more training to their managers than in less innovative companies (Barnett and Storey, 2000; Chandler et al, 2000; Georgellis et al, 2000; Beaver and Prince, 2002; Salavou et al, 2004; Laforet and Tann, 2006).

Training interventions that teach managers how to foster their subordinate's creativity are more valuable than training interventions directed at the subordinates themselves (Williams, 2001). Innovative organizations operate training programs for their managers to make them aware of organization's competition, and to identify strategies to face the competition. These organizations ensure that each manager spends at least some fraction of his/her payroll on training (Business Week, 1987; William, 1990; Business Week, 1998). Apart from blue-collar workers who receive on-the-job training; supervisors, middle and senior managers receive outside and in house training. However, training is more limited in less innovative small scale manufacturing organizations. This seems to be consistent with the literature suggesting small manufacturing organizations have shortage of skills and technology and face training problems (Scott et al., 1996; Westhead and Storey, 1997; Marlow, 1998; Hill and Stewart, 2000; Lange et al., 2000; Matlay, 2004; Storey, 2004; Holden et al, 2006).

Maintaining competitive 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). Training greatly compresses the time to acquire skills over earlier methods, such as apprenticeship. It achieves this condensation through a process involving the careful analysis of job requirements, the determination of skill needs, the specification of objectives, the design, delivery and evaluation of an instructional programme (James and Roffe, 2000).

A broad strategy for technical education and training (at technician level and below) should be to develop a system which is flexible and responsive to economic changes, i.e. to mount courses quickly to meet specific scarcities as they arise. It is critical that any expansion be 'phased in' so as to avoid the creation of a surplus in the short term and that any additional facilities built to provide for expansion of training in one field should be sufficiently flexible to switch to other training courses, to reflect changing demand (Castley, 1996).

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

#### **2.2.4 Scientific and Technical Human Resource**

Innovative organizations make strategic choices with regard to their human resources (Pihkala et al, 2002). Personality traits for innovation include broad interests, attraction to complexity, high energy, independence of judgment, intuition, self-confidence, and ability to accommodate opposites. Persistence, curiosity, intellectual honesty, and internal locus of control (reflective/introspective) are also important. Personality traits like intelligence, knowledge, eagerness to learn, inquisitiveness, diversity, risk taking and strong desire to fulfill goals are other traits required for innovation (Amabile, 1988; Woodman and Schoenfeldt, 1990; Dubina, 2005). Cognitive factors also appear to be associated with the ability to innovate (Guildford, 1983).

Although innovation is often seen as a technological breakthrough, it is also very much the art of an individual who has triumphed over the status quo. This triumph requires personal initiative. There are four common behaviors associated with taking initiative successfully: asking questions in order to identify problems and opportunities; teaching oneself new skills; taking action; and aligning strong personal beliefs with the organization's values and goals (Frohman, 1994). The 'Behavioral Model of Innovation', provides a framework for facilitating innovation within firms. The model prescribes a series of behaviors prominently manifested by R&D scientists and engineers employed in highly successful innovative companies. There are four behavioral dimensions posted in the model: inquisitiveness, advocating new ideas, collaboration and goal directedness (Gourthy et al., 1996). Although there appears to be general agreement that personality is related to creativity, attempts to try and use this inventory type of approach in an organizational setting as predictor of creative accomplishments is not always correct. Nevertheless it does highlight the need to focus on individual actors, and to try and nurture such characteristics or at least bring them out, if necessary, in an organizational setting.

Availability of scientific and technical manpower in adequate strength is critical to the success of technology development implementation program. At the specific occupational level, there are many reasons which may account for shortages. These include outward migration, poor wages, inadequate training, mobility factors, working conditions, and social objections. Two critical aspects of the diagnostic approach are financial incentives and carrier prospects. The structure of financial incentives is a major determinant of the supply of skilled manpower. The negative effects of skill shortages can often be offset by better utilization or by improving the quality of existing staff. Frequently it is not necessary to pour additional manpower into a sector but to make more effective use of what is already available. Hence, in seeking solutions of sector's manpower shortages, there are three possible directions. First, to increase the outflow of students from training institutions; second, to improve the utilization of those currently employed; and, third, to upgrade existing personnel.

#### **2.2.5 Favourable Reward Structure**

Recognizing individual and team accomplishment with awards encourages innovation. Whatever form an award might take (peer recognition, banquet, plaque, letter of appreciation. etc.), its very existence can galvanize employee contributions.

In-house reward systems to motivate employees for achieving goals of innovation, productivity and profitability are widely used by corporations. In organizations where innovation is 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). If creative behavior is rewarded, it becomes the general, dominant way of behaving with employees. The problem is that many organizations hope that personnel will think more creatively and take risks, but they are rewarded only for well-proven, trusted methods and fault-free work (Martins and Terblanche, 2003). Innovative organizations rely heavily on personalized intrinsic rewards whereas less innovative organizations tend to place almost exclusive emphasis on extrinsic awards (Plunkett, 1990; Ahmed, 1998b).

Extrinsic rewards include pay hikes, bonuses, shares and stock options. Pay hikes and financial benefits play an important role, especially in situations where an innovator might become dissatisfied if not adequately compensated. However, simply raising an employee's salary rarely makes him more innovative. Creative individuals often give up large salaries in order to work for innovative companies. The main purpose of pay hikes in innovative organizations is to reward creative performers just enough that they continue to excel, but not so excessively that the raise ceases to motivate.

Intrinsic rewards are based on internal feelings of accomplishment by the recipient and include increased autonomy and improved opportunities for personal and professional growth. Granting individuals the freedom to create and innovate is an important human resource management practice in successful organizations.

Innovative organizations allow their employees time to think creatively, to experiment and to engage in their own research projects (Mumford and Gustafson, 1988; Shalley, 1995). Employees should know how much time and effort they can spend on their pet projects so that their routine operations are not made sub-optimal (McFadzean, 1996; Filipczak, 1997). Creativity requires an incubation period. When managers do not allow time for proper experimentation, they unwittingly stand in the way of the creative process (Amabile, 1998; Anderson et al, 1992).

Freedom as a core value in stimulating creativity is manifested in autonomy, empowerment and decision making. Empowerment in the presence of strong cultures that guide actions

and behavior produces both energy and enthusiasm for consistent work. Top management prescribes a set of strategic goals, but allows personnel great freedom within the context of the goals. Employees have the freedom to do their work and determine procedures as they see fit within the guidelines provided. A serious problem with empowerment occurs in organizations without a strong value system. Such organizations are not capable of driving the activities in a unified and aligned manner. In these conditions, empowerment is little less than abdication of responsibility. In innovative organizations, employees understand the primacy of innovation agenda and know how far they are being empowered to achieve these ends. Such organizations draw action boundaries through a process of explicitly defining the domain of action and the priority, and the level of responsibility and empowerment provided to reach these ends. (Judge et al, 1997; Ahmed, 1998b; Martins and Terblanche, 2003).

Innovation based organizations reward their scientists and engineers by providing generous research budgets and a broad latitude to pursue projects without interference. Small in house grants are provided to ensure that good ideas do not languish due to lack of resources (Business Week, 1990).

Allowing employees some personal discretion, such as choice of clothing, suggests that they are valued for their contributions. Employees should be given autonomy concerning the process but not necessarily the ends. Autonomy around process fosters creativity because it strengthens employee's sense of ownership over a project or a situation. Discretion about the process also allows employees to resolve problems in ways that better utilize their expertise and their creativity thinking skills (Amabile, 1988; Andriopoulos, 2001).

Organizations often face a dilemma about promoting scientists and engineers who may not be interested in becoming managers with direct line responsibility. Should a scientist or researcher be dislocated from R&D and promoted into line management, or should be left in R&D with no possibility of further promotion? By dislocating the scientist from R&D, the company gains an average manager and loses a highly valuable researcher. Leaving the scientist in R&D with no possibility of further promotion is equally problematic for the scientist's morale. Salary increases alone are often not enough to solve this dilemma. One way out is to install a dual track career ladder. In a dual track career system, management and administrative employees move up a managerial track, while technical and professional employees move up the scientific track. Employees can switch tracks. Positions on both tracks are matched in proportion, pay, status, and influence. The dual track carrier system helps an organization to gain more well rounded employees, who learn the challenges of both

tracks. By moving employees back and forth between tracks, the employee never outgrows the company but grows with it (Business Week, 1990).

Developing new products requires teamwork. Innovative organizations strike a balance between rewarding a team as a whole and rewarding individual members for their contributions to the team. In a new product development project, the team members are highly interdependent and therefore the reward system should be designed to encourage cooperation rather than competition. The common belief is that when a team as a whole is rewarded, the best performers are demotivated. When only the best performers are rewarded, the others are demotivated. Innovative organizations strike a fine balance between team and individual rewards. These organizations clearly identify the specific situations in which team or individual rewards are warranted. However, research indicates that teams which are rewarded as a whole (where team members share rewards equally) almost always outperform teams in which some members are rewarded more than others (Johnson et al, 1981; Mower and Wilemon, 1989; Mosey et al., 2002; Mosey, 2005).

Numerous studies confirm that motivational or intrinsic orientation brings about far greater creativity in people than extrinsic orientation governed by the reward-for-creativity strategy (Plunkett, 1990). Extrinsic rewards have to be present at a base level to ensure that individuals are at least comfortable with their salary. Beyond the base salary thresholds, innovation is primarily driven by self-esteem level rather than monetary rewards. Extrinsic rewards promote competitive behaviors which disrupt workplace relationships, inhibit openness and learning, discourage risk-taking, and undermine interest in work itself. Individuals tend to channel their energies in trying to get the reward rather than unleashing their creative potential. With extrinsic rewards, people believe that every move they make is going to affect their compensation and tend to get risk averse. Such rewards can have a negative effect on creativity, especially when employees perceive the financial incentive as a means of being bribed or controlled. Research shows that employees put far more value on a work environment where creativity is supported, valued, and recognized. Employees want opportunity to deeply engage in their work and make real progress. It is critical to match employees to projects not only on the basis of their experience but also in terms of where their interests lie. Employees are most creative when they are about their work and are stretching their skills. If the challenge is far beyond their skill level, they tend to get frustrated; if it is far below their skill level, they tend to get bored. There is need to strike the right balance (Ahmed, 1998a)

### **2.2.6 Organizational Support to Innovation**

Creativity and innovation are truly enhanced when the entire organization supports them (Mishra and Srinivasan, 2008). Senior management support is very important for creativity and innovation. Experimenting and taking risks are behaviors associated with creative persons. Creative effort implies personal risk, as it involves ideas or activities that are not within the normal range of work (Todd, 2004). New ideas can pose a risk to an employee because they represent disturbances in routines, relationships, power balances, and job security. The assumption that risks may be taken as long as they do not harm the organization does not encourage employees to be creative (Filipczak, 1997; Berglund and Hellstrom, 2002). Too many management controls inhibit risk taking and consequently creativity (Judge et al, 1997). There should be freedom to experiment, to do things and fail, to challenge the status quo, discussion of dumb ideas, and no punishment for mistakes (Ahmed, 1998b). It is important that a balance be reached in the degree to which risk taking is allowed. This is achieved by spelling out expected results, assigning responsibility of monitoring and measuring risk taking to someone in the organization, creating a tolerant atmosphere in which mistakes are accepted as part of taking the initiative, regarding mistakes as learning experiences, and assuming that there is a fair chance of risks being successful (Martins and Terblanche, 2003). In innovative organizations, employees know the level of risks that can be taken safely. This helps them to define the space within which they are allowed to act in an empowered manner, and the occasions when they need to approach organizational ratification for engaging in actions. They know the penalties if inefficiencies creep into aspects of their task. Without knowing that risk tolerance exists within the organization, employees tend not to be willing to try and innovate, or engage in activities that are a departure from tradition (Ahmed, 1998b; Blumentritt, 2004).

Employees think creatively when they are not afraid of criticism or punishment. If a project fails and the employee is in the fear of losing his/her job, he/she will never take the risk of thinking creatively again (Anderson et al, 1992). 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). In highly innovative organizations, as much as 70-90% of the projects end in a failure. These failures are not discarded. Instead they are stored for possible adoption at a later time when they may provide answers to future problems. The logic is to institutionalize an effective method for maintaining organizational memory. Allowing individual's space to fail without

attributing blame promotes innovation over convention (Ahmed, 1998a). Rigid and punishing norms promote conformity and restrict creativity.

## **2.3 Physical Resources**

Research shows that more innovative companies have better systems and technology in place than less innovative companies (Laforet and Tann, 2006). 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). Thus, availability of adequate physical resources is another critical component of technology development initiatives of industrial units. The important issues under this component are as follows:

### **2.3.1 Infrastructure Resources**

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). For better technological advances, new infrastructures (mainly telecommunication), information technology, modern production systems and new strategic thinking practices are needed (Man et al., 2002; Sheel, 2002; Vargas and Rangel, 2007).

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 and Gryskiewicz, 1989; Amabile et al, 1996; Williams, 2001; Pihkala et al, 2002). Organizational structure should be such that there are adequate funds, materials, production facilities and information support system to sustain innovation (Amabile et al, 1996; Ghorbani and Bagheri, 2008).

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. The physical environment or setting can influence the degree to which divergent thought process is used. Divergent thinking has a broad, relaxed focus of attention that requires a sense of psychological safety and peacefulness. Appropriate space and resources enhance organizational creativity (Smilor et al, 1988; Odette et al, 2006; Ridley et al, 2006).

### **2.3.2 Support to Research Function**

Higher R&D spending heightens the level of research activity within a firm and builds specialized scientific and technical expertise as a result. The tangible outcome of this is the ability to develop several significant product technologies (Charles and Burton, 1995; Parthasarthy and Hammond, 2002; Huang, 2008). One way to motivate companies to spend the money is to demonstrate that their competitors are getting ahead of them. Demonstrate cost savings (Best and May, 1997).

One of the most important benefits of a well-managed, appropriately funded infrastructure is the fact that it allows the organization to globalize with a common touch and feel. Infrastructure is a money problem and it does not end. It could be portrayed as a negative annuity. The most important thing to remember is that infrastructure is an ongoing responsibility. It never finishes because technology is always moving (Best and May, 1997).

SMEs engaged in the innovation process have different and special financing requirements that arise because of the need for seed capital and development capital. The process of research and development can take some time before the firm has a commercially viable product with which to go to market and during this period there are no returns for the investors who are required to provide 'long-term patient money'. Access to finance and the presence of equity gaps are commonly cited as major barriers to innovation throughout the small business literature. Innovation often requires considerable front-end sunk costs, invariably beyond the scope of the small firm's internal resources. This, allied with the frequent inability of the funding providers to adequately assess either the technological validity or the project viability, often militates against finance provision.

Manufacturing organizations in developed countries spend substantial fraction of annual turnover on technology development. It appears that in response to increasing global competition, many companies are continuing to pour money into research and development. According to the 2006 international R&D Scorecard produced by the Department of Trade and Industry (Government of UK) there has been a 7% increase in R&D spending by the world's top 1,250 companies. The Scoreboard shows that Chinese and Indian organizations are still funding relatively little R&D of their own. In India, the research and development investments are very low, ranging between 0.2-0.5 percent of the total turnover. The total investment in R&D in U.S. is about 80 times, in Japan about 45 times, in France and Germany about 20 times and in South Korea about two times as compared to what is in India (Chandrashekar, 1995). Japan's R&D expenditure as a percentage of GNP has continued to

rise until it now approaches 3% and leads the industrialized world. However, R&D expenditure as a percentage can be misleading: Belgium spends 1.5% of its GNP in R&D, a percentage comparable to USA, but actual expenditure of Belgium in research is roughly 1-2% of total US non- military R&D spending (Herbig and Palumbo, 1996).

US firms devote about two-third of their R&D expenditure to improved product technology (new products and product changes) and about one-third to improved process technology (new process and process changes). Among Japanese firms, the proportions are reversed: Japanese R&D expenditure largely focuses on development, followed by applied research and the remaining minimal expenditure (2-4%) is on basic research (Mansfield, 1988).

Capital is a necessary component for innovation but is not in itself sufficient. Not only the quantity of financial support important, it is the efficient usage of funds that is important in R&D spending. The real issue for businesses looking for competitive advantages from innovation should not be how much they spend on R&D, but how effectively they spend it. Capital simply cannot buy effective innovation. According to Annual Global Innovation Study (The Global Innovation 1000) there are no significant statistical relationships between R&D spending and the primary measures of financial or corporate success: sales and earnings growth, gross and operating profitability, market capitalization growth, and total shareholder returns. In fact, the single performance variable with a statistical relationship to R&D spending is gross profits as a percentage of sales. Innovation can lead to higher performance, but the process is not automatic and it does not necessarily require above average levels of investment. There is no silver bullet, and just throwing money at the problem is not the answer (Herbig and Palumbo, 1996).

There is a 'threshold of sufficiency', and when resources are added above this threshold, creativity is not enhanced. Below this threshold, a restriction of resources also limits creativity and innovation (Herbig and Palumbo, 1996; Amabile, 1998).

## **2.4 Regulatory Support**

Government can create the right economic, fiscal and regulatory framework within which innovation and entrepreneurship can flourish and remove the current ambiguities and anomalies, especially with regard to tax credits. It can also 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. Government and policy makers need to understand much better the motivations and requirements that shape and drive

an innovative firm. In short, government and the business support infrastructure that it has created must also be innovative (Beaver and Prince, 2002; Hyland and Beckett, 2005).

#### **2.4.1 Policies to Support Industry**

Government aid is paramount in case of small scale manufacturing organizations. Government can assist organizations in several ways such as through collaborative training programs, R&D programs among government-funded research centers, universities for specific sectors of the manufacturing industry. Government can encourage networking, promote growth ambitions and encourage new product development by making them aware that it is a risky option to continue with their existing products/customers regardless of market changes. Government can provide sector specific specialist advice within the manufacturing industry and provide more financial and tax incentives (Laforet and Tann, 2006; McCole et al., 2001).

Government policies in most countries assist organizations to innovate through funding assistance, consultancy, and other policies. New roles of government could lie in supporting learning, innovation and building competitiveness. Government can act as a facilitator of technical change and leveraging, working in collaboration with other stakeholders rather than dictating policies from above (Kim, 2001; Seeman et al, 2007).

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 (Thomas, 1993; Breif and Motowidlo, 1996; Sheel, 2002; Hyland, 2004). Increase in technological innovation demands that government should enhance spending on R&D (Liyanage, 2003).

The Government can actively promote growth in the small scale sector. Resources can be provided to support training, which has been linked to organization's longevity and success. Effective deployment of these resources entails organization's participation in training activities. However, prior research has indicated a range of factors as being implicated in a relatively low level of training take up by small scale organizations (Johnston and Loader, 2003).

### **2.4.2 Financial Support to Research Initiatives**

Increase in technological innovation demands that government should enhance spending on R&D. In some developed economies, government supports investment in more formalized creative activities such as R&D. R&D tax credit is available when a project seeks to achieve an evidence in overall knowledge or capability in a field of science or technology, but not a company's own state of knowledge or capability alone. The government also supports R&D through targeted expenditure and collaborative research programs. The government plays an important role in financial markets, particularly in helping small firms. At the aggregate level, ensuring a stable macro environment has helped keep interest rates relatively low and stable over recent years. At the business level, government works in partnership with the private sector to ensure adequate funding, for example by providing guarantees on loans or venture funding (Liyana, 2003).

### **2.5 External Bonding**

Knowledge is generated not only by individuals and organizations, but also by their complex pattern of interaction (Wani et al, 2004; Santos, 2006). Organizations need a culture that supports collaboration and a systematic approach for managing innovation (Hyland and Beckett, 2005). 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). Manufacturing organizations have to operate in a very competitive environment and their need for support and information is high. What is essential for these firms is that they are provided with access to more resources than they would have if they were not a part of the network.

Organizations and individuals dedicated to industrial development agree that one of the main producers of wealth and prosperity of industrialized countries is the existence of well coordinated and sustainable system that supports interaction with other organizations and formation of networks, capable of converting innovation assets into new technology (Sheel, 2002). Business networks are an increasingly popular form of alliance in most countries. It can be said that all organizations are part of a network to some extent. Each organization develops a relationship with its suppliers, customers and with other businesses in the same industry, and this can include competitors. Networks can be described as form of collaborative relationships that organizations enter into with their competitors for strategic reasons (Hagedoorn and Shakenraad, 1994; Love and Thomas, 2004).

There are several reasons for the increase in the use of networks. To begin with, there has been an increase in competition over the last two decades. There is also the impact of technological developments that contributes to their development (Love and Thomas, 2004; Nohria, 1992). All R&D managers are becoming 'Information Managers' and all companies are now 'Information Machines'. The paradigm then is that R&D must 'either network or not work'.

### **2.5.1 Mutual Interaction of Industries**

Competition within organizations can sometimes be more destructive than benefits and that partnership with other organizations can be beneficial. Usually, it is argued that inter-firm networks are one of the main reasons that some of the most successful regions in the world develop to be more competitive in their industry than those who have not adopted these methods. (Thorelli, 1986; Fabi et al, 2009).

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

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

Collaborations and linkages with external organizations for industrial technology development and acquisition are important especially in the early growth stages of a firm (Sugasawa and Liyanage, 1999).

Active collaboration between firms can enable them to achieve outcomes that they could not achieve of their own, while allowing each individual partner enterprise to realize its own

strategic goals. This requires a well developed capacity to collaborate and to learn across differing organizational cultures. Also there need to be business activities that improve the market positioning for the individual partners, if an alliance is to be ongoing. Further, a range of collaborative management, learning competencies and organizational capabilities are needed. Just establishing a collaboration is not enough, there must be both business and housekeeping activities carried out and clear benefits for it to endure (Marceau, 1999). Taking part in co-operative ventures, alliances and networks demands a lot of trust in alliances and also in co-operation (Thorelli, 1986).

### **2.5.2 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. There is compelling evidence to suggest that innovative SMEs do better when they are part of a community of like-minded firms that can participate in a supportive infrastructure that encourages their development and prosperity. Several studies have found that firms that use and fashion their competitive advantage around information and external networking consistently achieve better results and were more optimistic about the future (Barnir and Smith, 2002; Beaver and Prince, 2002).

Research shows that SMEs are better able to innovate when they are part of clusters (networking). Additionally, a study conducted among Australian manufacturing SMEs suggested that small manufacturing organizations are more likely to improve their chances of achieving business excellence through networking than without. Strong ties can offer steady flows of new ideas, technological innovations, and operational support (Capaldo, 2007; Mitra, 2000; Terziovski, 2003).

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. Networks can be a cost-effective way of improving small firm performance, particularly manufacturing firms (Love and Thomas, 2004; Xu et al, 2008).

To develop new-to-market products, firms must continually build new networks of customers and suppliers by using a trial and error approach (Urbonavicius, 2005; Ha-Brookshire, 2009). Only in this way, they can gain the requisite new market and technological knowledge. However this approach, successfully utilized by large firms in their study, may be more challenging for SMEs. For instance SMEs may have 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. Collaboration with much larger organizations can provide resources, in the forms of finance or expertise, as well as future sales and international opportunities (Moorman et al., 1992; Rycroft and Kash, 2002; Singh, et al, 2008).

### **2.5.3 Industry-Institute Bonding**

Creating and maintaining relationship between academic and industrial organizations is a highly recognized mechanism to manage the changing demands of industrial society.

Although, it is recognized that companies need to invest in in-house research and development (R&D) with the purpose to gain competitiveness, studies show that firms must be connected not only to the open science community, but must be as well strongly engaged in research collaboration (Cockburn and Henderson, 1998, Brennenraedts et al., 2006, Sandelin, 2003).

Universities and private research laboratories which are engaged in the supply of scientific, technological and market knowledge can be sources of taking competitive advantage, if these resources are carefully managed and applied. The University-Industry partnership has been considered as one of the main factors contributing to successful US innovation and growth in the past two decades (Thomas, 1993).

It appears that while universities spend much of their time on abstract conceptualization and reflection, industrial partners spend much of their time on the practical aspects of experience and experiment. This leaves industrial partners with little time for the reflection and conceptualization necessary for learning and innovation (Meredith and Burkle, 2008).

This gap in the Learning Cycle means that both sides receive only a partial view of what is happening and full learning cannot take place. In a university environment, there is theory and abstract concepts, but without concrete experience and the opportunity to experiment and test ideas, full learning is difficult to achieve. On the other side of the divide, industry is always under pressure to produce; they are always using concrete experience and active testing, but have little time for abstract conceptualization or reflection on what has occurred so that their learning can be used in the innovation process. Formal learning in the classroom is important because it gives students the structures, concepts and theories that support the real-life experience and learning. Experiential learning is effective and reinforces formal learning because it becomes personal (Holman et al., 1997; Kolb and Kolb, 2005).

Although the theoretically based education that is taught in the classroom is very necessary, evidence from students and companies supports the argument that supplementing this education with practical projects, such as a consultancy team approach, allows full learning to take place. It is undoubtedly true that all learning and knowledge requires a sound theoretical base laid down by clear and professional teaching in the classroom. However, combining theory and practice brings a balanced approach to learning. Plus, when this is achieved, students are educationally and professionally prepared to join the realms of the fast changing, global business environment in which they will be working (Meredith and Burkle, 2008). Policy makers and researchers commonly agree on the necessity of establishing knowledge flow between academia and industry as one of the most promising factors to strengthen economic development and to foster innovation capability (Hofer, 2004, 2005).

The skill base of the firm, linked with support from organizations such as universities and enterprise councils, could add value and introduce new thinking. Encouraging links between universities and enterprise councils with the business community can also enable SMEs to access a greater knowledge base (Maniukiewicz et al., 1999). A degree of empathy is necessary for training providers, such as universities and enterprise councils; to be effective, teaching and training approaches must be relevant to the learning needs and situation of SMEs (Gibb, 1997).

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

**Gupta and Singhal (1993)** proposed that HRM strategies that foster innovation and creativity can be conceptualized along four dimensions:

- (1) *Human Resource Planning* - This strategy analyzes and determines personnel needs in order to create effective innovative teams.
- (2) *Performance Appraisal* - This strategy appraises individual and team performance so that there is a link between individual innovativeness and company profitability. This strategy takes into account what tasks should be rewarded and who should assess employee performance.
- (3) *Reward Systems* - This strategy uses rewards to motivate personnel to achieve an organization's goals of productivity, innovation and profitability.
- (4) *Career Management* - This strategy matches an employee's long-term career goals with the organization's goals through continuing education and training.

**Cooper (1998)** proposed a multidimensional model of innovation for thinking about and evaluating the relationship between organizational characteristics and the adoption of innovation. The model suggests that strategic approaches to the adoption of innovation must at a minimum consider innovation in terms of the three major dichotomies: product versus process, radical versus incremental, and technological versus administrative.

**Keogh and Evans (1998)** developed a methodology to investigate the key question of the extent to which the new technology based small firms carry out any form of strategic planning and, if so, whether they have policies in place to deal with the key issues identified in their strategic plan. The barriers to growth for new technology based small firms are a complex interaction of factors and determining these barriers is an essential part of preparing a meaningful strategic plan.

**Keogh and Stewart (2000)** employed research methodology to study fourteen innovative, technology based small and medium enterprises with the aim of investigating the processes currently in place to aid in the establishment of a skilled workforce, and the extent to which future skill requirements were identified. In order to grow, to develop new ideas and to reach new markets, the knowledge base of the organizations must be nurtured and maintained.

**Lange et al (2000)** identified and clarified the barriers to skills development in SMEs and sub-divided these barriers into four simplified categories:

- (1) *Cultural barriers* which include primarily attitudes towards skills development.
- (2) *Financial barriers* which refer to those barriers directly relating to the cost or perceived cost of training and learning.
- (3) *Access and provision barriers*, referring to problems which either prevent interested parties from accessing skills development opportunities or manifest themselves in the lack of suitable provision of learning.
- (4) *Awareness barriers* which relate to the knowledge of learning opportunities.

**Silversides (2001)** developed a methodology that offers a positive example of how networking influences the success of small firms and examines an industry sector where it occurs naturally as part of the industry culture.

**Johnston and Loader (2003)** investigated the phenomenon of design and delivery of SME training at the University of Teesside during a period from October 1998 to June 2000. The research is both quantitative and qualitative in nature. It takes a holistic case study approach

(Yin, 1994) to the exploration of a large of evidence about the training (Strauss and Corbin, 1998) in the light of previous research relating to SME participation in training.

**Love and Thomas (2004)** discovered the extent of the effect of business networks on SMEs in MidWales. This research study shows 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. This study also proves that networks for small manufacturing firms can be a very cost effective way of improving their performance.

**Hyland and Beckett (2005)** assessed the workings of innovation within small firms which are evaluated using a system engineering modeling approach to both represent these workings and to assess the effectiveness of enterprise innovation. The model developed can be applied equally well to both technological and non-technological innovation, and helps understand the interaction a variety factor that may support or inhibit innovation. It is argued that if it is possible to represent innovation as a system, then deficiencies can be explored in that system using fault-tree analysis concepts.

**Laforet and Tann (2006)** conducted a survey of 1000 Birmingham and West-Midlands based small and medium manufacturing enterprises. The findings suggest the drivers of innovation in small manufacturing firms are: culture, leadership, process innovation and company strategic orientation. Study highlights the problems of knowledge, training, attitude to learning, networking and employees' contribution to new ideas, which are embedded in innovative activities of companies, are problematic to SMMEs.

**Jayawarna et al (2007)** found that formal training is likely to be a targeted activity that contributes more significantly to performance than informal training. SMEs that conduct management training show a statistically significant advantage in terms of both employee and turnover growth, compared with those that either do not conduct training, or prefer to invest in informal training. Small Firms Enterprise Development Initiative, SFEDI (2004) note that it is important to distinguish between what is practiced (due to resource scarcity) and what is appropriate. In this research there is a clear and significant finding that formal training is associated with performance over and above that provided by informal training in small manufacturing firms.

**Kelly (2007)** 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. It is concluded that this classification of relationship benefits and provides a clearer understanding of how value is transferred to small firms engaged in rich and deep relationships.

**Li and Qian (2007)** suggest that SMEs engaged in technology industries are different from traditional industries in three significant ways:

1. innovation is much more frequent in technology industries;
2. frequent innovation in technology industries leads to short product life cycles and constant product obsolescence; and
3. frequent innovation in technology industries means that economies of scale and scope are not necessarily important competitive advantages.

In technology industries, innovation is the key competitive advantage. 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.

**Dickson et al (2008)** suggest strong evidence supporting the relationship between levels of general education and several entrepreneurial success measures. The findings of research, suggesting positive links between general education and both selection into entrepreneurship and entrepreneurial success, however measured, has important implications from a public policy and support perspective. The consistent evidence that education is linked to higher entrepreneurial performance and productivity is supported by the economic evidence provided by the Organization for Economic Co-Operation and Development (OECD) suggesting significant productivity increases for each year of added education.

**Ledwith and O'Dwyer (2008)** identified the empirical findings which contribute to existing literature by demonstrating that market orientation as well as having a direct impact on organizational performance also affects new product development activities. The study has indicated several areas in which small firms can improve their new product and organizational performance. These include improving the product launch process;

maintaining high levels of customer orientation, competitor orientation and inter-functional coordination; and determining the new product characteristics linked with new product success.

**Singh et al (2008)** show that SMEs have not given due attention for developing their effective strategies in the past. They are localized in functioning. On export fronts 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 the best in 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. SMEs are also not following any comprehensive framework for developing their strategies and quantifying their competitiveness.

**Xu et al (2008)** found that firms participating in a business network should develop a thorough understanding of the structure of the network because; structural characteristics are relevant to the development of innovative capabilities of the firms. Second, within a business network, firms could facilitate innovation by increasing and diversifying network contacts, in light that network density and multiplicity are likely associated with better innovatively capabilities. Finally, long-term interdependence in business collaborations tends to be a catalyst of innovation, given the positive association between network reciprocity and innovative capabilities of the participating firms. In short, 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.

**Zhang et al (2008)** analyzed that the characteristics of the entrepreneur of a firm, along with firm resources and capacities, task environment, and entrepreneurial strategies, are important in helping a firm achieve rapid growth. The results of the study are important because they confirm the results in existing literature based on quantitative analysis on larger scale survey in China. For example, favorite firm resources and capacities, task environment, and entrepreneurial strategies can create greater value for success with certain entrepreneurs, which might spur them to push their firms onto a trajectory of rapid growth.

**Bjerregaard (2009)** examines the collaboration strategies employed by collaborating small and medium sized enterprises (SMEs) and university researchers for initiating and optimizing the process and outcome of R&D collaboration. The findings show how partners choose to pursue difference short or long-term strategies to optimize the process and outcome of

university-industry (UI) collaboration. Some collaborations were thus informed by a short-term strategy aimed at achieving immediate R&D results. However, to a high extent, many SME partners relied upon a long-term strategy aiming at developing UI relations beyond the immediate project and practical learning.

**Cruz et al (2009)** attempt to shed light on the effect of educational programmes aimed at entrepreneurs on innovation and business success. By means of the relationship between innovation and success, specific entrepreneurship education contributes to obtaining better business results. However, to have reached high levels of formal education makes entrepreneurs less conformist regarding the activity of innovation. The existence of a direct effect of innovative behavior on business success is confirmed. The influence of personality of the individuals, their professional experience and education on their satisfaction with the results of innovation is evaluated.

Enormous research has taken place to explain why certain individuals, teams or organizations are more creative and innovative than others. Through this study, it is tried to identify and establish the relationship between various factors which foster technological innovation in organizations and research output issues. The literature review highlights two broad technology development implementation factors that enhance technological innovation at workplace: Internal Factors for creative input and facilities for R&D and External Factors to support development efforts of the industry. Internal Factors include management proficiency and physical resources for research. External Factors include support from regulatory agencies and interaction with external sources of knowledge. The present work will analyze the role and present status of these factors in supporting development initiatives in the industry.

## **CHAPTER III**

### **DESIGN OF STUDY**

#### **3.1 Introduction**

This chapter includes the overall design of study and the methodology adopted for carrying out the present research work. It contains the summary of work done and provides details regarding the tools and techniques used in the dissertation work.

#### **3.2 Methodology**

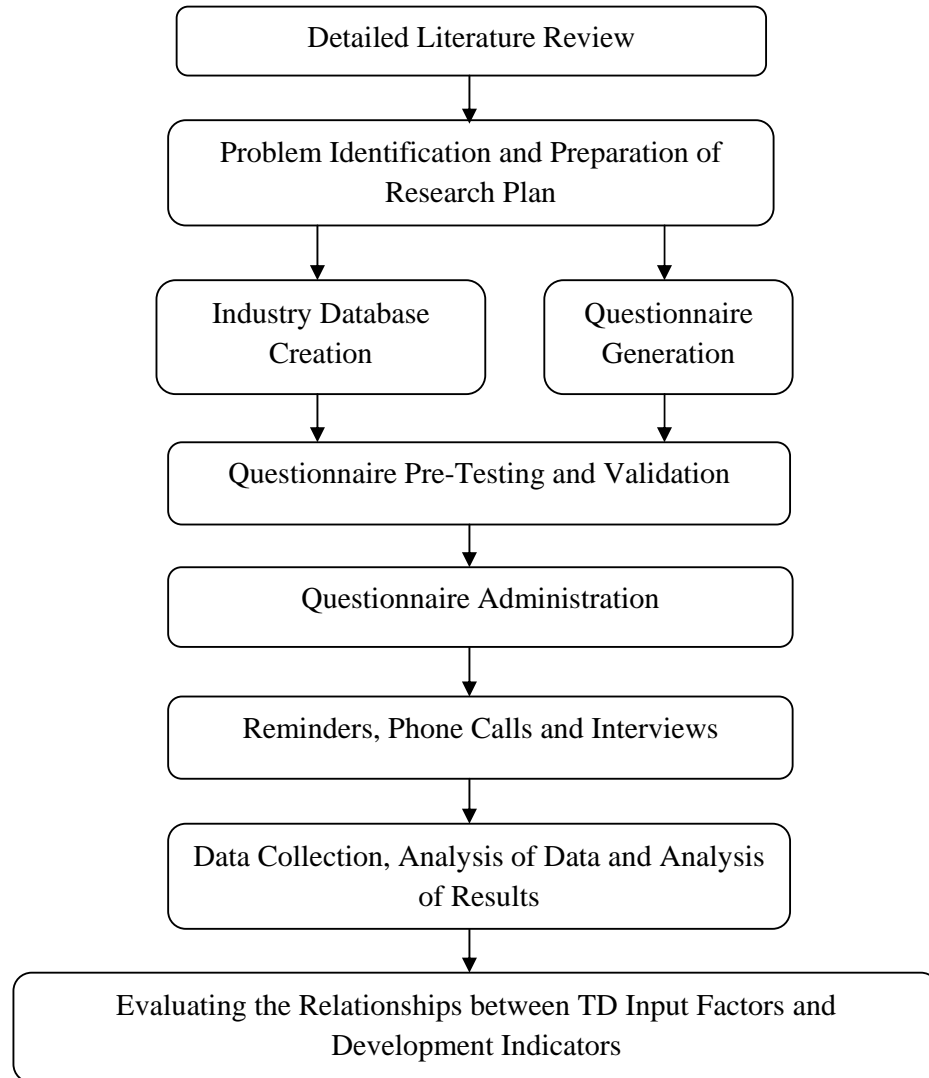
The study has been carried out with the objective to review the status of technology development initiatives through indigenous research efforts in the small scale cutting tool manufacturing sector in Patiala district of the state of Punjab. The study tends to explore the status of each critical issue of the various components of a technology development program in the selected class of industry. Further, the analysis of survey establishes the relationship of various technology development input factors with manufacturing performance indicators. The methodology employed in the study has been depicted in Figure 3.1.

##### **3.2.1 Questionnaire Generation**

In order to carry out the research, a survey of various manufacturing organizations involved in technology development at tactical and 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 designed to seek information on the status of various components and issues of technology development initiatives in cutting tool engineering industry in the region. For effectively conducting the survey, the 'TD Questionnaire' has been designed through extensive literature review (Choi, 1989; Ahmed, 1998a; Ahmed, 1998b; Kim, 2001; Sheel, 2002; Martins and Terblanche, 2003; Shaw and Craig, 2003; Swann and Birke, 2005), and validated through peer review from academicians, consultants, and practitioners from the industry.

To ensure the relevance and effectiveness of the questions to the manufacturing industry, the questionnaire has been pre-tested on a representative sample of industry. The suggestions from proprietors and senior executives from industries, consultants, and academicians have been incorporated to make the questionnaire more relevant for the purpose. The survey has been conducted through mails, personal visits, interviews and other communication means.

**Figure 3.1: Methodology employed for the Study**



The questionnaire is divided into two sections. Section 1 seeks information on general aspects of the industrial organizations (product range, annual turnover, year of inception etc). Section 2 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 2 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.

### **3.3 Analysis of the Questionnaire**

The present work considers three key broad areas (components) for overall assessment of technology development initiatives in the industry. These include *Internal Factors* for creative input; *External Factors* to support development efforts of industry; and *Development Indicators* accrued as a result of innovation initiatives. These broad areas have been further classified into several input and output factors, details of which are available in Appendix-II and Appendix-III.

A structured approach has been employed in this study for managing the input success factors effectively to enhance the probability of success through such initiatives. There are several key measures that can assist in tracking progress during technology implementation. Thus, the performance evaluation has been based on multiple inputs and multiple outputs. Since the evaluation involves multiple inputs and multiple outputs, it can be thought of as a multi-criteria decision problem.

The analysis of the questionnaire has been carried out to assess the status of each component (aspect) of technology development (TD) in the industry and to evaluate contributions of TD input factors towards achieving manufacturing performance improvements (Development Indicators).

### **3.4 Quantitative Tools for Analysis**

The first task in the analysis of questionnaire has been to assess the status of all the issues under each component (or aspect) of technology development in the manufacturing sector. A set of questions (from the questionnaire) which reflect different issues under each component is selected. For each question, central tendency (C.T) 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. Finally, overall average for each component is calculated (considering all the issues under the component), which represents the status of the entire component.

The next task in the analysis has been to assess the contributions of TD initiatives in the industry for accruing core competencies for meeting the challenges posed by global competition. In order to ascertain the benefits realized by an effective TD approach, it becomes imperative that various input factors and output performance parameters for such a program be scrutinized carefully. In the present work, four input factors called 'TD Input

Factors' (I1, I2, I3, I4) and four output parameters called 'Development Indicators' (O1, O2, O3, O4) 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 parameters with key development indicators (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.

The internal reliability of the 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.

The contributions of each input parameter in achieving performance improvements in the industry have been discussed in the present work. For this, Pearson's correlation coefficient values (r values) between various input parameters and the Development Indicators (output parameters) have been calculated. The correlation values obtained have been further validated and authenticated using other statistical tools like t-Test and Multiple Regression analysis.

### **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.

## **CHAPTER IV**

### **SURVEY BASED RESEARCH RESULTS**

#### **4.1 General**

This chapter presents the results of a detailed survey conducted in the cutting tool manufacturing industry in the region. The objective of the survey is to assess the status of technology development (TD) initiatives through indigenous efforts in the selected industry. The survey explores the present status of development capabilities of the industry with regards to policies, infrastructural facilities, investments in research projects, support from government, academic institutes etc. and the reasons for poor performance of the tool industry in the area of technological innovations. The analysis of survey establishes the relationship of various technology development implementation dimensions with manufacturing performance indicators.

#### **4.2 Methodology**

A simple, relevant and a comprehensive questionnaire covering various aspects of technology development through in house research efforts have been specially designed. The design methodology for framing 'TD Questionnaire' is elaborated in Chapter III.

##### **4.2.1 Industries Covered**

Small scale cutting tool manufacturing industries in the district of Patiala have been surveyed. The main products of the cutting tool industry are 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 56 industries had been selected, and in the first place, the questionnaire was mailed to all the 56 industrial units along with a covering letter stating the objectives of the study and its usefulness to the industry. A request to respond at the earliest had been made and subsequent reminders were also sent. 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 industries and having discussions with the proprietors or senior executives.

##### **4.2.2 Response to the Survey**

The questionnaire had been sent to 56 industrial units. The response of the industry is presented in Table 4.1. A total of 34 industries (out of 56) responded to the questionnaire.

**Table 4.1: Response of the Industry**

S.No.	Industry	Questionnaire sent to		Response	
		No. of Companies	Number	Percentage	
1.	Cutting Tool Industry	56	34	60.71	

The salient details of industries participating in the survey have been compiled in Appendix-II. The researcher acknowledges the contributions of industrial experts and sincerely admits that this work would not have been possible without active and enabling support from all the industrial resource persons.

### **4.3 Analysis of Data**

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

1. To assess the status of each component (aspect) of technology development (TD) in the industry.
2. To evaluate contributions of TD initiatives towards achieving Manufacturing Performance Improvements.

### **4.4 Status of Various Components of TD Program**

The present work considers three main factors (components or aspects) for the overall assessment of technology development initiatives (TD Program) in the small scale tool industry. These include Internal Factors, External Factors and Development Indicators. Internal Factors comprise of issues related to the manpower competence, management commitment and technology infrastructure and financial support available for research initiatives in the industry. Internal Factors consist of two main components namely Management Proficiency and Physical Resources.

External Factors include issues on support to industry for development initiatives from external regulatory bodies and interaction with other organizations, academic and research institutes etc. external Factors consist of two main components namely Government Regulations and External Bonding.

The third factor, Development Indicators, is the research output achieved by the organizations as a result of innovation initiatives. The first two factors can be treated as inputs of TD Program and the third factor as the resultant output.

The purpose of this section is to assess the status of each component (and its issues) of technology development in the manufacturing sector.

Table 4.2 presents the status of the component, Internal Factors. A set of questions (from the questionnaire) which reflect different issues of this component are presented in the table. For each question, central tendency (C.T) and percent points scored (P.P.S) are calculated. These measures reflect as to how well the area (issue) represented by a question is being looked after in the industry. Finally, overall average for each component is calculated (considering all the issues under the component), which represents the status of the entire component.

#### **4.4.1 Status of Internal Factors**

This section discusses the status of the component, '*Internal Factors*' in the industry. The questions on these factors aim at collecting information on the following:

- i) Capability of the employees to contribute in technology development efforts. Here information is collected regarding availability of workforce with multiple skill base, education level of the employees, availability of scientific and technical manpower for research work, personnel, formal training to employees to enhance creativity and innovation skills.
- ii) Commitment of management to utilize the human resources efficiently and effectively. Here information is collected regarding encouragement provided to undertake research initiatives, reward schemes for innovative efforts, reaction to project failures.
- iii) Availability of financial support for developmental work, allocation of funds for research, source of funds, investments in research initiatives as a proportion of annual turnover of the industry.
- iv) Availability of facilities to carry out technology development work and the role of modernization and renovation programs.

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

Non availability of multi-skilled workforce can be a significant factor impairing technology innovation efforts of the manufacturing organizations but cutting tool sector in the region is doing fairly well in this issue with a high rating (PPS= 72.79). About two third of the organizations have this workforce in adequate strength. Education level of the employees can be helpful in enhancing their creative potential. About one fifth of the organizations consider education level of their workforce at a very good level. In nearly half the units, education

level is good. However, the remaining one third of the organizations consider poor education level of employees to be a serious concern.

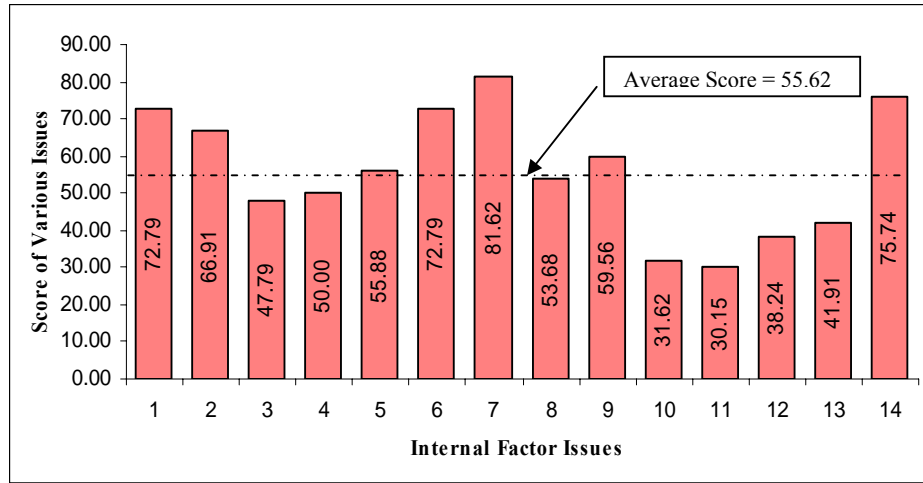
**Table 4.2: Evaluation of Internal Factor Issues**

S.No	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring				Total Points Scored (TPS)#	Percent Points Scored (PPS)	Central Tendency (C.T) TPS/N
			1 (J)	2 (K)	3 (L)	4 (M)			
1	Availability of multiskilled labour	34	2	8	15	9	99	72.79	2.91
2	Education level of workers	34	4	8	17	5	91	66.91	2.68
3	Formal training to employees	34	5	27	2	0	65	47.79	1.91
4	Scientific and Technical personnel	34	12	14	4	4	68	50.00	2.00
5	Undertake R&D work or obtain patents	34	9	9	15	1	76	55.88	2.24
6	Reward schemes for employees	34	1	2	30	1	99	72.79	2.91
7	Reaction to project failures	34	1	2	18	13	111	81.62	3.26
8	Funds for development	34	11	9	12	2	73	53.68	2.15
9	Modernization and renovation programs	34	6	14	9	5	81	59.56	2.38
10	Facilities for experimentation	34	27	5	2	0	43	31.62	1.26
11	State of the art production facilities	34	29	3	2	0	41	30.15	1.21
12	Earmarkig funds for R&D activities	34	24	3	6	1	52	38.24	1.53
13	Investments in research projects	34	18	9	7	0	57	41.91	1.68
14	Source of funds for R&D	34	2	9	9	14	103	75.74	3.03
Overall Score									2.22

# (Total Points Scored "TPS" = 1xJ + 2xK + 3xL + 4xM)

Literature reveals that innovative organizations rely heavily on proper training of employees to enhance creativity and innovation skills. Tool industry in the region seems to overlook this fact. Organizations have shown unreasonably low rating, in terms of percent points scored in this issue (PPS= 47.79 only). About 15% of the organizations do not provide any formal training to the employees to enhance innovation skills. The remaining organizations provide training either during orientation period through senior executives or on the job training where employees learn through experience. Surprisingly, none of the organizations make use of standard creativity tests to improve innovation level of employees. Also, there is no encouragement to participate in conferences, workshops, seminars etc. which is discouraging. Inadequacy of technical and scientific manpower to undertake research initiatives is a serious concern (PPS= 50) for the industry in the region. Majority of the organizations do not have scientific personnel in required numbers. Only about one tenth of the organizations have their employees in sufficient strength.

**Figure 4.1: Issue wise Performance regarding Internal Factor Issues**



The level of encouragement to employees by senior management for undertaking development work and obtain patents is very low (PPS= 55.88 only). Generally, there is only very little to reasonable pressure on the employees to put efforts for technology development. Patents can be used as a strategic tool for technological innovations but industry in the region does not seem to value this fact. In the last fifteen years, none of the units in the cutting tool sector in the region has obtained a patent.

One of the key strategies to stimulate interest of employees in research initiatives is to suitably reward their innovative efforts. The results reveal that contributions of employees are adequately recognized by the organizations (PPS=72.79) in case profits are made because of innovative endeavors. Majority of the organizations provide either a fixed monetary reward or an increment in salary or a share in the profits made on account of innovation. Very few organizations (about 2%) go to the extent of providing promotion in designation for contributions in the area of technology development. In another few (about 8%), recognition is in the form of an appreciation letter.

Management role has been observed to be supportive in majority of the organizations in situations of project failures. A large fraction of the organizations advise the employees to learn from current failures to improve for future and encourage them to continue with innovation efforts. About two fifth of the organizations conduct a through analysis to find the root causes of failure and plan a future action by consensus. However, a few organizations (8% units) take strict action against members of the project team when a failure occurs.

Financial support to the research function is critical for the success of development initiatives. However, one third of the organizations face acute shortage of funds for developmental work and consider this factor as most significant in impairing the performance of industry. Majority of the organizations have only little to reasonable support for their development projects. Only a very few industrial units (about 5%) do not consider shortage of funds as a reason for poor performance.

Absence of modernization and renovation programs is preventing development in majority of the organizations. About one fifth of the organizations consider this factor as most significant in causing sickness in the regional industry. There are only a few organizations (15%) which regularly implement such programs for technology modernization.

For technological innovations, dedicated laboratories with facilities for experimentation and subsequent analysis are essential. Cutting tool industry in the region has shown an extremely poor rating (PPS= 31.62) in this issue. Majority of the organizations (79%) do not have these amenities. Also, state of the art production equipment, machining centers, robots etc. are not available in nearly 85% of the industrial units and thus a very low (PPS= 30.15) rating is obtained in this issue. Only less than one tenth (6%) of the organizations have these facilities at an acceptable level which is discouraging.

As far as earmarking of funds for research activities is concerned, the state of affairs in the regional industry is disappointing (PPS= 38.24). About three fourth (71%) of the organizations do not clearly allocate funds for research and development initiatives. A few organizations (26%), club these funds with other developmental activities. There are only very few industrial units (3%) where management clearly assigns funds for research projects aimed at innovations for new product and process developments. This strategic initiative needs to be strengthened for reaping the potential benefits from TD program.

Manufacturing organizations in developed economies spend a significant fraction of their annual turnover on technology development projects. Tool industry in the region with a very low rating (PPS= 41.91) in this issue fails to notice this fact. More than half of the organizations do not spend even 0.5% of annual turnover on research and development initiatives. Another one fourth spend between 0.5-2.5% of annual turnover on development projects.

Though the investments in technology development initiatives are very low, all the blame does not lie with the industry. Small scale sector is financially not self sufficient and largely

depends on support from government and other agencies. However, two third of the organizations have to support their research initiatives through their own funds.

The average score of this aspect is 2.22 (out of 4.00). Formal training to the employees, availability of scientific personnel, availability of technology infrastructure and funds for research initiatives are critical areas needing improvement. Substantial improvements need to be affected for ensuring effectiveness of this component.

#### **4.4.2 Status of External Factors**

This section discusses the role of '*External Factors*' in supporting the industry in its technology development efforts. The questions on these factors aim at collecting information on the following:

- i) Availability and cost of electric power, condition of transportation infrastructure, government policies regarding subsidies.
- ii) Status of government funding for research initiatives, reward schemes, programs for technology awareness, availability of government laboratories for research projects, sponsoring employee development programs.
- iii) Awareness regarding government subsidiaries for small scale sector, assistance from these organizations.
- iv) Extent of technology acquired from abroad, from within the country, developed in collaboration with other agencies. Industry–Institute collaborations for solving technology related problems. Collaborations with R&D institutes for technology development etc.

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

Shortage and cost of electric power in the region shows a relatively low rating (PPS= 44.85 only) and is considered as a major problem impairing the performance of industry. Nearly half of the organizations consider this factor amongst the most significant reasons behind poor performance of industry. Another one third consider this factor as a significant hurdle in their progress. Only the remaining one fifth of the organizations do not face any significant problem as far as availability and cost of power is concerned.

Good transportation infrastructure plays a vital role in increasing competitiveness of any manufacturing industry. Government is performing fairly well (PPS= 72.06) as far as rail and road infrastructure in the region is concerned. Only a few organizations (15%) consider the

condition of transportation infrastructure as below standards and significant in impairing performance of industry.

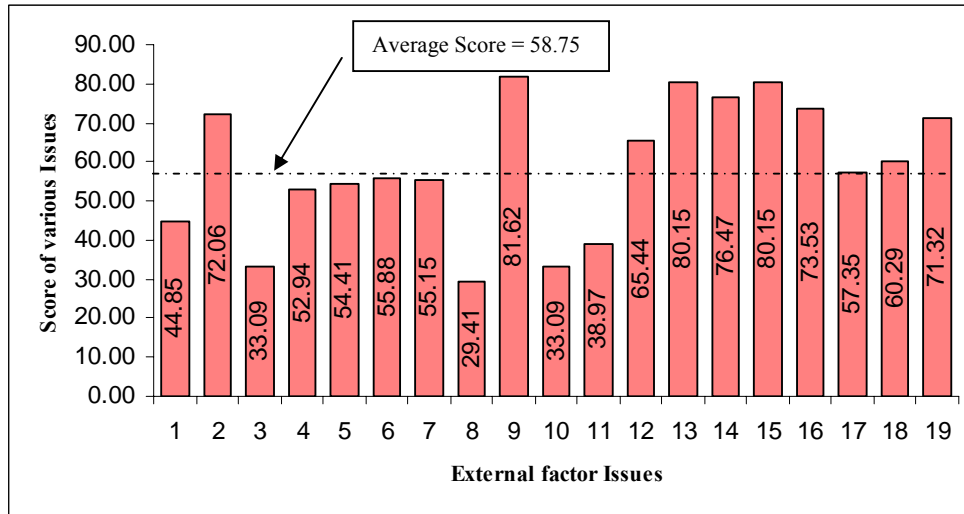
**Table 4.3: Evaluation of External Factor Issues**

S.No.	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring				Total Points Scored (TPS)#	Percent Points Scored (PPS)	Central Tendency (C.T) TPS/N
			1 (J)	2 (K)	3 (L)	4 (M)			
1	Shortage and cost of power	34	16	11	5	2	61	44.85	1.79
2	Transportation infrastructure	34	5	5	13	11	98	72.06	2.88
3	Funding for R&D activities	34	28	2	3	1	45	33.09	1.32
4	Reward schemes of R&D initiatives	34	12	11	6	5	72	52.94	2.12
5	Organizing seminars for technology awareness	34	10	11	10	3	74	54.41	2.18
6	Providing labs for R&D projects	34	10	13	4	7	76	55.88	2.24
7	Assistance in acquiring imported technologies	34	9	13	8	4	75	55.15	2.21
8	Technology acquired from abroad	34	30	2	2	0	40	29.41	1.18
9	Technology from within the country	34	6	2	3	23	111	81.62	3.26
10	Technology developed in collaboration	34	25	7	2	0	45	33.09	1.32
11	Industry-Institute tie on R&D	34	22	6	5	1	53	38.97	1.56
12	Academia for preparing road maps	34	6	11	7	10	89	65.44	2.62
13	Expert lectures by academicians	34	2	4	13	15	109	80.15	3.21
14	Training through S.T courses	34	2	6	14	12	104	76.47	3.06
15	Combined teams for R&D	34	1	5	14	14	109	80.15	3.21
16	Institute laboratories for analysis	34	2	6	18	8	100	73.53	2.94
17	Combined supervision of dissertations	34	4	20	6	4	78	57.35	2.29
18	Assistance from service institutes	34	18	0	0	16	82	60.29	2.41
19	Awareness regarding govt. subsidiaries	34	2	8	17	7	97	71.32	2.85
<b>Overall Score</b>									<b>2.35</b>

$$\# \text{ (Total Points Scored "TPS"} = 1xJ + 2xK + 3xL + 4xM)$$

Small scale industrial sector requires active support from government with regards to availability of funds for development activities, loans at low interest rates, assistance in import of technologies, favorable excise duties etc. Most of the organizations consider lack for government support as the most significant factor in lowering the performance of industry. Government has failed miserably (PPS= 33.09) in providing financial support to the industry for technology innovation initiatives. Majority of the units (82%) do not receive any financial help from the government which is discouraging.

**Figure 4.2: Issue wise Performance regarding External Factor Issues**



Only a few organizations are of the opinion that government can suitably reward entrepreneurs for contributions in the field of technological innovations.

Government can support industry by organizing seminars to increase awareness about new and upcoming technologies. It can also lend assistance to the industry in acquisition of imported technologies. About one third of the industrial units consider this government support to be really helpful.

Small scale manufacturing sector is greatly dependent on external help for its process technology needs. However, the dependency has been mainly on large scale Indian organizations rather than foreign firms. Majority of the small scale organizations do not acquire any technology from abroad. About one tenth of the organizations depend partially on industry outside the country. Majority of the organizations (71%) acquire almost all process technology from large Indian firms.

Tool industry in the region is not interacting much with other manufacturing units, research institutions or other agencies for technology development projects. The industry has shown unreasonably low rating, in terms of percent points scored in this issue (PPS= 33.09 only). Nearly three fourth (71%) the units have never worked in collaboration with external agencies.

Creating and maintaining relationship between academic and industrial organizations is a highly recognized mechanism to manage the changing demands of industrial society. However, regional cutting tool industry has failed to appreciate this fact. This is validated by

the extremely poor rating (PPS= 38.97) shown by the industrial sector in obtaining positive results through industry-institute interactions. Nearly two third (64%) of the manufacturing units have not experienced any affirmative results through industry-institute collaborations, which is discouraging. Only less than one fifth of the organizations have successfully collaborated with regional technical institutions for technology development.

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

Technical institutions can help the manufacturing organizations in product innovation efforts through expert lectures on upcoming key technologies. This seems to be the most preferred interaction mode by the industry (PPS= 80.15). Majority of the organizations consider this option to be useful to a large extent.

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

Another attribute of industry-institute collaboration is formation of combined project teams comprising of members both from industry and technical institutions. The teams work on research projects of mutual interest by sharing specialized knowledge. Majority of the organizations regard this option to be largely helpful (PPS= 80.15) in increasing technological capabilities of the industry.

Small scale manufacturing organizations are generally not financially self-sufficient to create state of the art infrastructure facilities for research and development. Most of these organizations do not possess state of the art production facilities and laboratories for experimentation and analysis. In the light of this fact, industry can utilize facilities at regional technical institutions. More than three fourth of the units consider this alternative to be helpful definitely or to a large extent.

Several institutions (here, referred as Service Institutes) have been set up by the government with the objective to provide support to the small scale manufacturing sector for technology innovation initiatives. These include Small Industries Service Institutes (SISI), District Industrial Centers (DIC) etc. More than half of the organizations are not seeking any support from these service institutes.

The average score of this aspect is 2.35 (out of 4.00). The analysis of data reveals that major improvements need to be made regarding effective deployment of various government support mechanisms in the manufacturing industry. Majority of the industries have acquired technology from large Indian industries rather than developing technology through External Bonding. The performance of industry in developing technology through collaborations with academic institutes or R&D institutes is also below desired levels.

#### **4.4.3 Status of Development Indicators**

This section presents the status of research initiatives being undertaken in the manufacturing industry and the consequent developments occurring as result thereof. The questions aim at collecting information on the following:

- i) Response of manufacturing sector to increased competition by increasing product mix, improving product features, collecting data for specific customer requirements.
- ii) Awareness as regards to significance of technology development through in-house initiatives, limitations of upgrading technology through acquisition or purchasing approach
- iii) Level of technology employed in the industry, extent of technology developed through indigenous research, role of research function in developing new processes, products, solving maintenance related problems and improving product quality.
- iv) Organization and structure of research function in the industry, strategic implementation of innovation, use of R&D policy in the industry.

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

Technology development initiatives can be deemed as successful if they enable the manufacturing organization to respond to the market demands by increasing its product mix and adding features to its current product range. Unfortunately, the performance of industry is not very encouraging in these areas. Organizations have shown unreasonably low ratings, in terms of percent points scored in these issues (PPS= 55.15 and PPS= 53.68 respectively). There are even less than one tenth of the organizations who have increased their product mix or improved product features considerably in the last few years. Another one third have increased the product mix and features marginally.

Most of the organizations value the fact (PPS= 86.76) that technology is the most important resource and the main driver of survival and growth. Though the industry appreciates the importance of technology as a resource for meeting competition, a lot needs to be done. Not

even one tenth of the organizations have employed latest process technology to produce products. Nearly one third of the industries are producing products based on old technology.

**Table 4.4: Evaluation of Development Indicator Issues**

S.No	Topics in the Aspect	No. of Responses (N)	No. of Companies Scoring				Total Points Scored (TPS)#	Percent Points Scored (PPS)	Central Tendency (C.T) TPS/N
			1 (J)	2 (K)	3 (L)	4 (M)			
1	Increase in product mix	34	10	10	11	3	75	55.15	2.21
2	Improvement in product features	34	10	11	11	2	73	53.68	2.15
3	Significance of technology upgradation	34	1	1	13	19	118	86.76	3.47
4	Need of in-house R&D	34	0	8	18	8	102	75.00	3.00
5	Type of technology employed	34	10	10	12	2	74	54.41	2.18
6	Technology developed through in-house R&D	34	8	19	5	2	69	50.74	2.03
7	Option for technology upgradation	34	8	10	4	12	88	64.71	2.59
8	Collecting data for customer needs	34	7	20	5	2	70	51.47	2.06
9	Use of R&D policy	34	12	16	4	2	64	47.06	1.88
10	R&D for developing new processes	34	4	14	6	10	90	66.18	2.65
11	R&D for developing new products	34	3	14	9	8	90	66.18	2.65
12	R&D for maintenance related problems	34	1	16	14	3	87	63.97	2.56
13	Organization of R&D function	34	27	3	2	2	47	34.56	1.38
14	Risky Research strategy	34	9	14	6	5	75	55.15	2.21
15	Imitation for creation strategy	34	13	16	4	1	61	44.85	1.79
Overall Score									2.32

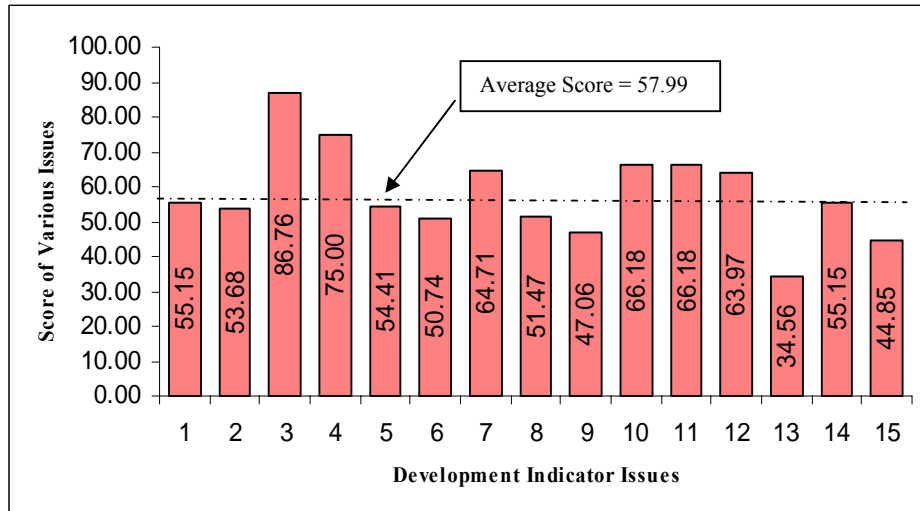
# (Total Points Scored "TPS" = 1xJ + 2xK + 3xL + 4xM)

There are two options for upgrading the level of technology. The first option is *Technology Acquisition* (purchasing technology) from an outside source. This alternative does not demand much investment in research and development but makes the organization totally dependent on other organizations for technology needs. More than half of the industrial units consider that their over dependence on external technology acquisition has rendered their available technologies and skills incompetent and archaic. The second option for technology upgradation is indigenous *Technology Development* through in-house research efforts. Most of the organizations (76%) consider that technology development through indigenous research is the only option to face global competition. Though the industry appreciates the importance of technology as a resource for meeting competition, a lot needs to be done on the practical front. At present, not even one tenth of the industrial units are employing latest technology to produce products. Nearly one third of the manufacturing organizations are

producing products based on old technology, which is a cause of concern. The actual performance of industry in developing indigenous technology through in-house research efforts is not very encouraging with a relatively low rating (PPS= 50.74). A little less than one third of the organizations have never developed any process or product technologies through indigenous research. More than half of the organizations have partially developed some technology. There are only less than one tenth of the organizations (6%) which completely meet their technology needs independently through indigenous technology development programs.

To respond to the changing market demands, data collection on customer requirements is very important. About one fifth of the organizations perform this job in a structured manner. Out of these, a few organizations (6%) have a separate marketing department to perform this function whereas in the remaining, a team of senior executives perform this job. In a large number of industries (59%), information is collected in an informal manner from the existing customers. The remaining, nearly one fifth of the units do not make any special efforts to collect information on customer needs.

**Figure 4.3: Issue wise Performance regarding Development Indicators**



There appears to be a strong correlation between extent of technology developed by organizations through in-house research initiatives and use of a well defined R&D policy for technological innovations. A little more than one third of the organizations do not work with a well defined R&D policy and majority of these have never developed any technology in-

house. Nearly half of the organizations have just started formulating their R&D policy. There are only a few organizations (6%) in which a well defined R&D policy exists and is followed. R&D function is used for various errands in the industry. These include development of new processes, new products, solving maintenance related problems, improving product quality etc. A little less than one third of the organizations (29%) tend to develop all new processes through in-house research efforts. About one fourth of the organizations tend to use research function to develop new products. Majority of the industrial units (50%) use research initiatives to solve maintenance related problems also. However, the industrial sector needs to comprehend that research function should be used for technology development initiatives and not for fire fighting of production problems.

Literature reveals that firms with separate research facilities are more innovative than their counterparts without these facilities. Tool industry in the region fails to learn from this fact. Not even one tenth of the industrial units (only 6%) have R&D function as a separate department. In another 6% of the organizations, teams are formed by top management for specific research projects and in another one tenth; design department is responsible for product innovations. In the remaining, about 79% of the organizations, the structure of R&D function is not clearly defined, which is discouraging.

Organizations in developed economies work with specific product innovation strategies to achieve long term gains. One of the successful strategic approaches which are extensively followed in the Japanese industry is '*Risky Research*' strategy. A little less than one third of the organizations completely depend on this strategy and believe there is no survival otherwise. Another one tenth of the organizations use it to a large extent. The remaining industries (68%) do not use this strategy much.

Another strategic approach behind the success of Japanese firms is '*Imitation for Creation*' strategy. Here, the firms purchase raw technologies developed by others through basic research. These raw technologies are developed into innovative products through indigenous research programs. Thus imported technology is used as a complimentary means of technology development. A relatively low rating scored by the industry (PPS= 44.85) in this issue shows that manufacturing sector is not influenced much by this thriving Japanese strategy. Most of the organizations have either not used this strategy or have used it only occasionally.

The overall score of this aspect is 2.32 (out of 4.00). The critical analysis of this component reveals that some issues have shown very low ratings. There is an urgent need to use the research function for technology upgradation rather than using it for solving production or maintenance problems. Further, utilization of well defined R&D policy and strategic approaches for technology development can greatly improve the effectiveness of research function in the manufacturing organizations.

#### **4.5 Contributions of TD initiatives in achieving Performance Improvements**

In the present work, a structured approach has been employed to manage the ‘Technology Development Program (TD Program)’ effectively to enhance the probability of success through such initiatives. This underlines the significance of identifying specific metrics to track the progress of such a program in organizations. Literature reveals that very limited information is available regarding the contributions of technology development initiatives in small scale sector towards harnessing core competencies in the organizations. Thus the present study assumes high significance as it brings forward contributions of TD initiatives in the industry for accruing core competencies to meet competition.

In order to ascertain the benefits realized by an effective TD approach, it becomes imperative that various input factors and output performance parameters for such a program be scrutinized carefully. Four input factors called ‘TD Input Factors’ (I1, I2, I3, I4) and four output performance parameters called ‘Development Indicators’ (O1, O2, O3, O4) have been identified as significant in analyzing the impact of development initiatives towards achieving performance improvements in organizations. These input and output factors are presented in Table 4.5.

**Table 4.5: Inputs and Outputs for tracking success of TD Program**

<b>TD Input Factors</b>	<b>Development Indicators</b>
<b>(INPUTS)</b>	<b>(OUTPUTS)</b>
I1. Management Proficiency	O1. Level of Technology
I2. Physical Resources	O2. Strategic Implementation of Innovation
I3. Government Regulations	O3. Structure and Output of R&D Function
I4. External Bonding	O4. Response to Market Demands

The detailed description of issues (statements/ items) related to these factors 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 parameters with key development indicators (output parameters) has been made.

The score of each input and output parameter has been calculated from the average of scores of the items comprising it. For example, the output parameter, ‘Strategic Implementation of Innovation (O2)’ consists of five items. The score for this output parameter has been obtained by averaging the scores of its five items.

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). This static measures the extent to which a set of variables are consistent in what they are intended to measure (Hair et al., 1998). Cronbach’s Alpha values for various categories are more than 0.5, which is considered adequate for exploratory work. This indicates high reliability of data collected through the ‘TD Questionnaire’. The Cronbach’s alpha values are presented in Table 4.6.

**Table 4.6: Cronbach’s Alpha for Key Parameters**

Parameter		Cronbach's Alpha Value
Management Proficiency	I1	0.586
Physical Resources	I2	0.662
Government Regulations	I3	0.815
External Bonding	I4	0.689
Level of Technology	O1	0.810
Strategic Implementation of Innovation	O2	0.698
Structure and Output of R&D Function	O3	0.685
Response to Market Demands	O4	0.948

#### 4.5.1 Correlation between TD Input Factors and Development Indicators

‘TD Input Factors’ are the key success factors for strategic implementation of TD program in an organization. The contributions of these input parameters in achieving performance improvements in the industry have been discussed in this section. For this, Pearson’s correlation coefficient values (r values) between each input factor and the ‘Development Indicators’ (output parameters) have been calculated. The correlation values obtained have been further validated and authenticated using statistical tools like t-Test and Multiple Regression analysis.

Pearson’s correlation values and t-values (obtained from t-Test) have been worked out to ascertain significant factors contributing to the success of TD program implementation in the

industry. Table 4.6 depicts the Pearson’s correlations, t-values and significance levels (p-values) for pairs of interrelationships of various ‘TD Input Factors’ with ‘Development Indicators’.

The t-values can also be worked out through empirical expression indicated in Equation – 4.1.

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

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

**Table 4.7: Pearson’s Correlation and t-Test Analysis between ‘TD Input Factors’ and ‘Development Indicators’**

DEVELOPMENT INDICATORS (OUTPUT PARAMETERS)						
			Level of Technology	Strategic Implementation of Innovation	Structure and Output of R&D Function	Response to Market Demands
			O1	O2	O3	O4
<b>Management Proficiency</b>	<b>I1</b>	r	0.34*	0.15	0.34*	0.38*
		t (p)	2.04(0.0483)	0.86(0.3971)	2.05(0.0491)	2.32(0.0266)
<b>Physical Resources</b>	<b>I2</b>	r	0.33*	-0.35*	0.04	0.02
		t (p)	1.99(0.0511)	-2.11(0.041)	0.23(0.8223)	0.11(0.9106)
<b>Government Regulations</b>	<b>I3</b>	r	-0.19	0.11	-0.27	0.35*
		t (p)	1.09(0.2818)	0.63(0.5357)	-1.59(0.1225)	2.11(0.0410)
<b>External Bonding</b>	<b>I4</b>	r	0.14	-0.03	0.38*	0.01
		t (p)	0.8(0.4297)	-0.17(0.8663)	2.32(0.0266)	0.06(0.9552)

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

The results of t test can be used to identify the input parameters (TD Input Factors) which have a significant contribution towards realization of performance improvements in the organizations. The ‘ $t_{\text{Critical}}$ ’ value for the confidence limits corresponding to ‘n-2’ (= 32) degrees of freedom and significance level of 5 percent (from statistical t-tables) works out to be 1.96. So, pairs with t-value greater than or equal to 1.96 are considered as having a significant association.

Finally, the inter-relationships between significant ‘TD Input Factors’ and ‘Development Indicators’ have been validated through multiple regression analysis as depicted in Table 4.8. The notations employed in this test include:  $\beta$ = Regression Coefficient (Beta Coefficient), R= Multiple Correlation Coefficient. The results of the analysis imply that there is a strong association of several input parameters with output parameters.

**Table 4.8: Multiple Regression Analysis between ‘TD Input Factors’ and ‘Development Indicators’**

Development Indicators	Significance Factors	Beta Value ( $\beta$ )	t Value	Significance Value (p)	R Value
O1	I1	0.94007	1.69488	0.10081	0.394809
	I2	0.89184	1.52446	0.13243	
O2	I2	-0.36652	-2.21143	0.03125	0.393867
O3	I1	0.53716	1.72058	0.09598	0.584705
	I3	-0.3852	-2.33113	0.02690	
	I4	0.57900	2.53868	0.01675	
O4	I1	1.08796	2.02924	0.0517	0.444309
	I3	0.48955	1.72478	0.09521	

#### 4.5.2 Discussion of Results

The present research provides an empirical evidence of a significant relationship between various TD Input Factors and Development Indicators. Management Proficiency (I1) is the first key input parameter for strategic implementation of TD program in an organization. The main issues of this component are presented in Appendix- II.

The critical examination of Pearson’s correlations and t-test results explicitly depict that adaptation of strategic Management Proficiency (I1) initiatives in the organizations have a significant impact on realization of overall performance improvements. The results highlight that Management Proficiency (I1) initiatives can strategically contribute towards realization of Development Indicators by adequately affecting organizational cultural transformations, thereby institutionalizing a favorable environment towards managing innovations in organizations.

Management Proficiency issues are significantly associated with level of technology (O1) in small scale organizations. Availability of workforce with multiple-skill base to run manufacturing operations can facilitate organizations to harness significant improvements in the level of technology. Further, higher education level and better technical know-how of employees can upgrade technology levels thereby allowing organizations to compete

effectively in dynamic environments. Thus, Management Proficiency (I1) as an input to technology development initiatives of an organization contributes significantly in improving the level of technology being used (O1).

The results show that Management Proficiency initiatives (I1) do not significantly affect the realization of strategic implementation of innovation (O2).

It has been observed that Management Proficiency issues (I1) influence the structure and output of R&D function (O3) in organizations. When trained aptly, employees work with a well defined policy and the research function is effectively utilized to improve and develop new processes and products. Research activities can be organized well and can produce positive results when necessary intellectual capital resource is available to execute its functions. Thus, Management Proficiency (I1) as a TD Input Factor has a significant impact on the structure and output of R&D function (O3).

Management Proficiency (I1) has exhibited a significant linkage with response to market demands (O4). Availability of multi skilled workforce and technical manpower can significantly improve organization's response to market demands. Manufacturing enterprises can continuously increase their product mix and cater to needs of international markets when workforce can perform varied tasks requiring multiple skills. Similarly better education level and technical knowledge of workforce level employees can help organizations to compete effectively in the global market place and become market leaders in appropriate business domains. Thus, Management Proficiency issues are critical in meeting changing needs of the marketplace.

Physical Resources (I2) are the second main input parameter for success of TD programs in manufacturing enterprises. The issues under this component are presented in Appendix- II.

The results highlight that Physical Resources (I2) can strategically contribute towards improvement of Development Indicators. Developing an adequate financial program that supports training and educational activities for innovation, and building a physical infrastructure for enhancing organizational capabilities are the key success factors of highly innovative organizations. Physical Resources (I2) as an input factor can facilitate organizations to upgrade technology levels (OI) if proper modernization initiatives and adequate financial support to R&D function is provided. These measures can facilitate realization of technological improvements in production systems to garner enhanced manufacturing capabilities.

Physical Resources (I2) and strategic implementation of innovation (O2) have a significant negative correlation. This shows that small scale organizations are aware of the benefits of strategic measures of innovation (i.e. benefits of in-house R&D, limitations of technology acquisition, different strategies for technology development) but implementation of these strategies has remained poor because of lack of adequate financial support and technology infrastructure.

Physical Resources and Structure (I2) have not exhibited a significant association with structure and output of R&D function (O3). Small scale sector can respond to the cut throat competition by embedding latest technology in its products. This requires extensive R&D efforts in experimentation and analysis. Majority of the Indian organizations do not even spend 2.5% of annual turnover on development initiatives and hence have not been effective in responding to the global market demands. Thus, Physical Resources (I2) have not exhibited a significant association with response to changing requirements of the marketplace (O4). Industry must realize that resources are important not only for functional support, but also having an adequate level of resources for the project influences workers perception that the project is valuable and worthy of organizational support.

Government Regulations (I3) are the next key input for successful implementation of TD initiatives in an organization. The main issues of this parameter are available in Appendix- II. Government Regulations (I3) have not shown any significant linkage with level of technology in firms (O1), strategic implementation of innovation (O2), and structure of R&D function (O3).

Government Regulations (I3) as an input to technology development initiatives can help the industry in responding to changing needs of the marketplace (O4), if effective policies for material pricing, subsidies to organizations and adequate support structure are present. Materials limit the level of technology of any age and material cost is a major fraction of production cost.

If government can facilitate material availability at reasonable prices, the savings achieved can be invested in technology development projects to improve product features and product mix. Further, favorable industrial policies regarding subsidies can help the organizations to respond effectively to the needs of market place. There has been lack of active government support and hence the small scale sector is just serving local markets and finding it difficult to compete with global counterparts.

External Bonding (I4) is the fourth key input parameter for strategic implementation of TD program in an organization. The main issues under this parameter are presented in Appendix-II. External Bonding (I4) includes interaction of industrial units with other manufacturing organizations, research institutions, academic institutes and service institutes set up by government to support small scale sector. The purpose of interaction is to generate technological innovations through mutual collaboration.

The contributions of the input parameter, External Bonding in achieving performance improvements in the industry have been discussed as follows:

External Bonding (I4) for technological improvement (O1) in firms have not exhibited any significant linkage. Industrial collaborations have been reported to be successful in many developed economies, especially in large scale manufacturing sector but have not yielded results in small scale industry in the region. Further, very few organizations collaborate with regional academic institutes for development initiatives, which is discouraging. Small scale sector and academic institutes have lived and grown apart developing diverse views and wide communication gaps. Paradigm shift is warranted to mitigate this dismal solution. Also, industrial collaborations with research institutions are not contributing in enhancing the level of technology. This is because manufacturing units are collaborating with such institutes for solution of production and maintenance problems and not for production or process innovations.

The results show that collaborations of industry with external agencies (I4) have not contributed towards implementation of strategic approaches for technology development (O2).

External Bonding (I4) as an input parameter for technology development initiatives has been found to be statistically significant towards improvement of structure and output of research activities (O3). When organizations collaborate with external agencies, they learn from R&D institutions, technical institutes and have a more organized research function.

#### **4.6 Scope of future research work**

- The study has been conducted in small scale units of a specific product category. Similar study can be extended further for other product categories. Further, the study can be conducted for medium and large scale organizations also.
- The study is based upon discrete parts manufacturing units. Similar research can be conducted for process industries and service sector also.

- The present work has conducted an empirical study of data obtained through questionnaire. The results obtained through questionnaire can be sustained and validated by performing case studies in a few selected industries.

## CHAPTER V

### CONCLUSIONS

The advent of liberalization, privatization and globalization has brought forth profound economic, social, environmental and technological pressures on the organizations. Markets have become more open, competitive and the customers more demanding. 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. 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. The present work presents three key broad areas (components) for overall assessment of technology development initiatives in the tool industry. These include *Internal Factors* for creative input; *External Factors* to support development efforts of industry; and *Development Indicators* accrued as a result of innovation initiatives. Internal Factors comprise of Management Proficiency and Physical Resources; External Factors consist of Government Regulations and External Bonding.

The main conclusions of this study are described as follows:

Tool industry is doing fairly well in availability of multi skilled workforce. 70% of the organizations have adequate strength of skilled manpower.

Industry lacks in proper training to employees to enhance creativity and innovation skills.

The results reveal that contributions of employees are adequately recognized by the organizations though more through extrinsic measures and less through intrinsic means.

Management role has been observed to be supportive in majority of the organizations in situations of project failures. In 91% of the organizations, strict action against employees is not taken and they are advised to learn from current failures.

For technological innovations, dedicated laboratories with facilities for experimentation and subsequent analysis are essential. 79% of the organizations do not have these amenities and state of the art production equipment, machining centers, robots etc. are not available in 85% of the industrial units.

As far as earmarking of funds for research activities is concerned, the state of affairs in the regional industry is disappointing because 71% of the organizations do not clearly allocate funds for research and development initiatives.

Shortage and cost of electric power in the region is considered as a major problem and 47% of the organizations consider this factor amongst the most significant reasons behind poor performance of industry.

Small scale manufacturing sector is greatly dependent on external help for its process technology needs. 76% of the organizations acquire almost all process technology from large scale Indian firms.

Tool industry in the region is not interacting much with other manufacturing units, research institutions or other agencies for technology development projects. 74% the units have never worked in collaboration with external agencies. Creating and maintaining relationship between academic and industrial organizations is a highly recognized mechanism to manage the changing demands of industrial society. However, regional cutting tool industry has failed to appreciate this fact.

Tool industry values the fact that technology is the most important resource and main driver of survival and growth. 76% of the organizations consider that technology development through indigenous research is the only option to face global competition.

Actual performance of industry in the area of technology development is poor. Only 6% of the industrial units are employing latest technology to produce products.

The actual performance of industry in developing indigenous technology through in-house research efforts is not very encouraging. 26% of the organizations have never developed any process or product technologies through indigenous research. Further, there are only 6% organizations which execute their technology development initiatives with a well defined R&D policy.

Literature reveals that firms with separate research facilities are more innovative than their counterparts without these facilities. Tool industry in the region fails to learn from this fact as only 6% of the industrial units have R&D function as a separate department.

One of the successful strategic approaches which is extensively followed in developed economies is the '*Risky Research*' strategy. 32% of the organizations completely depend on this strategy and believe there is no survival otherwise.

Another strategic approach behind the success of Japanese firms is the '*Imitation for Creation*' strategy. Manufacturing sector is not influenced much by this thriving Japanese strategy.

The level of technology in firms (O1) has shown significant correlation with Management Proficiency issues (I1) and Physical Resources (I2).

The results reveal that significant implementation of innovation (O2) can be mainly achieved through availability of suitable research infrastructure (I2).

Organizational structure and output of research function has depicted significant association with Management Proficiency (I1), Regulatory Provisions (I3) and External Bonding (I4).

The firm's ability to respond to the market needs (O4) mainly depends upon Management Proficiency (I1) and Government Regulations (I3).

The areas such as formal training to the employees, availability of scientific personnel, availability of technology infrastructure and funds for research initiatives are critical areas needing improvement. Also, major improvements need to be made regarding effective deployment of various government support mechanisms in the manufacturing industry. Tool industry is acquiring technology from large Indian industries rather than developing technology through External Bonding. The performance of industry in developing technology through collaborations with academic institutes or R&D institutes is also below desired levels. The critical analysis reveals that here is an urgent need to use the research function for technology upgradation rather than using it for solving production or maintenance problems. Further, utilization of well defined strategic approaches for technology development can greatly improve the effectiveness of research function in the manufacturing organizations.

Finally, it can be said that if technology development programs implemented successfully in the organizations, it can lead manufacturing organizations to attain new levels of achievements in technological innovations and can really differentiate between success and failure.

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## APPENDIX-I

<b>Details of Respondents to TD Questionnaire</b>			
<b>S.No.</b>	<b>Name of Organization</b>	<b>Address</b>	<b>Designation of Respondent</b>
1.	Capital Tool industries	7-A, Industrial Estate	Proprietor
2.	Patiala Tools Corporation	1 - A , Industrial Estate	Partner
3.	S.S. Tools	Sirhind Road	Proprietor
4.	Super Hobs and Broaches Pvt. Ltd.	B - 22, Focal Point	Director
5.	Techcellence	C - 17, Focal Point	Proprietor
6.	Versa Agro industries	33-D, Focal Point	Managing Partner
7.	Vishal Tools Corporation	D-83' Focal Point	Proprietor
8.	iM Tools	D-112, Focal Point	Proprietor
9.	M/S R.J. Tools	D -8, Focal Point Industrial Estate	Partner
10.	Aro Industries	D-9, Focal Point	Proprietor
11.	Amar Tool Corporation	D-88, Focal Point	Proprietor
12.	Super Capital Tools	D-101, Focal Point	Proprietor
13.	Shakti industries	D-141, Focal Point	Partner
14.	Perfect Engg. Tools	D-116, Focal Point	Proprietor
15.	Sunrise Industries	11-A, Factory area	Proprietor
16.	Kapson India	D-99, Focal Point	Partner
17.	Jindal Tool Industries	Gaushala Road	Proprietor
18.	Shakti Engineering Works	3-A, Upkar Nagar, Factory Area	Proprietor
19.	Simran Engineering Works	D-18, Focal Point	Proprietor
20.	Prince Industries	D-95, Industrial Focal Point	Proprietor
21.	Kapil Agro Industries	42-D, Focal Point	Partner
22.	Perfect Auto Liner's	C-1, Focal Point	M.D
23.	Precision Machines	D-331, Focal Point	Proprietor
24.	A.A. Industries	D-57, Focal Point, Industrial Estate	Chief Executive
25.	Super Auto manufacturers	A – 26, Industrial Estate	Partner
26.	Simran Engineering Works	D-18, Industrial Focal point	Proprietor
27.	AV Engineering Works	12-9, Factory Area	Proprietor
28.	Tool Masters	C-36, Focal Point	Partner
29.	Karan Enterprises	B-9/526, Factory Area	Proprietor
30.	Steelmans Cutting Tools	183, Ajit Nagar	Proprietor
31.	United Tool Company	# 1598, Ragho Majra	Proprietor
32.	Olmec Engineers	D-269, Focal Point	Partner
33.	Star Industries	C-75, Focal Point	Partner
34.	Jeevandeep Tools	D-110, Focal Point	Proprietor

## APPENDIX-II

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### Various TD Input Factors

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#### I1. Management Proficiency

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1. Multi-skilled workforce for innovation work.
2. Level of education of employees.
3. Training to employees to enhance creativity skills in formal manner.
4. Scientific and technical staff for R&D work.
5. Reward structure for employees.
6. Management response to project failures.

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#### I2. Physical Resources

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1. Renovation initiatives for technology development.
2. Technology infrastructure for research.
3. Financial support to research function.
4. Investments in R&D as a function of annual turnover.

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#### I3. Government Regulations

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1. Raw materials availability and prices.
2. Cost and availability of power in region.
3. Government regulations to support research.
4. Financial support to research projects.
5. Government mechanism for technology development initiatives.

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#### I4. External Bonding

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1. Industrial collaboration for technology developed.
  2. University-Institute bonding on research.
  3. Collaboration with R&D institutions.
  4. Collaboration with service institutes of small scale industry.
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## APPENDIX-III

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### Various Development Indicators

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#### O1. Level of Technology

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1. Level of process technology in use.
2. Role of old technology in impairing performance.

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#### O2. Strategic Implementation of Innovation

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1. External sources for technology needs.
2. In-house R&D for developing new technology products and processes.
3. Technology developed through in-house research.
4. Use of 'Risky Research', as a strategic approach.
5. Use of 'Imitation for creation', as a strategic approach.

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#### O3. Structure and Output of R&D Function

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1. Collecting customer requirements through a separate marketing department
2. Well defined R&D policy for technology development.
3. New processes developed through in-house research efforts.
4. New products developed through in-house research efforts.
5. Organizational structure for R&D function.

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#### O4. Response to Market Needs

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1. Increase in product features to respond to needs of marketplace.
  2. Product quality and attributes as compared to competitors.
  3. Markets served by the industrial units.
  4. Improvement in product-mix offered by the industrial units.
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