

Assessment Of Determinants Of Technology Development: An Empirical Study

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INTRODUCTION

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 the aspects of business such as technology, cost, product quality and service (Chan and Mauborgne, 1999; Gottardi, 2000). The changes in current business environment are characterized by intense competition on the supply side, and heightened volatility in customer requirements on the demand side. These changes have left unmistakable marks on the different facets of manufacturing organizations (Gomes et al, 2006). 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 (Hipkin and Cock, 2000). These formidable changes have forced the organizations around the world to adopt innovative and state of the art strategies to suitably address the all-important issues of organizational growth and excellence. Thus, organizations are left with no choice but to upgrade the existing systems, products and technologies for survival (Martins and Terblanche, 2003; Yang, 2007).

TECHNOLOGY

The word 'technology' comes from two Greek words 'Techne' and 'Logos'. 'Techne' means the skill or craft needed to make something and 'Logos' mean discussion or knowledge of something (Rao, 1996). Technology is defined as the practical knowledge, know-how, skill and artifacts that can be used to develop a new product or service and/or a new production/delivery system (Moriarty et al., 1990).

TECHNOLOGY UPGRADATION AND ITS SIGNIFICANCE

In this modern age, technology is the most important resource to any nation. It is the main driver of a nation's economic development (Beets, 1994). 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. In this rapid paced environment, the organizations are faced with the 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. 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. (Choi, 1989).

LITERATURE REVIEW

1) Organizational Culture: Competent manpower is an important element of technology development initiatives of a firm. Innovative organizations have a significant approach towards manpower development in order to achieve long

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term organizational gains (**Yahya and Goh, 2002; Kim and Choi, 1997**). Lack of proper capital and human resources are the major impediments to manufacturing enterprise's efforts in new industrial technology development and such firms have to increasingly rely on external knowledge sources to build up technological competence (**Sugasawa and Liyanage, 1999**). Organizations must explicitly strive towards the attraction, development and retention of creative talent. Many innovation champions must be identified, recruited, developed, trained, encouraged and acknowledged throughout the organization (**Cook, 1998**). Innovative companies believe that the bottom line difference between success and failure is finding, developing and nurturing the right people (**Ahmed, 1998a**). People should be creative in their thinking process and willing to work tenaciously to attain their goals. Organizations should focus on employing people with broader interests, who are eager to learn and prepared to take some risks (**Bresnahan, 1997; Brand, 1998; Gardenswartz and Rowe, 1998; Martins and Terblanche, 2003**). Successful organizations manage their human resources well. Their strategies include effective manpower planning, realistic performance plans, development oriented performance appraisal, effective learning system, performance guidance and other mechanisms such as mentoring (**Wang et al, 2007**). Such 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**). Highly innovative organizations create and maintain a learning environment by keeping knowledge and skills of employees' up to date (**Lock and Kirkpatrick, 1995; Samaha, 1996; Arad et al, 1997; Goncalo and Staw, 2006**). Studies evaluating creative training find that trained subjects perform better than untrained subjects at using instructions to defer judgment and there is moderate to large effect on creativity (**Rose and Lin, 1984**).

In-house reward systems to motivate employees for achieving goals of innovation, productivity and profitability are widely used by corporations. Personnel should be rewarded for risk taking, generating new product ideas, experimenting and developing new products. 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**).

2) Resource Support: The absence of adequate infrastructure services is one of the main problems that hinder efforts to develop technology (**Ridley et al, 2006; Odette et al, 2006; Ahuja and Khamba, 2007**). Developing adequate financial program, which supports training and educational activities for innovation, and building physical infrastructure for enhancing organizational capabilities are the key success factors for highly innovative companies. Advanced equipment and resources are the most important factors to support public and private projects regarding research and development, innovation and technology modernization. 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**). For better technological advances, new infrastructures, mainly telecommunication, modern production systems, latest software for modeling and analysis, new strategic thinking practices are needed for hypercompetitive environment (**Sheel, 2002**). 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**). Manufacturing organizations in developed countries spend 2.5-18% of annual turnover on technology development on an average (**Chandrashekar, 1995**).

The Management must clearly earmark funds for R&D activities aimed at innovations for new product and process developments (**Huang, 2008**). Resources are important not only for functional support, but also because having an adequate level of resources for the task/project influences worker's perception that the project is valuable and worthy of organizational support (**Arad et al, 1997, Amabile et al, 1996**).

3) Regulatory Framework : The scientific and technological development in developing countries depend upon the assistance of several government spheres, in particular from the federal one, in order to formulate policies and generate financial support mechanisms (**Passos et al, 2004**). The 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). Increase in technological innovation demands that the government should enhance spending on R&D (Liyanage, 2003). The Government can play an important role in enabling industry to be creative through correction of market failures, providing support where the benefits of creativity and design are wider than those for the firm itself or where there are gaps in the efficient supply of finance by the market (DTI Economic Paper, 2005; Jong and Stout, 2007).

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

4) Alliance With External Organizations : 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). Companies are feeling the pressure of shifting markets because of globalization and must make improvements in internal strategies to start interacting with external organizations (Wani et al, 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).

Knowledge is generated not only by individuals and organizations, but also by their complex pattern of interaction (Santos, 2006). Coates (1998) claims that 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*'. Larson (1998) predicts that technology will become increasingly complex and more expensive to develop. Therefore, many companies will choose to maintain their competencies only in selected core technologies and obtain additional capabilities through partnerships and alliances with other companies, government laboratories, universities and contract R&D organizations. Roy (2000) critically analyses the implications of adopting networking as a strategy for technological innovation in the laboratories of Council of Scientific and Industrial Research (CSIR), India. The 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. 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 (Thomas, 1993; Shaw and Craig, 2003; Jaffe, 2003).

V) Research Output: In the present work, Research Output refers to the functions performed by the R&D function in a firm, its organizational structure, strategies adopted for innovation and the contributions of R&D function towards technological competence building of the firm. Research Output is the manner in which R&D is managed in the industry and the role it plays in indigenous technology development. Technological innovation demands unceasing R&D efforts (Tipping et al, 1995). Market intelligence and vision are critical ingredients in effective technology development (Mayers and Rosenbloom, 1996). The R&D function in innovative organizations is customer driven and market focused. Such firms have proper support from the marketing department to collect information on customer needs. These firms increase their product mix regularly and bring changes in product features faster than their counterparts. In highly innovative firms, R&D acts beyond just providing technical support. It has the responsibility of identifying latent customer requirements that create business opportunities enabled by technology, developing the architecture for new applications and concepts responding to mutual discovery of unprecedented needs (Miller, 1995; Wonglimpiyarat, 2008). These firms work with a well defined R&D policy. By coupling R&D with business units, innovative organizations are in a better position to generate ideas for technological innovation and achieve better competitive edge (Mourthy et al, 1996; Lakemond et. al, 2007).

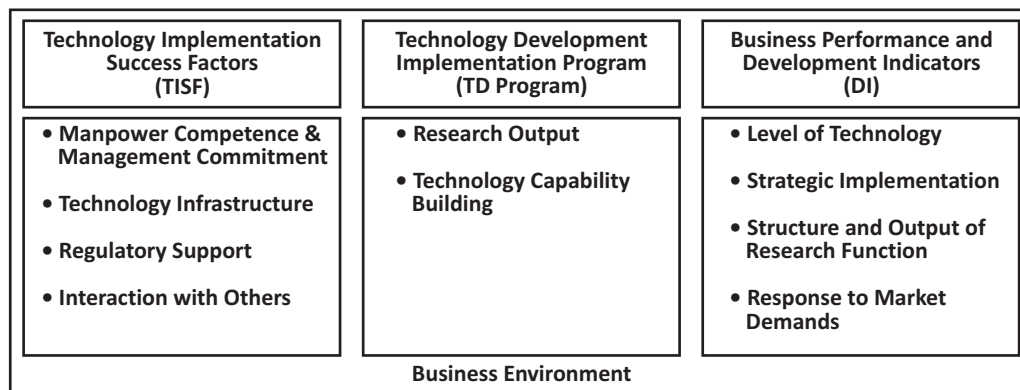
Manufacturing organizations use their R&D function to perform varied activities ranging from developing new products and processes, to solving maintenance related problems or improving product features. In highly successful innovative firms, R&D function is used for improving the process and product technologies, whereas in less innovative firms, it is largely used for fire fighting of production problems.

Firms with separate research facilities are more innovative than firms without these facilities (**Cardinal and Hatfield, 2000**). Innovative firms carry out their research efforts with well defined strategies. Strategies like '*Risky Research*' and '*Imitation for Creation*' are the key factors behind the success of many Japanese firms (**Choi, 1989**).

METHODOLOGY

A simple, relevant and a comprehensive questionnaire covering various aspects of technology development through in house research efforts was specially designed. A detailed survey was conducted in the cutting tool manufacturing industry in the region. The objective of the survey was 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, and 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. Small scale cutting tool manufacturing industries in the district of Patiala, Punjab were surveyed. A total of 86 industries had been selected, and the questionnaire was mailed to all the 86 industrial units. A total of 52 industries(60%) responded to the questionnaire.

Figure 1 : Conceptual Framework Of The Study



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.

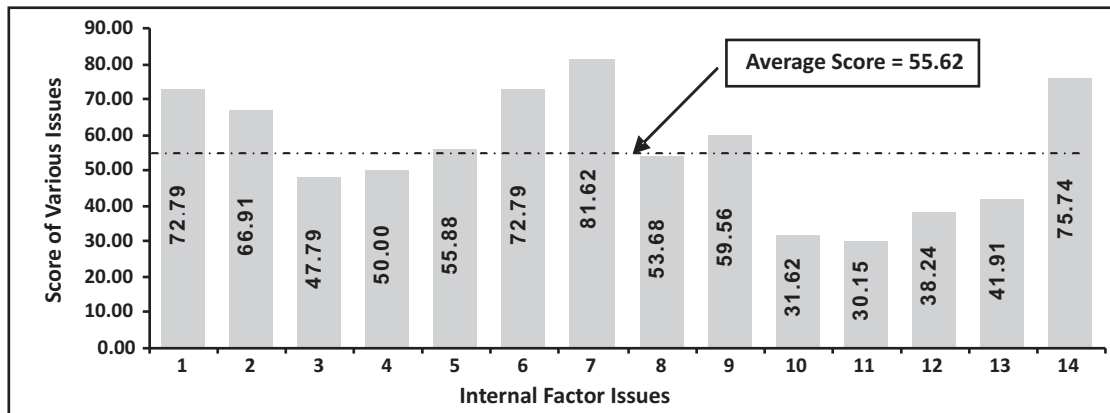
The purpose of this section is to access the status of each component (and its issues) of technology development in the manufacturing sector. A set of questions (from the questionnaire) which reflect different issues of the component, Internal Factor are taken and for each question, central tendency (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.

STATUS OF INTERNAL FACTORS

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

Figure 2: Issue Wise Performance Regarding Internal Factor Issues



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.

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 had 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.

The 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 thorough 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 the 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 the 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 the 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 spends 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.

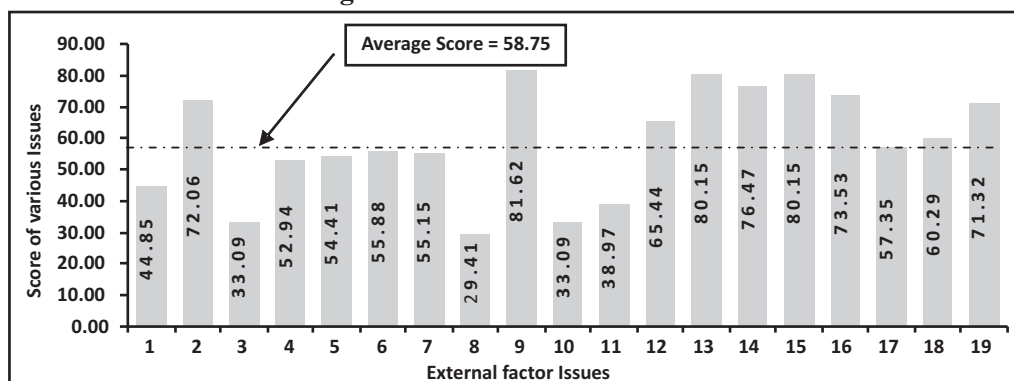
The average score of this aspect is 2.22 (out of 4.00). Formal training to the employees, availability of scientific personnel, availability of technology infrastructure and funds for research initiatives are critical areas needing improvement. Substantial improvements need to be affected for ensuring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

STATUS OF EXTERNAL FACTORS

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 the industry. Nearly half of the organizations consider this factor amongst the most significant reasons behind poor performance of the 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. The 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

Figure 3 : External Factor Issues



significant in impairing performance of the industry.

The small scale industrial sector requires active support from the 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 the 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.

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

The 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 on foreign firms. Majority of the small scale organizations do not acquire any technology from abroad. About one tenth of the organizations depend partially on the 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%) of 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 thirds (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 a 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 fourths 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 the 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, the 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.

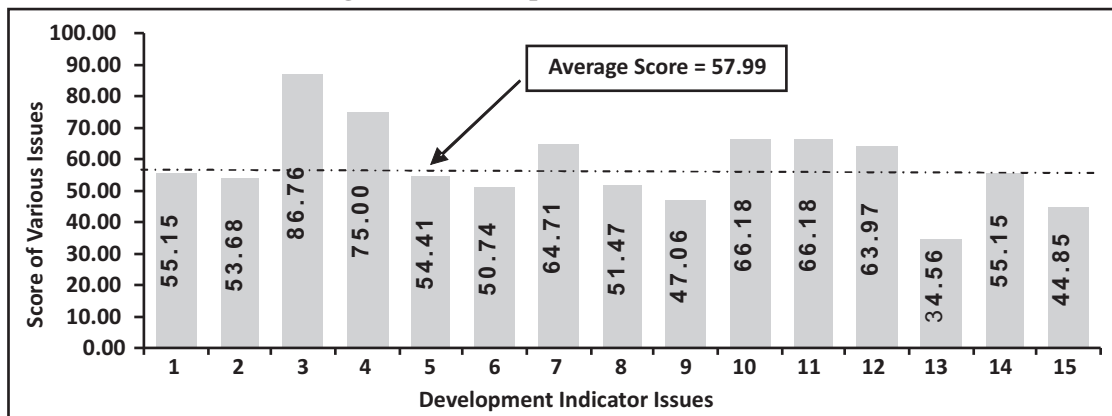
The average score of this aspect is 2.35 (out of 4.00). The analysis of data reveals that major improvements need to be made regarding effective deployment of various government support mechanisms in the manufacturing industry.

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.

STATUS OF DEVELOPMENT INDICATORS

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 the 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.

Figure 4 : Development Indicator Issues



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.

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. 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 in-house technology. 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.

The 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 functions 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 the 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 a 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; the 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 the 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 the research function in the manufacturing organizations.

CONCLUSIONS

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.
- ✿ The Industry lacks in proper training of employees to enhance creativity and innovation skills.
- ✿ The results reveal that contributions of employees are adequately recognized by the organizations more through extrinsic measures and less through intrinsic means.
- ✿ The role of the Management 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 industries 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 the 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% of 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 the 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 the 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. The 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. The Manufacturing sector is not influenced much by this thriving Japanese strategy.

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