fields, drains, etc. (v) Personal protection methods: mosquito nets, preferably treated with synthetic pyrethroid insecticides (treated nets are safe); wire mesh doors, windows and ventilators can be used; and (vi) Neem oil can be extracted from the seeds of *Azadirachta indica* and used as neem cream[20]; neem oil 5 parts and 95 parts edible oil like coconut or mustard oil[21] or mats treated with neem oil[22] or burning neem oil in kerosene[23] would be a cost effective alternative to chemical repellents. Neem oil is safe when used as mosquito repellent[24].

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Facilitating innovation in Indian small and medium enterprises – The role of clusters

V. P. Kharbanda

The present-day knowledge economy demands knowledge-intensive enterprises which only can survive in the ongoing process of globalization and increased international competition. Knowledge as a factor for competitive advantage has replaced traditional factors like labour and capital. As knowledge resides only in the human mind, it can only be harnessed by focusing on increasing human capabilities through the process of increased communication, cooperation and linkages, both within the enterprise as well as across enterprises and knowledge-producing organizations. This paper dwells upon a few case studies, how enterprises in India are facing this challenge, and particularly, how small-scale enterprises are moving towards clusters for international competition.

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

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facturing[1]. It produces a diverse range of products (about 8000), including consumer items, capital and intermediate goods.

However, the SMEs in India, which constitute more than 80% of the total number of industrial enterprises and form the backbone of industrial development, are as yet, in technological backwaters *vis-á-vis* advances in science and technology. These suffer from problems of sub-optimal scales of operations and technological obsolescence. While most of the large companies, even in developing countries, have financial as well as technical capacity to identify technological sources and evaluate alternate technologies that would suit their requirements, unfortunately, this capacity is conspicuously missing in most SMEs. It is these features of SMEs that make them an ideal target for technological upgradation through technological cooperation with foreign and local enterprises, with R&D institutions and centres of technology development.

As the countries integrate into the global village, these SMEs will have to respond accordingly and thus deserve special attention. To enable SMEs to mitigate problems of technological backwardness and enhance their access to new technologies, it is imperative to give them a conducive environment, which in the present context of globalization, calls for an human-centred approach with tacit knowledge playing a predominant role. As knowledge resides only in the human mind, it can only be harnessed by focusing on increasing human capabilities through the process of increased communication, cooperation and linkages, both within the enterprise as well as across enterprises and knowledge-producing organizations. How are SMEs in India facing this challenge? How are these moving towards industrial clusters for international competition? What policy measures are required? These are some of the questions, which are dealt with in this paper, taking a few examples from the Indian scenario.

Need for access to new technology

Small enterprises in India, with their dynamism, flexibility and innovative drive are increasingly focusing on improved production methods, penetrative marketing strategies and modern scientific management capabilities to sustain and strengthen their operations. They are poised for global partnership and have the potential to absorb latest technologies in diverse industrial fields.

Small in India is more than beautiful – it is efficient, adaptable and add value in economic and social spheres. As the country integrates into the global village, the small and medium sectors will have to respond accordingly. They deserve special attention as they play a pivotal role in a country's socio-economic development.

The problems faced by the SMEs, particularly in accessing technology and maintaining competitiveness have been formidable. The reasons for the inability of SMEs to identify their technology needs are:

- Poor financial situations and low levels of R&D;
- Poor adaptability to changing trade trends;
- Desire to avoid risk;
- Non-availability of technically trained human resources;
- Emphasis on production and not on production costs;
- Lack of management skills;
- Lack of access to technological information and consultancy services;
- Isolation from technology hubs.

To enable SMEs to mitigate the above problems and enhance their access to new technologies for increasing their competitiveness in the international market, it is imperative to give them a conducive environment which includes:

(1) Formulation of appropriate national policies and programmes;
(2) Building up technological capacity;
(3) Knowledge flows and technology databases;
(4) R&D and inter firm linkages.

Formulation of policies and programmes

Conducive policy environment is a pre-requisite. Major policy reforms aimed at substantially deregulating industrial sector and liberalizing foreign investment as well as technology imports, have been the most significant development since 1991. The post-liberalization era in the Indian economy has enhanced opportunities and challenges for the small industries sector. The ultimate objective of promotional policies is to enhance SMEs[1] capacity to grow so that they become viable units. The national policies and programmes may be oriented to:

- Setting up Industrial Districts/Technology Parks/Clusters to promote sourcing of new technology, innovation and effective transfer;
- Organizing local level information services, data banks and seminars in collaboration with professional bodies;
- Sending experts to SMEs to assist them with the introduction of new technologies;
- Establishing training centres for human resource development for SMEs;
- Establishing business centres;
- Promoting strategic alliances with R&D institutions, universities and other enterprises at national, regional and international levels.

This calls for promoting indigenous industrialization with emphasis on self-reliance, through use and creation of local resources and at the same time adoption, absorption and diffusion of the imported technologies. This strategy involves an expanded role of SMEs which can alleviate high levels of unemployment and income inequality.

Building up technological capacity

Access to advanced technologies and assistance in its adoption is crucial to build up Indigenous Technological Capacity (ITC) to face international competition. In the present scenario of globalization, knowledge of and access to latest advances holds the key to international competition. In this venture the industrial sectors, which are able to identify their technology needs and adopt in time, will benefit the most. In India, the traditional sector which has shown this remarkable ability to adapt to technological change is leather. Central Leather Research Institute (CLRI), Chennai, has successfully introduced microprocessor control in tannery wet operations at industrial level and promoted cleaner processing, quality consistency and international equivalence. Anticipating the impact potential of computer-aided techniques in footwear and garment design, CLRI alerted and prepared the industry so well that CAD is today widely employed by export manufacturers of footwear and garments.

In another example, under NISTADS Bankura Project, a software package called as 'MADHU' (Modernization of Artistic Design for Handloom Unit) was developed in collaboration with Indian Institute of Technology, Kharagpur. [National Institute of Science Technology and Development Studies (NISTADS) has set up a S&T field station at Bankura, India to upgrade the technologies for artisans and craftsmen by blending the traditional technologies with new technologies and promoting commercialization.] This CAD software package facilitates computerized digitization of the picture/design produced by the artist/designer. This package has been successfully demonstrated to designers and weavers of Bankura. As a result, a large number of craftsmen have adopted blending of this new technology to increase efficiency, quality, flexibility and cost effectiveness. The above shows how information technology can be of immense use to upgrade and modernize the small-scale sector. Man and the machine can work together (in contrast to the most advanced automated systems) to bring out products with more flexibility and which are consumer-oriented, as also advocated by Brandt and Cernetic[2].

While a large number of CSIR laboratories all over the country help meet the technological needs of the SMEs, Mechanical Engineering Research and Development Organization (MERADO), Ludhiana, in particular, was established in 1965 to nurture the growing industrial clusters in Ludhiana in the field of knitwear, agro-industrial machine tools and bicycles industry. Since then, it has contributed significantly towards design, development and standardization of industrial machinery, agriculture machinery, machine tools, special purpose machines, consumer durables, etc. Some of the notable examples are design and development of 10 TPD modern oil expeller, sugarcane harvester, electric cloth cutting machine, high-speed overlock machine, leather shaving machine, flat bed and post bed leather sewing machines, button hole attachment for domestic sewing machine, wool knitting machine, friction welding machine, etc. The technologies developed by MERADO have benefited not only the SMEs in the state, but also in other states like West Bengal, Haryana and UP. It also caters to major testing facilities for the SMEs in Ludhiana[3]. However, in the present scenario of globalization and liberalization, stronger linkages still need to be promoted not only between technology support institutions and SMEs, but also between SMEs for horizontal transfer of technologies. In this direction human resource development in the technology support institution is one area of crucial importance, which needs attention.

Similarly, other SME sectors which need to be technologically upgraded are electrical and electronics, light engineering, food processing, building materials, chemicals, drugs and pharmaceutical, ceramics and telecommunication. In this direction, a number of efforts are being made by the Indian government. For example, the National Small Industries Corporation (NSIC) has pioneered several schemes for the growth and development of the small-scale sector. In the initial stages of development of the small-scale industries after independence, it was the innovative and novel schemes of the NSIC such as government purchase, hire purchase, development of prototypes, technical training, etc. which led to the establishment of new enterprises, development of appropriate manufacturing technologies and creation of a strong first-generation entrepreneurial base. These schemes of the Corporation acted as a catalyst for this sector. It has helped the small units in identification, adoption, absorption and transfer of technology, entrepreneurial and technical training, common production facilities, marketing and financial support. With the successful implementation of NSIC schemes, a number of financial institutions and banks have also come forward to assist this sector, thus creating an important constituent of the Indian economy. Further, Council of Scientific and Industrial Research (CSIR) is also an important technology generator in the country and has a lot of S&T inputs to offer to the small-scale sector. To further invigorate this sector, the NSIC, CSIR and Asia and Pacific Center for Transfer of Technology (APCTT) have pooled their resources and have formed a strategic alliance to help upgrade technology in the small-scale sector. APCTT has a comprehensive data bank of information on appropriate technologies in diverse industrial sectors with access in the ESCAP region and elsewhere. It has been assisting technology buyers and technology sellers from different countries to come together. The alliance of these three organizations will assist the small-scale industry (SSI) units through a single point in technology sourcing. APCTT, NSIC and the CSIR, India, have, thus, formed a consortium to assist SSIs in the country with emphasis on the following aspects – improve and secure access of SSIs to advanced

technologies, strengthen linkages between R&D institutions and create and strengthen the local innovative system. To start with eight technology acquisition and modernization workshops (two days each) in selected industrial centres (New Delhi, Bangalore, Chennai, Mumbai, Ahmedabad, Ludhiana, Indore, Kolkata) were organized during 1994 to deliberate on specific technologies in identified sectors[16]. These workshops provided an opportunity to identify specific technological needs and capabilities of small-scale units and the nature of technical assistance sought from promotional and financial agencies.

In India, most of the SMEs are building up ITCs through the process of 'learning by doing'. This is central to incremental innovation and technological change. It has been pointed out that engineers on the shop floor play a vital role in supporting the operator's effort to acquire new skills and come up with new ideas[4]. This is a must for a learning organization. In such an organization, everyone in a group is an expert and can give his/her knowledge to the process of complex problem-solving[5]. The fact that proper linkages between the managerial staff, including engineers and workers at the shop floor within an enterprise, are an important factor in the information flow and the innovation process is exemplified by the studies on firms in the electronics sector in India[6,7]. The studies show that learning by doing and entrepreneurial capabilities have been instrumental in strengthening humanware and technoware at the enterprise level.

Knowledge flows and technology databases

Dynamism of SMEs is crucial for their long-term competitiveness. For this they need to focus on systems of knowledge accumulation rather than just production system[8]. The SMEs should have capabilities for generating, accessing and diffusing knowledge and also have openness to external sources of knowledge, including new technology databases. For this efficient national information services and networks are essential. In developing countries, most of the SMEs do not have access to well-researched technology databases that provide information pro-actively on a regular basis. The information usually remains in the banks untapped, while the purveyors of the information wait for the targeted beneficiaries to request it.

In India, an important technology information data bank is the National Research and Development Corporation (NRDC), which serves as an important link between research and SMEs. NRDC acquires, evaluates, develops and transfers all worthwhile technologies generated at the various national laboratories. The technologies available with NRDC for commercial exploitation cover a wide range of products, namely drugs and pharmaceuticals, pesticides and herbicides, plasticizers, resins, electrochemical products, metals, paints and varnishes, leather chemicals and auxilliaries, electrical and electronic goods, building materials, etc. It provides a comprehensive international patent search and also has a few renowned international databases on-line for carrying out the search.

Through the Ministry of Science and Technology, the Government of India has also established information centres in specific areas for assisting academic institutions and industry under the scheme called National Information System for Science and Technology (NISSAT). There are information banks on food, leather, drugs and pharmaceutical, machine tools and aeronautics. SME units can approach them for assistance, especially with regard to the latest developments in the field of technology.

An important database on local innovations is the 'Honey Bee Database' supported by SRISTI. [The Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) is a voluntary organization in India, which has received national and international recognition as a centre of excellence for research on people's innovations]. This is one of the biggest stores of knowledge on local innovations by farmers and artisans, covering about 72 countries. It is a knowledge network, which pools the technological solutions developed by people around the world. Networking of these databases can be of immense use to mitigate the numerous technological problems of the SMEs.

R&D and inter firm linkages

At present, there are 2900 R&D institutions in India, of which 1350 are in the private sector. Out of these, over 1250 are in-house R&D units, employing over 45,000 scientific and technical personnel and incurring an expenditure of the order of seven billion rupees per annum. However, the small-scale sector is largely devoid of such facilities and is mainly supported by public R&D for acquisition of new technologies. In general, SMEs are encouraged to invest in localized technological development. As most SMEs lack financial resources, the best way is to enter into linkages and partnerships with other enterprises, academia and/or R&D institutions.

Over the past decade, emphasis in the concept of technology transfer has gradually shifted towards a new set of strategies which can be described as 'creative partnerships' or 'strategic alliances' to form learning organizations[9]. This underlines the idea that forms of technological cooperation are no longer 'one-way', but involve a longer-term mutual benefit beyond short-term financial success. According to Cooley[10], learning by doing is not enough. Those who know what they are doing – crafts people with skill and experience – are the ones who best understand what needs to be done. This depicts an inherent feature of entrepreneurial capabilities, which helps pushing the organization towards a learning organization. 'Learning by interaction' is an important feature of technological

upgradation and can only happen when firms cooperate and interact through strategic alliances and other forms of linkages. For this to happen, the most viable systems are the clusters, which offer good opportunities for interaction and industrial upgrading[11]. The common feature of these new forms lies in the sharing of knowledge in technological capabilities and in cooperative intentions, which may or may not include government incentives. The diverse forms of alliances include:

- Long-term multi-project partnerships that pool the production, research and marketing divisions in a single country or across several countries to accomplish strategic goals;
- Flexible networking mechanisms that promote research consortia at the pre-competitive and development phases.

Such partnerships have technical education, training and retraining, innovation and sustainability as inherent features.

Networking/industrial districts/clusters

The approach encompassed by the concept of industrial districts/technology parks/clusters, offers new insights into the potential role of SMEs in enhancing their access to new technology. Sector-specific and geographically-bounded clusters seem to be a common phenomenon for small-scale manufacturing in developing countries. Most of them have been very successful, which are primarily based on tacit and accumulated knowledge through learning by doing and learning by interaction. For example, in India there have been a large number of 'spatial clusters' of small firms engaged in specialized industries such as: locks in Aligarh, leather footwear in Agra and Kanpur; cotton hosiery in Kolkata and Delhi; blankets in Panipat; power looms at Bhiwadi; diamond polishing in Surat. Space-bound 'dense clusters' related to a specialized industry are even more pronounced in Punjab with woollen garments, bicycle and bicycle parts, sewing machine parts and machine tools in Ludhiana; printing and printing goods, water pipes and bathroom fixtures in Jallandhar; foundries in Batala, etc. Ludhiana clusters make 95% of the country's woollen knitwear; 85% of the sewing machines and 60% of the bicycle and bicycle parts. The Agra cluster makes 15 million pairs of shoes per day with a production value of US $ 1.3 million and exporting shoes worth US $ 57.14 million per year[12]. The knitwear cluster in Tiruppur, Tamil Nadu is responsible for 85% of Indian market and its export earnings have expanded from US $ 25 million in 1986 to US $ 636 million in 1997. What is interesting about the Tiruppur cluster is that it is organized in a web of small work places through which the entire town works like a living industrial organization[13].

Characteristics of a successful industrial district mentioned by various researchers are: inter-firm cooperation, cooperation blended with competition, the importance of local value systems, flexibility and innovative capacity, geographic proximity, sectoral specialization, the provisions of a local pool of skilled labour and the presence of a large number of firms. It also includes willingness to work together to resolve potential clashes of interest, widespread entrepreneurial spirit and ability, promotion of a social compromise, etc. Best[14] mentions the institutional capacity of industrial districts is to learn, adjust and improve their economic performance continuously.

The above characteristics, more or less, are inherent in the Indian clusters. These clusters form a kind of knowledge network which works like a honey beehive, where there is constant sharing of knowledge and the benefits. It links not only people, but both formal and informal science, i.e. tacit knowledge.

The innovative atmosphere and entrepreneurial dynamism are part of the secret of success of these districts, which need to be studied in detail.

Role of financial institutions

The availability of financial resources on affordable terms and in a non-bureaucratic manner is yet another problem the SMEs confront, hindering access to new technologies. It is imperative, therefore, to influence existing financial networks and, if need be, to set-up a separate mechanism for funding smaller enterprises, especially those categorized as micro-enterprises.

One of the important ways to promote access to new technologies among SMEs in developing countries is to provide venture capital, which in a way helps in indigenous development of technologies. Financial institutions such as Industrial Development Bank of India (IDBI), Industrial Credit and Investment Corporation of India (ICICI), Industrial Finance Corporation of India (IFCI), and banks are providing assistance for commercialization of indigenously developed technologies and adoption of imported technologies for wider domestic applications through venture capital companies. A large number of small innovations are also being supported by SRISTI Venture Capital Fund[15]. One of the main factors of the success of knitwear cluster at Tiruppur is the state intervention in the supply of short-term credit to facilitate networked production[13].

In order to create a business environment, with adoption and assimilation of new technologies that are resource-efficient and have little waste output, the supportive infrastructure also needs to be strengthened in many developing countries. There is a need for such institutions to deal exclusively with the myriad problems that SMEs face in their day-to-day work. In India Department of Scientific and Industrial Research (DSIR) is one such institution. It is engaged in technology promotion, development, utilization and transfer activities. The department has launched several initiatives to encourage

increased utilization of locally available R&D options through its major schemes, viz. Programme Aimed at Technological Self-Reliance (PATSER), and Scheme to Enhance the Efficacy of Transfer of Technology (SEETOT). Technology Bureau for Small Enterprises – a result of collaboration between APCTT and Small Industries Development Bank of India (SIDBI), represents under one roof, synergy of technology and finance which facilitates capability building and identifying market channels.

Conclusions

In conclusion, any effective technological capacity-building exercise to enhance competitiveness of SMEs will have to address issues that can be broadly classified under the generic heads of a conductive policy framework, knowledge acquisition and dissemination, new technology demonstration and networking, and financing and institutional support systems. In each of the above categories, the barriers must be clearly identified and enabling strategies developed so that the technological capacity-building process in SMEs becomes meaningful, in terms not only of international trade and business or of the environment, but also of making it responsive to the needs of the people. Constant learning by doing and interaction is the hub of the activities for innovation with tacit knowledge playing a crucial role, as exemplified by Indian SMEs and clusters. Here human-centred systems play a crucial role for flexible manufacturing and customer orientation. There have been many successful examples of industrial clusters in India, China, South Korea, Japan and European countries. The study of these innovation models can be highly useful for greater cross-culture exchange of innovative experiences between different countries.

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