SMALL AND MEDIUM ENTERPRISES
IN THE NATIONAL SYSTEMS OF INNOVATION:
EXPLORING THE BARRIERS TO TECHNOLOGY TRANSFER

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1. INTRODUCTION

The dynamic engine of a nation's economic growth is driven by a collective of small and medium enterprises (SMEs) whose activities are the spur to aggregate economic and social benefits. Several studies confirm that a nation's growth and sustenance is dictated, to a large extent, by the performance of small businesses. However, the reality is that SMEs are constantly struggling to survive and maintain their schedule of activities.[1] This is evident in the track record of the majority of SMEs in the developing and transition countries: they have been unable to reap the benefits of globalization and, to add to their inadequacy, they frequently face pressure, on the local or domestic markets, from cheaper imports and foreign competition (OECD, 2004). This unfortunate predicament may be attributed to the fact that many developing countries face major challenges in suitably developing, attracting, and using modern technologies (UNIDO, 2002). The productive entities that have been most affected by problems specific to technology transfer are the SMEs (Ramanathan, 2008). It is, therefore, inevitable that a large majority of micro and small firms in countries in the Asian and Pacific region have focused on traditional industries[2] where the activities are mostly characterized by low technological complexity and extensive use of unqualified labour.

The limited availability of technological, human, financial, and management resources on the one hand, and the weaker capability and bargaining power of SMEs on the other hand, are amongst the most crucial barriers that must be overcome when it comes to dealing with actors in their external environment, including suppliers, clients, the labour market, development agencies, and fund providers. As a corollary to this scenario, specific initiatives and policies to support small firms were increasingly seen to be implemented in the last decade of the twentieth century. In India, the Ministry of Industry and the Department of Science and Technology (DST), along with other agencies, introduced specific programmes for SMEs and cluster development in the recent past, which are directed towards networking their needs and demands with knowledge institutions.[3]

Several studies address the problems faced by SMEs in their development at the macro, meso, and micro levels in an enabling environment. These problems include limited access to finance; cumbersome bureaucratic procedures in setting up, operating, and sustaining a business; poor infrastructure; and the lack of effective institutional structures. While acknowledging the importance of these issues, this study limits its focus to the problems faced by SMEs in technology transfer and the process thereof.

[1] See UNIDO, Annual Report (2002).
[2] These industries differ from one country to another – food and beverages, clothing and footwear, software – with barriers to entry being low. India's technology economy is highly characterized by SMEs, particularly in the IT sector (Benjamin, 2000; Basant and Chandra, 2007)
[3] The definition of small-scale industry in India includes all enterprises with a capital investment of Rs.1 crore and below.

This study also emphasizes the role of SMEs in the national innovation system and explores the relevant theoretical literature on innovation studies. This facet is apparent in the vital role that SMEs play in a nation's economy: In the Asian and Pacific countries, SMEs have been contributing significantly towards the creation of a healthy, entrepreneurial climate and the generation of employment, thereby commanding a sizeable share in the region's economy.[4] For instance, SMEs constitute 99.8% of the total number of enterprises in the Republic of Korea. This is true also of other countries in the region: 99.7% in Singapore and Thailand; 99.6% in the Philippines; 99.0% in China; 98.9% in Japan; 98.0% in Hong Kong; and 97.7% in Taiwan. Malaysia has a comparatively lower figure: 92.0% of the total 689,160 registered enterprises. In terms of employment, the SME employees account for a sizeable percentage of the total employed population: Republic of Korea, 86.7%; the Philippines, 70.0%; Japan, 69.2%; Taiwan, 68.8%; Hong Kong and Thailand, 60.0%; and Singapore, 57.0%.[5] In the manufacturing sector in Malaysia, SMEs account for 30.7% of the total employment.[6] Research has established that a country's emergence and growth is influenced by critical factors such as learning and the capabilities of domestic firms; result-oriented government policies; a highly skilled labour force; flourishing entrepreneurship; some key large firms; and the dominant driver of growth – the highly dynamic SMEs.[7] In the last decade, several policy measures have been taken by the government in different countries for promoting SMEs and their activities.

2. OBJECTIVES OF THE STUDY

In addition to addressing the crucial place of SMEs in innovation systems, the study highlights the problems they encounter in technology transfer so that favourable conditions are created for the development of the SME sector, which, we propose, can be achieved through the following objectives:

- Building an inventory of problems faced by SMEs in technology transfer at three levels: the source level (technology provider); the sink level (technology recipient: the SMEs); and the common problems level (pertaining to source, sink, and the external environment).
- Examining the reasons for the technical and technological backwardness of SMEs, as also the measures that may be employed to strengthen them and thus improve their product/service competitiveness.

[4] According to the Country Report of Thailand: Mephokee (2006), SMEs are currently the most important and fundamental organizations for accelerating national economic development.

[5] Source: White Paper on Small and Medium Enterprises in Taiwan, 2006 as cited in Kotelnikov (2008) – *www.apdip.net/publications/esprimers/eprimer-sme.pdf* accessed on 11 November 2008. Data source on Malaysia is from Bank Negara Malaysia (2004) wherein the Economic Report on SMEs presented an assessment of the situation of SMEs in Malaysia. The main reason for this focus is the high concentration of MNCs in Malaysia and the low level of local sourcing by these MNCs.

[6] Economic Report on SMEs by Bank Negara Malaysia (BNM, 2004).

[7] Some of these studies are Odagiri and Goto (1993), highlighting the automobiles and electronics sector in Japan, and the same sectors in the Republic of Korea covered by Lee and Lim (2001). The study by Amsden and Chu (2003) focuses on Taiwan where electronics are in the lead, and Malaysia's electrical and electronics sector is covered in the study by Malakolunthu, 2006.

- Understanding the support linkages and cooperation between technology sources (large firms, industry and/or government R&D labs, and academia) and SMEs.

Since the success of technology transfer depends on suitable capacity being created, and institutional arrangements being established for successful implementation of appropriate policies, this study aims to provide research reference and documentary support to policy-makers interested in the development of knowledge infrastructure in countries/clusters; and in so doing, to facilitate understanding the importance of creating suitable conditions for the development of SMEs in the technology transfer process.

3. PLACING SMEs IN NATIONAL SYSTEMS OF INNOVATION

Our understanding of innovation has evolved over time from the concept of discovery (invention), as in the old Schumpeterian sense, to market (Schumpeter, 1975 [1942]), to a more iterative and interactive understanding of the term *innovation* in general (Rothwell, 1986; Von Hippel, 1988) and technology transfer in particular (Capart and Sandelin, 2007), to its current broader interpretation in contemporary literature. It now covers not just the development of products and processes that are novel, but also the adoption and adaptation of products and processes that are already in use in the industrially advanced countries. While the large, established firms are able to make use of technology in either situation, it is the SMEs that face daunting challenges in adopting and adapting technologies to their needs. This aspect of innovation is, increasingly, of critical relevance to developing countries today.

Apart from the technological innovations, the institutional innovations involved are specifically concerned with the adaptation/adoption of technologies in time, and in the building and diffusion of technological, human, and other capabilities as rapidly as possible. In view of these considerations, this study suggests that it might be appropriate to refer to the system of institutions and policies as the National Systems of Innovation (NSI) in the case of SMEs.

There are several definitions of NSI. These can be classified into broad and narrow definitions. The broad definition encompasses all interrelated institutional actors that create, diffuse, and exploit innovations, whereas the narrow definition includes organizations and institutions directly related to searching and exploring technological innovations, such as R&D departments, universities, and public institutes (Chung, 2002). Here we would like to include the related policy frameworks that facilitate innovations. In the broad definition, NSI is responsible for innovations primarily through the creation and the application of new knowledge (Lundvall, 1985, 1988, 1992; Freeman, 1987; Nelson, 1993; Edquist, 1997).[8] It is composed of

[8] The study of innovation systems and its application to developing countries is recent, and critical attempts are being made to evaluate the performance of developing and newly industrialized countries (see Kim, 1993; Gu, 1999; Sarma, 2005; Abrol, 2003; Nath, 2003; Wong, 1996).

three comprehensive innovation actor groups: public research institutes, academia, and industry. In addition, the governments, i.e. the
central and provincial or regional governments, play the role of coordinator among research producers in terms of their policy instruments, visions, and perspectives for the future. This study, however, uses the narrow definition in the context of SMEs.

Policy changes, globalization, and an intensified focus on knowledge in society have contributed to a new role for NSI constituents in the post-industrial society. This focus on applied technology (Hargadon, 2006; Rosenberg and Nelson, 1994) has become evident with concepts such as National Systems of Innovation (Lundvall et al, 2002; Freeman, 1987; Nelson, 1993; Lundvall, 1992, 2005), Triple Helix (Etzkowitz and Leydesdorff, 2000; Etzkowitz and Webster, 1998), and Mode 1/Mode 2 (Gibbons et al, 1994; Gibbons, 1998; Nowotny et al, 2003) which emphasize the importance of knowledge creation in society at large, and point towards a trend where research becomes more applied and is pursued, to a larger extent, in cooperation with industry. As key actors in the innovation system, SMEs assume a critical role in the diffusion and the nurturing of innovations – rather in their creation – and thus turn to knowledge-generating institutions for their technological needs. Of the above-mentioned three conceptual frameworks, Triple Helix and Mode 1/Mode 2 look critically at academic research institutes. In simple terms, while Triple Helix observes academic institutions to be playing a dominant role in the innovation system, the *New Production of Knowledge* (Gibbons et al, 1994) explains two distinct ways in which knowledge is produced: Mode 1 and Mode 2. In Mode 1, knowledge is observed to be generated in an autonomous university: in self-defined and self-sustained scientific disciplines and specialities, and governed by peer group scientists. In Mode 2, knowledge, particularly in science, is characterized by inter-disciplinary learning and plurality, and is no longer the prerogative of university settings alone, but is found increasingly also in many different loci, such as government laboratories, industries, and other think-tanks, and it tends to be produced in the context of application.

Although the third framework, NSI, considers firms as the key drivers of innovation, the concept has lately emphasized the significant role of universities in the systems of innovation.[9] This is evident from Lundvall (2002:9), drawing upon Nelson's (1993) observation of universities being widely cited as a critical institutional actor in NSIs, when he says that "the universities have become more directly involved in market-driven processes and more exposed to competition from other producers of knowledge…..universities now have 'a third task' with focus on their direct contribution to a more dynamic development of the business sector."

[9] In Lundvall's view (1988), the role of demand and supply, i.e. market forces, is important in determining the rate and the direction of the process of innovation, and firms are largely carriers of the innovation process.

The concept of NSI is based on the assumption that understanding the linkages among the actors involved in innovation is the key to improving technology performance.[10] The SMEs foresee their development in an ongoing quest for technological innovations, as also in the forging of linkages with the technology provider and related institutional actors of NSI. Innovation and technical progress are the result of a complex set of relationships among actors, producing, distributing, and applying various kinds of knowledge (OECD, 1997; Edquist and Hommen, 1999).

Elements Critical to NSI

The chosen crucial indicators that combine to provide a holistic picture of NSI are given below.[11] Here it is apparent that the indicators in the form of knowledge flows, cluster formation, and policies are much more vital to SMEs than the role in creating innovations which is seen to be limited, given the resource constraints.

Innovation: Though an individual measure, the production of innovations is the integral feature of NSI. Typically, input measures are concerned with expenditure on innovation whereas outputs are considered to be at least one technically new or improved product or process from a firm (OECD, 2002: A11). The innovation output indicators also include the number of Intellectual Property Rights (IPR) filed, the quantum of scientific publications, the aggregate of postgraduates and PhDs in the case of academic research institutes, and such other factors.

Knowledge Flows: The creation and the diffusion of knowledge throughout the system is required to aid in the creation of increased knowledge from the current available stock. This applies to almost all elements within the system. To analyze this will require an examination of statistics relating to R&D, human resource aspects, linkages between institutions, and the technical balance of payments.

Cluster Formation: A group of firms that has a common infrastructure for facilitating innovation, and with similar functionality for performing to compete and to succeed, is called a cluster formation. For instance, electronic clusters are differentiated from software clusters. The SMEs, in particular, are typically located in such clusters, and their performance is evaluated in numerous studies.[12]

Policies: Policy cannot be measured statistically but is nonetheless vital to estimating NSI as a process. Policies provide an insight into governmental priorities and how governments attempt to drive institutional

[10] As per Lundvall (1992), a national system of innovation is constituted by institutions and economic structures, affecting the rate and the direction of technological change in the society; it must, for example, include how new technology affects productivity and economic growth.
[11] Adapted from Golden et al (2003).
[12] See for instance, Pouder and St. John (1996); Bell and Albu (1999); Bresnahan et al. (2001).

behaviour. It is important to consider recent policy implementation that directly affects constituent elements of individual NSIs. The NSI policy has been built upon, and is still heavily dependent on, the strategy of encouraging, for example, Foreign Direct Investment (FDI). Increasing attention in promoting innovations has prompted the government to set up institutions for the transfer of knowledge from academia to industry, showing early understanding of the importance of diffusion in the innovation process.[13]

These four critical elements reportedly not only effectuate a system of innovation, but also innovate in order to survive and prosper in the rapidly changing environment.

Systems of Innovation at Other Levels of the Economy

The systemic character of innovation at other levels of the economy is evident from the literature on 'regional systems of innovation' – which has grown rapidly since the middle of the nineties (Malmberg and Maskell, 1997; Cooke, 1998) – and on 'sectoral systems of innovation' (by Franco Malerba and colleagues [Breschi and Malerba, 1997; Malerba, 2002]). As already explained, the analytical focus of regional systems of innovation is uniform with the theoretical roots of the mainstream 'innovation system' tradition (Cooke, 1998; 2002), i.e. with theories of interactive learning (Lundvall, 1992) and models of the innovation process (Dosi, 1988; Kline and Rosenberg, 1986; Von Hippel, 1988).

Early traditional literature shows how it is possible to close the performance gap through the transfer of technology and the adoption of easily available technology. Current literature on competences has moved ahead to focus on the central role of capability accumulation by domestic firms, and the need for various types of capabilities to meet success targets: absorptive capabilities, innovation capabilities, and complementary assets in order to adopt, adapt, and modify technologies developed elsewhere or eventually generate new ones (Malerba, 2006). Oyeyinka (2003) and Rasaiah (1993) also describe how firms move up the technology trajectory from initial lessons in basic technology to, later on, more complex technological capabilities before eventually participating in R&D activities. Actually, the most current research has established that any process of development and growth implies some kind of innovation, and that a series of preparatory steps in the capability-building process is necessary for development. The literature also stresses the role of social capabilities (Abramovitz, 1986) and the role of a country's major institutions, including its research infrastructure (Mazzoleni and Nelson, 2006) and financial institutions (Gerschenkron, 1962).

The extent to which SMEs can learn through interaction with the local environment is a measure of their absorptive capacity (Cohen and Levinthal, 1990), i.e. the ability to utilize both available information and the

[13] In India, the Science and Technology Policy (2003) states that "every effort will be made to achieve synergy between industry and scientific research. Autonomous Technology Transfer Organizations will be created as associate organizations of universities and national laboratories to facilitate transfer of the know-how generated to industry."

knowledge that results from interaction with users or knowledge providers. Central to building absorptive capacity is the accumulation of human capital and other providers of knowledge. Firms need to have the necessary human capital to identify, acquire, and transform the knowledge required for innovation. However, SMEs generally find it difficult to attract and retain qualified human resources, especially when the SMEs are competing with Trans-National Corporations (TNCs) – more so in developing countries.

Regional Innovation Systems are especially suited to SMEs, as their interaction takes place mainly at the local level in both developed countries (Cooke and Morgan, 1998) and developing countries (Giuliani, 2004; Giuliani and Bell, 2005). Moreover, the literature on the subject clearly observes a predominance of SMEs' relations rooted in the regional system as compared with those of large firms (Cooke and Morgan, 1998; Asheim et al, 2003) – a reason being that SMEs are more dependent on tacit knowledge and less capable of searching for and using codified knowledge. This compels them to rely more on personal ways of transferring (tacit) knowledge and on learning-by-doing and interaction. Interestingly, some scholars observe that NSI needs to be understood and analyzed as a complex of sub-systems which can be classified according to individual sectors and regions (Chung, 1996, 1999). Following the classification of the industrial sector, many sub-systems of an NSI can be formulated (see Senker, 1996; Breschi and Malerba, 1997).

The study of the regional and the local systems of innovations has gained considerable importance, since the regional and the local spaces are regarded as the milieu where agents operate and where the strategies of technological capability accumulation of firms can be given viability. This appears to be more so for SMEs, as most of these firms evolve in local environments (Cooke et al, 1997). The reality is that, within the regions and the localities, a number of networks are created between firms, clients, suppliers, universities, and other agents that play an important role in the innovation process. Often, SMEs organizationally take on the characteristics of the cluster. Within the cluster, a strong integration is observed between local institutions, service centres, training organizations, and enterprises (DELOS, 2004)[14].

The analysis of the market for innovations at the regional level shows structural imbalances between the supply and the demand for different characteristics of the innovation development. In many respects, this is connected with the special features of NSI, in which the institutes that carry out the technology transfer are insufficiently developed. Among these institutes, the small innovative companies which play a special role are the "engine" of technology transfer.

[14] Final Report, EU Fifth Framework Report on NIS.

Systems of Innovation Approach

Often, in order to enhance trust and exchange among the constituents of NSI, and in particular the different innovation actors, a systems approach is adopted and applied. Among innovation actor groups, the critical actor group of SMEs plays a key role, as national competitiveness depends heavily on industrial competitiveness. Systems of Innovation (SI) are the network of government and non-government agencies, science and technology institutes, academic institutions, and firms, including SMEs, among other organizations, among which knowledge flows and exchanges make it possible to know if they are able to influence the direction and the extent of innovation. The narrow definition of innovation, which was mentioned earlier, focuses on a country's macro-economic and industrial policies, international regulations, market governance, and socio-cultural institutions related to SMEs. The SI approach helps to elucidate how these constituents influence the network dynamism and the innovation trajectory.

The NSI approach, using the broader definition, emphasizes the importance of relations (particularly technological) that exist between firms, industry, academic research institutes, public R&D organizations, the government, and other actors in national systems. Such systems need not be defined along the lines of individual industries or be confined to sectors, region, or, for that matter, local labour markets. Rather, the sub-systems – for instance, the SME sector –, collectively as constituents, reportedly, constitute an SI for specific countries. Lundvall (1992) assumes that the differences among different nations is an outcome of the differences in historical experience, language, and culture which are reflected through internal organization forms, the role of the public sector, relationships between firms/organizations, R&D intensity, the financial sector's institutional framework, et al.

The reason behind the focus on such a systems approach is that technological innovations nowadays require substantial resources and carry a high level of risk, hindering any single innovation actor from access to their benefits. In order to appropriate technological innovation, innovation actors would need to cooperate very closely with each other, based on a strong level of trust, with governments needing to ignite and promote the trust and the interaction between the different constituents of NSI. The research on learning and technological capability accumulation in SMEs has studied the learning processes involved in the gradual build-up of a minimum basis of technological expertise which enables them to engage in innovative activities. Here, learning is evaluated as a process that involves repetition and experimentation, enabling tasks to be carried out better and faster, and new production opportunities to be identified (Lundvall and Johnson, 1994). The literature on SI suggests that the innovative activity of SMEs depends strongly on technological learning and technological capability creation processes, and that these processes are influenced by the NSI and by the type of linkages created between the agents in specific contexts.

The integral role of SMEs in the innovation system gains clarity by using the NSI approach to consider the SMEs' adoption/adaptation of technology and relevant facilitating policies. A prerequisite to such an understanding is a grasp of how bilateral/multilateral efforts, initiated by entities involved in technology transfer, promote technology cooperation and advance knowledge. It is therefore imperative to know how SMEs promote the removal of barriers to technology transfer. It is also important to ascertain if certain indicators and monitoring systems can be developed to track the progress on technology transfer.

4. BARRIERS TO TECHNOLOGY TRANSFER IN SMEs

Research has shown that the indigenous technological capabilities of developing countries are generally weak and that, in the import of technology, a number of obstacles render the technology acquisition process less effective or a failure economically and/or technically (Awny, 2005). The general problems of the SME sector, apart from capacity-building in technology as reflected in various studies, highlight the inadequacy of SMEs in legislation, business networks (particularly international), and various support services – financial, legal, and marketing. Even more pertinent is the lack of access to crucially needed venture capital for the creation of new SMEs and the continuance of existing operations. With interest rates on loans being quite high, and repayment periods relatively very short, SMEs cannot be expected to flourish. Currently, the progress of SMEs is hampered by weak infrastructure, insufficiency of electric power, and high costs of energy, water, and industrial space. The other drawbacks, such as the inability of SMEs to keep pace with the rapid development in global finance and economy, and the inadequacy of their management and organizational practice, add to their burgeoning problems. The continuance of the enterprise reform process and the strengthening of SMEs are largely dependent on aid from international agencies and foreign countries.

Typical Barriers to Technology Transfer [15]

The barriers to technology transfer that SMEs encounter vary across different sectors in different countries. However, many of the general problems can be classified under specific categories. Those problems that are typical to SMEs as recipients of technology (sink) – i.e. the problems they face within the firm –, and also those that occur at the source level from the SMEs' perspective of the technology providers (source) as problem centres may be grouped under the first category. (See below where the problems that are common to both source and sink have been listed separately.) The sources of technology for SMEs are large firms; public research institutes or R&D laboratories; and academic research institutes. The second category, based

[15] The problems noted in the table have been specified in various studies; the prominent ones are listed within parentheses alongside the corresponding constraint(s). The SME's constraints against which the sources are not listed are based on the author's understanding and experience during his MPhil/PhD study.

on the review of literature, is formed on the basis of the type of problems SMEs encounter.[16] These problems are associated primarily with the pre-acquisition stage, the post-acquisition stage, and external factors. (A summary of these categories is given in Table 4.1 at the end of this section.)

PRE-TECHNOLOGY ACQUISITION STRATEGY

Organizational and Management Aspects; Organization Preparedness

SMEs Level: The success of technology transfer depends largely on the decisions made prior to the acquisition of the technology in question. Here, planning has to take place at different levels, be it the organizational and management aspects of technology choice, or organization preparedness for the acquisition. From the organizational and management perspective, SMEs as recipients feel hindered by the lack of a formalized and institutionalized mechanism within the firm, where technology choice could be discussed comprehensively. Alternative or similar technologies are not evaluated, particularly in terms of their pricing (Voll, 1980; Godkin, 1988). SMEs admit that often they fail to be realistic, and their selection of technology is inappropriate (Godkin, 1988; Roberts and Frohman, 1978). Probing a little more into the absence of institutional mechanisms, we observe a lack of coordination among different planning entities, and their inability to reach a consensus on the criteria to be used for technology choice as also on prioritization, if more than one related technology needs to be acquired. Observations have been recorded on inadequate planning in choosing appropriate technology for adoption/adaptation at the pre-acquisition stage, laboratory scale, pilot plant, or commercially proven level – as the case may be (Desai, 1985; Kahen, 1995; Rosenberg and Frischtak, 1985; Saad et al, 2002; Ramanathan, 1994). These cover the following:

- No assessment of the number of research units that need to be engaged in the transfer process.
- No assessment of the number and the nature of employees to be involved.
- No serious consideration of the project's viability.
- No regard for the division of work into small, manageable units.
- No/limited attention to technology obsolescence.
- No study of the utilization of excess capacity and the volume of resources such as suitability/availability of local raw material.
- No training of personnel and no assessment of skill levels.

Problems also arise from the non-assessment of forward and backward linkages with the present set-up, and inappropriate mechanisms for implementing the transfer (Kotelnikov, 2008). The studies by Fagerberg (1987), Freeman (1982), and Mansfield et al (1982) also note the lack of R&D capability within SMEs for effective adoption/adaptation, or even imitation, of technologies. According to Intarakumnerd et al (2002),

[16] Though an attempt has been made to group similar problems together, problems may overlap across different categories.

only a small minority of large subsidiaries of TNCs, large domestic firms, and SMEs have the requisite capability in R&D, whereas the majority still struggle with improving their design and engineering capability.

SMEs are also impeded by the differences in the competence level of source and sink in technical knowledge, the lack of skill in the collection and the analysis of relevant data, and inadequate information on service/product mix.

A crucial issue often ignored by SME management is the lack of provision of incentive systems for learning and assimilating new technologies or the process thereof. Chen and Sun (2000) have recorded their observations on the lack of motivational policies for professionals to engage in the technology transfer process.

Source Level: SMEs, on the other hand, have witnessed at the source level too a lack of formalized and institutionalized criteria, resulting in the adoption of the monocular dimension (Moon et al, 2004). The delivery of technology and systems is too complex at the source which has already to contend with a general inability of planners or key decision-makers to extend their 'field of vision' (Godkin, 1988) as also inadequate research of the mechanisms chosen for implementing the technology transfer. SMEs too encounter problems since they observe inadequate planning in choosing appropriate technology for commercialization, even at the source level when the provider has alternative options available..Yang (2001) and Dahlman et al (1987) note that such unsound technology expertise or tacit knowledge makes it difficult for SMEs to comprehend the technology on offer.

Underestimation by the source of problems in transferring technology to a developing country setting, or overestimation of SMEs' technological capabilities, results in unrealistic expectations in meeting deadlines and targets (Awny, 2005; Lall, 1987; Bell and Pavitt, 1993; Godkin, 1988). The source's limited understanding of the sink's needs and the over-emphasis on hardware with meagre focus on soft skills (Saad et al, 2002) add to the problems. Further, the complexities in the collection and the analysis of relevant data hold true for the technology provider's domain too. SMEs often complain of the technology provider's over-dependence on a key individual or on predicted contingencies (e.g. an oil price hike) which aggravates complexities once the key person leaves or the expected emergency does not occur.

Partner Selection for Technology Choice

SMEs Level: Inadequate information about the transferor; the lack of easy access and linkages to technology transfer agencies, and to other intermediary organizations, as also to the transferor's bank references, balance sheets, and/or annual reports slow down, or at times even stall, the technology transfer process (Saji

et al, 2005). Tidd and Izumimoto (2002), Feldman et al (2002), and Bell (1984) suggest that the indecisiveness on the nature of partnerships (joint venture, strategic alliance) as also the lack of surety about the mechanisms of technology acquisition (licensing, sub-contracting, acquisition of company, imitation, foreign purchase, or informal means) often thwart the transfer of technology.

Obstacles to successful foreign affiliations are another major concern for SMEs. McNamara (2005) found that the global SMEs were adept in adjusting to international market standards, but less skilled in forging ties with local sector networks. This study highlighted the disparate leanings in Korean and Japanese manufacturing SMEs in China and Thailand, respectively, which revealed strong home country links but relatively weak ties with local host country networks.

Source Level: A similar scenario prevails at the source, where SMEs encounter inadequate information and, due to the technology provider's over-dependence on their foreign partner, unnecessary delay in decision-making.

Financial Aspects of Technology Choice

SMEs Level: The most crucial barrier for SMEs in choosing appropriate technology is the high cost of acquisiton and installation of technology (Bhalla, 1987; Contractor and Sagafi-Nejad, 1981; Saad et al, 2002; Chaudhuri, 1980). After a consensus is reached within the firm on the specific technology to meet their objectives, the market price of the chosen technology is often found to be exorbitantly high, necessitating a redraft of the SME's objectives as also a search for other sources of finance. The studies by Avnimelech and Teubal (2006), Mohan (2004), and Zucker et al (2002) reveal problems in seeking venture capital/early stage funds in the case of start-ups.[17] In a similar context, problems arise due to the lack of incubation units (Menon, 2002; Macdonald and Joseph, 2001). SMEs face considerable difficulty due to the management's poor clarity on the capital requirements, its mistiming of expenditures, and inability to carry out a financial analysis, for example, in the form of input-output ratio calculation, and related subjects. The consequences of such lapses are that the management takes expedient rather than rational decisions.

Source Level: SMEs consider that the technology offered by the transferor has a very high valuation (Godkin, 1988; Reddy and Zhao, 1990).

[17] The growth of early-stage financing for SMEs is constrained by both supply and demand factors, pointing to the need for a realignment of expectations and business models in the venture capital industry. In India, on the one hand, entrepreneurs complain about the lack of early-stage financing. On the other hand, venture capital-private equity activity had been expected to almost triple in 2006 relative to 2005. Evalueserve, a knowledge outsourcing organization in India, estimates venture capital and private equity investment at more than $6 billion in 2006. But again, most of this increase is unlikely to be for seed and early-stage funding.

POST-TECHNOLOGY ACQUISITION

SMEs Level: The small firms find it extremely difficult to accept and to implement available technology, as their employees lack the requisite education and the appropriate skills (Andersen and Lundvall, 1988; Lundvall, 2002). The lack of proper documentation and inept handling of information and people at different stages of development – be it during transfer, at the production stage, or at the post-acquisition level – lead to problems at the time of implementation. The inability of the staff involved at the pre-acquisition level to explain the procedural know-how to members at the implementation level is a major setback. The lack of face-to-face talks with key implementers, both at source and sink, and the non-involvement of competent people in the implementation and the operation of new technology cause serious bottlenecks in the delivery of technology and its operationalization (Baranson, 1967; Roberts and Frohman, 1978; Saad et al, 2002). SMEs also experience difficulty in team integration.

Another barrier to technology transfer at this stage is the problems encountered in the integration of new technology. This arises from the neglect to monitor the performance of the new technology and its synchronization with other technology interfaces. In other words, the key people involved in implementation fail to grasp the essentials of plant and machine layout, equipment positioning, repairs and troubleshooting, testing, quality control, and other operational procedures (Bell and Pavitt, 1993; Mowery and Rosenberg, 1989). Other closely related problems arise from constraints in production and conformity assessment (Preece, 1990; Bessant and Lamming, 1985; Rothwell, 1977; Saad et al, 2002), where the technology's novelty has been wrongly assessed, particularly in the absence of a comparative evaluation with other domestic or international counterparts. Further, the failure to estimate the technology's cost and pricing and to arrange working capital for smooth operations adds to the existing risks.

Another crucial problem during the post-acquisition stage is the inability of SMEs to adapt the chosen technology to local needs (Ranis, 1984; Dahlman and Valadares Fonseca, 1987, Katz, 1984; Chaudhuri, 1980). This is often due to the high cost and the poor quality of locally available materials.

Other barriers hindering the smooth transfer of technology are the highly centralized transfer and implementation process; and, often due to reasons of secrecy, the interminable delays, and sometimes even the project's termination. The case study in Manimala and Thomas (2005) of an Indian firm acquiring technology from a German source is a classic illustration of the problems cited above.

Source Level: SMEs consider that the shortage of experienced technology transfer professionals (Gaither and Naiman, 1978) and inadequate technological maturity are serious hindrances in the delivery system. And delays in the supply of supplementary materials and equipment required for speedier implementation further stymie operation targets.

The SME perspective also reflects the improper handling and the inadequate availability of technical know-how at different stages of development at the source. This may be the case at the initial documentation stage, pre-production, small-scale production, or mass production level.

Market Forces and Combating Competitiveness

SMEs Level: The failure of SMEs to conduct a professional market research deprives them of an accurate evaluation of the acquired technology's market potential (Avnimelech and Teubal, 2003; Mann, 1989). This is especially so in the case of start-ups, which are at a disadvantage because of their limited or complete absence of focus on marketing channels comprised of distributors, wholesalers, retailers, and such other entities. Motohashi (2003) observes that SMEs concentrate too much on immediate sales, and show scant attention to the importance of collating and analyzing broad-based information and formulating a long-term strategy for dealing with major fluctuations in the business environment.

In the case of combating competitiveness, the major shortcoming of SMEs is the total disregard of an assessment of suppliers and competition in their limited research efforts (Berry, 1997; Grieve, 2004).

Source Level: The study by Grieve (2004) highlights the SMEs' stance on the lack of assessment of market size, segmentation, customers, suppliers, competitors, price, etc. on the part of technology providers. SMEs feel that some effort towards such estimation needs to be carried out at the source.

SMEs allege that the technology provider is unable to outsmart competition in similar business; and that its grasp of the tactics of competition warfare is deficient (Porter, 1990).

Financial Factors

SMEs Level: A common yet crucial problem for SMEs is the high transaction cost involved and the restricted cash flow (Kotelnikov, 2008). Augmenting this financial bind is the ongoing deprivation of sufficient capital at the development stage, which is essential in the case of start-up firms. At the management level, the fault lies in poor timing of expenditures, and the neglect of a professional financial analysis and assessment of the risks entailed and the expected returns. For instance, many SMEs tend to ignore the calculation of the debt/equity ratio or the equity/capital structure; the break-even point or profitability; and the estimation of the growth potential due to the technology transaction.

Intellectual Property Rights and Other Legal Factors

SMEs Level: The most commonly stated problem of SMEs in respect of intellectual property rights (IPR) is the substantial expenditure required to file and maintain Intellectual Property (IP). The high costs involved, especially in the case of patents, are considered by SMEs to be the primary barrier to using the formal system of IPR more intensively (SME-IIP Final Benchmarking Report, 2007). The SMEs' apparent lack of interest in IP protection, the high cost of obtaining a patent, and the prospect of larger litigation costs – these factors combine to discourage SMEs from investing in patents, particularly in foreign countries (Xueyi, 2007). SMEs observe that often the absence of any assessment of the need for IP would also deter others in similar business from investing in patenting in the post-acquisition stage of the concerned technology[18] (Yang, 2001; Thursby and Thursby, 2007). This lack of a stated clause pertaining to ownership of IPR, particularly in the case of start-up firms offering technology to SMEs, leads to grave problems later on (Vohora et al, 2004). Due to resource constraints, SMEs are often unable to file IP in other countries for licensing the technologies which would result in the realization of revenue returns; Often, the alliances/tie-ups among big firms for innovation and patent strategy exclude SMEs and thereby erect an entry barrier.[19]

Source Level: The perception of SMEs is that the high cost of IP filing leads to escalation in the price of technology (Arora, 1995). SMEs also observe that the transferors do not assess the need for IP for commercialization (Aggarwal, 2000; Branstetter et al, 2005). The other drawback is the lack of clarity over ownership of the IPR title, which leads to disputes.

Government Support

SMEs Level: The limited incentives provided by the government to acquire technology place SMEs at a disadvantage. Further, governmental support in the technology transfer process is inadequate (Avnimelech and Teubal, 2003),,government approvals and certifications are impeded by long delays, and excessive interference by the government often adds to the existing problems (Jin and Zou, 2002). Some SMEs are also unaware of the regulatory norms.

Source Level: The viewpoint here is that the lack of adequate fiscal and monetary incentives in the technology transfer process (Jin and Zou, 2002) pushes up the price of the technology that the SMEs negotiate for purchase from the transferor. Similar to the problems faced by SMEs, the source is also subject to delays in getting approvals and certifications from the government, slowing down the entire technology transfer process.

[18] It has been observed that by strengthening IPRs the new rules may stimulate innovation and facilitate technology transfer (UNIDO, 2003).

[19] In large firms, IP has been found to be greatly exploited as a business strategy, which is quite different from innovation. The strategies include patent stacking, blocking, fencing and surrounding, clustering and bracketing, consolidation, blitzkreiging, blanketing and flooding, portfolio, and networking arrangements (see Macdonald, 2004).

International Agencies, Chambers of Commerce, Industry Associations

SMEs Level: SMEs often do not explore avenues for information and knowledge, be it prospective buyers/sellers, technology exhibitions/fairs, related on-line services, publications, conferences/seminars, and the patent literature and databases. At other times, problems may arise due to erroneous information from such sources. Another frustrating issue is the high service fees that some agencies charge for providing expertise to SMEs. The problem of information seepage is also not ignored when the same supporting agencies may be sharing vital technical or organization details with competitors of the SME.

Source Level: Often, no attention is paid to the supporting agencies in technology transfer.

SMEs also perceive that the technology provider's association with big supporting agencies and industry associations often hampers and/or delays the transfer process, as key decisions are taken in consultation with the latter.

Academia-Industry Partnerships

SMEs and Source Levels: The limited or complete lack of shared R&D infrastructure, which may be very cost-effective, is a constraint. The option of learning, knowledge access, and sharing is often overlooked by SMEs, depriving them of the privilege to be more forthcoming in technology transfer negotiations, as also in effective implementation post-acquisition. The same drawback applies to the technology provider who is unable to extend support to SMEs due to the lack of interaction with other knowledge production sites.

Negotiation Skills and Trust

SMEs and Source Levels: According to Baranson (1970, 1971), the inability to negotiate with the technology provider, particularly in respect of the cost of technology, as also in implementing parameters, hinders the transfer process..The lack of negotiation skills among members in the SMEs results in incompatibility in the stated objectives of source and sink. Another restraining factor is the lack of mutual trust (Jassawalla and Sashittal, 1998; Manimala and Thomas, 2005). Also, the differences in negotiation approaches and strategies lead to complexities.

Communication, Use of Information, and Communications Technology

SMEs Level: The lack of communication infrastructure and of a similar business network has been recognized as a drawback by Kotelnikov (2008) as also by SMEs. The other problems relating to

Information and Communications Technology (ICT) are the lack of reliance of SMEs on e-commerce and e-trading; insufficient resources to obtain information and to explore opportunities for technology transfer and up-to-date information about technology target markets (Kahen, 1997); and the lack of SMEs' knowledge in the application of ICT information technology in the production process. Difficulties also arise from the fact that most SMEs do not have a web presence which denies access to their profiles. Yet.another barrier is that the transfer of know-how and know-why (if applicable) is not language-specific. In a case involving transfer from Japanese source to Indian sink, the technology transfer agreement specified that all communication and know-how transfer should be in English (see Kumar and Bhat, 2001).

Source Level: SMEs experience inadequate communication and a deficient business network at the source (Berry, 1997; Rao, 2001). The lack of appropriate resources to obtain information and to explore the opportunities for technology transfer and up-to-date information on technology target markets, particularly about SMEs, is a serious impediment in the transfer process. The language barriers also inhibit effective communication between source and sink personnel. An interesting case of technology transfer from a German firm to an Indian company records that the language barrier caused significant complications (see Manimala and Thomas, 2005). The incompatibility of stated objectives with the SMEs is yet another problem at the source.

OTHER FACTORS

Safety Norms, Ecological and Environment Concerns, Sustainable Development [20]

SMEs Level: Often, SMEs ignore the established safety norms. They are not equipped to deal with environmental concerns (Carrol and Turpin, 2002) and pay scant attention to sustainable development, ignoring the importance of green technologies, even when they have an option. These drawbacks result in delays in getting government clearances and may lead the SMEs into difficult predicaments with environmentally conscious people and concerned NGOs, particularly on issues of health, education, and the environment.

Source Level: SMEs perceive that the technology providers do not follow adequate safety considerations nor do they convey the same at the time of negotiations at the pre-acquisition stage. Environmental concerns, such as the utilization of less energy, are also not addressed by the transferor.

[20] The Special Session of the General Assembly for the 5-year review of the Rio commitments in 1997 recognized the importance of technology transfer. The Report of the Secretary-General for the preparatory process of the World Summit on Sustainable Development, Implementing Agenda 21, identified technology transfer as one of the ten key areas in which progress is needed.

Locational, Cultural, and Insurance Factors

SMEs Level: Large geographical distance between source and sink not only escalates the cost of technology transfer but also obscures communication. Often, the need for successful technology choice or its implementation is facilitated by physical presence at the site for face-to-face talks.

SMEs are often at a disadvantage when they are not located in industrial clusters, and science/ technology/ entrepreneurs parks (Porter, 1990; Krishna, 2007; Saxenian, 1994, 2002). The common pool of knowledge and the space-sharing at such venues promote better business deals.

Cultural differences lead to the lack of adaptability to and understanding of the source's work culture. This problem is even more acute when the source is a foreign country whose different language is often misinterpreted. Yet another barrier is the lack of investment insurance which ensures risk coverage for the SMEs.

Source Level: Here too the wide geographical separation between source and sink escalates the cost of technology transfer. Difficulties also arise when the business mores and the work culture are unfamiliar. When the firms do not conduct any R&D of their own and rather use universities as vicarious research institutions, the development of an effective innovation system with its own 'technological culture' is highly unlikely (Lall, 2002; Schiller and Diez, 2007). Further, the diversity in language and legal provisions in different nations is yet another obstacle to technology transfer (Brown, 1985).

Common Barriers to Source and Sink

Some barriers to technology transfer are common to both source and sink, and can be classified at both the macro and the micro levels. The problems at the macro level include:

- lack of specialized centres of technology transfer, technology development, and adaptation centres as also clusters where exchanges are facilitated and are often fruitful (Freeman and Perez, 1988; King, 1984; Saad et al, 2002);
- ignoring the need for established institutions of education, and R&D, and extension centres that naturally benefit the SMEs (Freeman and Perez, 1988);
- low investment by the private sector;
- inadequate supportive infrastructure for finance, including venture capital/angel investments; neglect of a dynamic financial development system (Sharif and Ramanathan, 1995; Saltzman and Duggal, 1995);

- insufficient mechanisms for IP protection, including its examination (Aggarwal, 2000; Tihanyi and Roath, 2002);
- absence of a healthy economy and sound climate for innovation wherein problems are related to government monopolies, trade liberalization policies, uncertain tax environment, and ineffective legislations and incentives such as tax holidays, tariff adjustments, and so on (Freeman, 1988; Rosenberg, 1976; Malairaja and Zawdie, 2004; Krugman, 1979; Premus and Jain, 2005; Ranis, 1984; Tihanvi and Roath, 2002; Tambunnan, 2007);
- policy-related problems in respect of FDI in many countries; restrictions in foreign exchange (Fan, 1991; Findlay, 1978; Chaudhuri, 1980).

At the micro level, the problems in general are:

- extremely low science intensity of domestic production;
- actual and perceived risks arising from the higher failure rates of innovative SMEs, and unproven products and business models;
- long lead-times for projects and methodologies which include bureaucratic delays in getting approvals and clearances for finalizing technology transfer agreements;
- high dependency of domestic SMEs on foreign suppliers and on imports (Fontes, 2001; Katz, 1984; Parthasarathi, 1987; Pang and Hill, 1991; Stewart, 1992);
- difficulty in matching buying and selling interests, both source and sink attempting to achieve results in an unrealistically short period of time (Mann, 1989; Tidd and Izumimoto, 2002).

The inventory of problems in transferring technology which has been covered in our study thus far is summarized in Table 4.1 below.

Table 4. 1 Typical barriers to technology transfer

BARRIERS TO TECHNOLOGY TRANSFER FROM THE VIEWPOINT OF SMEs		
	SOURCE (LARGE FIRMS; PUBLIC RESEARCH INSTITUTES OR R&D LABS; ACADEMIC RESEARCH INSTITUTES)	SINK (SMALL AND MEDIUM ENTERPRISES)
STRATEGIC FOCUS		
ORGANIZATIONAL AND MANAGEMENT ASPECTS PLANNING: TECHNOLOGY CHOICE, ORGANIZATION PREPAREDNESS	Absence of formalized and institutionalized criteria, resulting in monocular dimension being adopted	Absence of formalized and institutionalized criteria Being unrealistic
		High price of technology; lack of

		evaluation of alternative technologies in terms of price
	Complex delivery of technology and systems	Inappropriate selection of technology
	Inability of planners or key decision- makers to extend their 'field of vision' Mechanisms chosen for implementing the transfer not suitably discussed initially	Lack of coordination by different planning entities and their inability to reach a consensus on the criteria to be used for technology choice and on prioritization Non-assessment of forward and backward linkages with present set-up; inappropriate mechanisms for implementing the transfer
		Lack of R&D capability within the SMEs for effective adoption/adaptation or imitation
	Inadequate planning in choosing appropriate technology for commercialization; unsound technology expertise or tacit knowledge Underestimation by the source of problems in transferring technology to a developing country setting or overestimation of the technological capabilities of sink, resulting in unrealistic expectations on meeting deadlines and targets Limited understanding of the needs of the sink; much emphasis placed on hardware and scant focus on soft skills	Inadequate planning in choosing appropriate technology for adoption/ adaptation to laboratory scale, pilot plant, or commercially proven level. Limited/no consideration of: • number of research units to be engaged in transfer process • number and nature of employees to be involved • project viability • splitting of the work into small manageable units • technology obsolescence • utilization of excess capacity • volume of resources; suitability to availability of local raw material • training of personnel and assessing skill levels Differences in competence level of source and sink in: • technical knowledge • overall economic environment
	Problems in collection and analysis of relevant data	Lack of skill in collection and analysis of relevant data Lack of information on service/product mix
	Over-dependence on any key individual or on predicted event (e.g. oil price hike)	Transfer and implementation highly centralized. Reasons of secrecy often cause long delays and sometimes termination of project
		Absence of incentive systems for learning and assimilating new technologies or process thereof Lack of motivational policies
FINANCIAL ASPECT OF TECHNOLOGY CHOICE	High valuation of offered technology	High cost of buying and installation of technology

		Lack of management ability in understanding: • capital requirements • timing the expenditure • input-output ratio calculation • making expedient rather than rational decisions
		Problems in seeking venture capital/early stage funds in case of start-ups;[21] lack of incubation units and related problems
PARTNER SELECTION FOR TECHNOLOGY CHOICE	Low company transparency; high dependence on foreign partner, leading to delay in decision-making	Inadequate information about transferor; lack of approach and linkages to technology transfer agencies; other intermediary organizations or bank references; balance sheets/annual reports
		Indecisiveness about nature of partnership: joint venture, strategic alliance, etc.; unsure about mechanisms of technology acquisition: licensing, sub-contracting, acquisition, imitation, or informal means
POST-TECHNOLOGY ACQUISITION	Inability to explain the know-how Shortage of experienced technology transfer professionals	Difficulty in accepting and implementing technology due to lack of education and appropriate skills Non-involvement of competent people in implementation and operation of new technology Lack of face-to-face talks with key implementers Problems in team integration
	Insufficient level of technological maturity Delays in supply of supplementary materials and equipment required for speedier implementation	Problem in technology delivery and its operation Problems of integration of new technology; • Non-monitoring performance of technology and its synchronization with other technology interfaces • Lack of familiarity with plant and machine layout, equipment positioning, repairs and troubleshooting, quality control, etc. operational procedures
		Inability to adapt technology to local needs (high cost and poor quality of locally available materials)
	Inability to locate advanced	Production and conformity assessment

[21] The growth of early-stage financing for SMEs is constrained by both supply and demand factors, pointing to the need for a realignment of expectations and business models in the venture capital industry. In India, on the one hand, entrepreneurs complain about the lack of early-stage financing. On the other hand, venture capital-private equity activity had been expected to almost triple in 2006 relative to 2005. Evalueserve, a knowledge outsourcing organization in India, estimates venture capital and private equity investment at more than $6billion in 2006. But again, most of this increase is unlikely to be for seed and early-stage funding.

	technology elsewhere, which might resolve issues on the acquired technology's failure at implementation	constraints: • Level of novelty (compared with other domestic or international counterparts) • Lack of cost and price estimation after technology has arrived • Problems in area of implementation
	Improper handling and availability of technical know-how at different stages of development: initial documentation, pre-production, small scale, or mass production	Lack of proper documentation and handling of information and people at different stages of development: initial discussion, pre-transfer, during transfer, production stage, and post transfer.
		Problems in planning working capital for smooth operations
MARKET FORCES	Lack of assessment of market size, segmentation, customers, suppliers, competitors, price, etc.	Improper market research resulting in inability to correctly evaluate market potential of acquired technology
		No/limited focus on marketing channels: distributors, wholesalers
		No/limited focus on building office, marketing, and selling plan, particularly in the case of start-ups
COMBATING COMPETITIVENESS	Unable to outsmart competition in similar business; limited learning the tactics of competition warfare	Assessment of suppliers and competition often ignored in limited research efforts
FINANCIAL FACTORS	Limited financial support in form of pay-up in easy instalments or easing terms of payments	Insufficient capital in development stages, which is even severe in case of start-ups. High transaction cost, restricted cash flow
		Poor timing of expenditures
		Lack of analysis in assessing risk and returns: debt/equity ratio, equity/capital structure; in assessing profitability, break-even point, and/or growth estimates
INTELLECTUAL PROPERTY (IP), OTHER LEGAL FACTORS[22]	Transferors do not assess need for IP for commercialization	Often there is no assessment of need for IP which would prevent others in similar business post-acquisition of technology
	Lack of clarity over ownership of IPR title leads to disputes	Lack of stated clause pertaining to ownership of IP, particularly in case of start-up firms offering technology to SMEs, leads to grave problems later on
		Often non-filing of IP in other countries to license technologies results in non-realization of revenue returns

[22] One cannot generalize the problems as IP varies from industry to industry.

	High cost of IP filing leads to high price of technology	Substantial expenditure is required to file and maintain IP
		Often alliances/tie-ups among big firms for innovation and patent strategy exclude SMEs which act as entry barrier.
GOVERNMENT SUPPORT	Lack of adequate fiscal and monetary incentives in technology transfer process	Limited incentives by government to buy technology; inadequate support in technology transfer process
	Delays in getting approvals and certifications	Long delays in getting government approvals and certifications
		Excessive interference by government often adds to problems
	Lack of knowledge on regulatory provisions	SMEs are not aware of regulatory norms
INTERNATIONAL AGENCIES: APCTT, UNIDO/CHAMBERS OF COMMERCE, INDUSTRY ASSOCIATIONS	Often no attention is paid towards supporting agencies in technology transfer	Avenues are not explored: • Prospective buyers/sellers • Technology exhibitions/fairs • Online services • Publications • Patent literature and databases • Conferences/seminars
ACADEMIA-INDUSTRY PARTNERSHIPS		Limited or no shared R&D infrastructure that may be very cost–effective
NEGOTIATION SKILLS AND TRUST	Lack of negotiation skills	Inability to negotiate with technology provider, particularly on cost of technology as also in implementing parameters Incompatibility in stated objectives of source and sink
	Lack of mutual trust	Lack of mutual trust
COMMUNICATION AND USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)	No proper communication and business network Incompatibility of stated objectives	Lack of communication infrastructure and similar business network Differences in negotiation approaches and strategies
	Lack of appropriate resources to obtain information and to explore opportunities for technology transfer and up-to-date information about technology target markets, particularly about SMEs	• Lack of confidence of SMEs in e-commerce and e-trading • Most SMEs don't have web presence so access to their profiles is unavailable • Lack of resources to obtain information and to explore opportunities for technology transfer and up-to-date information on target markets • Lack of SMEs' knowledge on use of ICT in production process
	Language barriers that inhibit effective communication between source and sink personnel	Transfer of know-how and know-why (if applicable) is not stated to be in which language
OTHER FACTORS		

SAFETY NORMS	Inadequate safety considerations	Often ignore safety norms
ECOLOGICAL & ENVIRONMENTAL CONCERNS SUSTAINABLE DEVELOPMENT	Environmental concerns are not addressed by transferor, e.g. use of less energy	Not equipped to deal with environmental concerns Lack of environmental concern, especially on green technologies, even if one has an option
LOCATIONAL FACTORS	Cost escalates due to larger geographical distance between source and sink	Often disadvantageous when not located in industrial clusters, science/technology/ entrepreneur park
CULTURAL FACTORS	Differences in business and work culture. Differences in language, legal provisions in different nations	Lack of adaptability and understanding of working culture of source. Serious drawback when source is foreign country and language is different
INSURANCE		Lack of investment insurance

APCTT: Asian and Pacific Centre for Transfer of Technology; UNIDO: United Nations Industrial Development Organisation; IP: Intellectual Property; ICT: Information and Communications Technology

5. STRENGTHENING TECHNOLOGY TRANSFER IN SMEs

Successful technology transfer depends heavily on the capability of the developing countries to successfully acquire, implement, and diffuse the selected technologies. Specific initiatives and programmes focus on strengthening technology transfer activities so as to minimize impediments in the process. For instance, the UNIDO initiative combines national technology needs assessments (TNAs) with a process for exploring national and sectoral priorities for building capabilities to acquire modern technologies. The TNA covers areas such as policy institutions, research and technology organizations, the links between government and firms, and the effectiveness of national technology strategies and technology development programmes.[23] Based on the systems approach, the NSI constituents that relate to the specific functionalities and associated constraints are identified. These are then made viable for nurturing innovations and strengthening the technology transfer process. With our discussion on NSI in section 4 and the inventory of barriers summarized in Table 4.1 as the basis, we now proceed to formulate the strengthening measures that need to be considered from the viewpoint of SMEs.

Strategic Focus at Organizational Level

SMEs need to establish their own infrastructure for meeting their organizational needs. This infrastructure should include training cells, and centres of learning which instil, at the least, an awareness of how the specific job know-how and competence are transmitted/diffused. This aspect is reflected in an international

[23] Source: UNIDO, 2002.

survey of global manufacturing companies by McKinsey and Company – as cited in Martin (2002)[24] – which identifies key organizational changes that are essential for maintaining pre-eminence in the SME's individual field of operation. These changes include international benchmarking, job redesign, job rotation in product development, teamwork in product development with suppliers, and co-location of product development staff.

Further evaluation and reassessment exercises of the acquired technology need to be carried out to help SMEs in assessing parameters such as the cost/benefit ratio in the learning process. According to McNamara (2005), who develops his arguments on the basis of case studies conducted in Korea, Japan, and China, the creation of a 'learning environment' among SMEs in the region provides a solution, promoting a continual process of integrating local craft with global standards. Conti (2002:33) also observes that a local system is one that makes it possible to link transferable knowledge to manufacturing while adapting the expertise to the local context. SMEs need a coherent organizational learning strategy to handle crisis – one that encourages a more participative style of collective learning. Cogent lessons may be learnt from Tambunnan (2007), who explores the SMEs in Indonesia under the impact of trade liberalization and suggests investment liberalization for the local SMEs to enable them to merge with the global production network. It is recommended that, at the local level, coordination between local governments and clusters of SMEs needs to be improved significantly. This is also in agreement with the study by Porter (1998:88) where he notes that local engagement permits access to important resources and relevant information.

Vital inputs to the SMEs' absorptive capacity are adequate managerial, organizational, and technical skills. Here, the negotiation skills for key personnel involved in the exchanges are extremely crucial. Support for cluster development also deserves close attention. This should be in addition to the government initiatives.[25] SMEs could exploit their vertical and horizontal linkages: they may absorb knowledge from vertical links with larger, more competitive firms and from horizontal links with enterprises facing similar challenges.

Carrying out technology and market research, dividing the project into small units, making an effort to build teams, effectively coordinating the different stages of the process, and overseeing the integration of acquired technology into the existing system would help SMEs in successfully completing the project in time. Many of the afore-mentioned positive influences are described in the successful case of technology transfer in information technology covered by Manimala and Thomas (2005).

[24] The report is by Kluge, J., Stein, W., and Licht, 2001. Knowledge Unplugged: The McKinsey and Company Global Survey on Knowledge Management, Basingstoke; Palgrave.

[25] Although the government has a wide range of policies and programmes to promote technology absorption by smaller enterprises, the Ministry of Science and Technology and the Ministry of Small Scale Industries have to conduct more analyses on how effective these have been.

Provision of an incentive system, proper documentation, exposure through trade fairs/exhibitions, and careful observation of safety, environment, and energy norms, and such other factors further reinforce the SMEs' capability in the technology transfer process. The industry report on climate change by Bernstein (2007) states that while regulations are moving large industrial enterprises towards the use of environmentally sound technology, SMEs may not have the economic or technical capacity to install the necessary control equipment (Chaudhuri and Gupta, 2003), or they may be slower to innovate (Swamidass, 2003).

In countries like Bangladesh, where SMEs progress on their own initiative, compliance with quality assurance and environment friendly standards through the adoption of tools such as total quality management and ISO 9000, and the necessary training for practising these are among the measures that are vital for their success (Mintoo, 2004).

Communications and ICT Support Level

SMEs need to prepare systems of information and ensure organizational support to encourage the development and the transfer of competence. A crucial area that needs their attention is the strengthening of knowledge-upgrading initiatives, including technology hardware support and softer organizational capabilities. To illustrate the point, we draw attention to the negligible number of SMEs in Thailand that are using ICT. The SMEs here are unable to compete in low-end, lower-labour cost markets such as China and Vietnam and, at the same time, they lag way behind the high-end, high product-quality markets such as Italy, South Korea, and Taiwan. Thus, according to Mephokee (2006), a nurturing interest in the adoption of IT will expedite the establishment of essential services such as on-line databases and electronic marketplace systems, the promotion of on-line learning, and the formation of an e-enablement service team for SMEs. Tanabe and Watanabe (2003) also show that the dramatic advance in IT has spurred the SMEs to a strong competitive position; and they attribute the excellent performances of certain SMEs in Japan to the business strategies of optimum utilization of external technology information.

Financial Support

Apart from governmental support, SMEs need to expand their network to seek support from the financial sector: bankers, financiers, including domestic and foreign investors, venture capitalists, and angel investors. At the intra-organizational level, cost-cutting measures need to be adopted – a requirement that is superfluous if financial planning is undertaken in advance, and reassessment is carried out at periodic intervals of the technology transfer process.

As per the UNCTAD (2004) report, the case of the Swiss Organization For Facilitating Investments (SOFI) illustrates the importance of the provision of information, business planning, and funding to SMEs and of the role SMEs should play in international technology transfer. The study also lists a few active organizations providing venture capital, for instance, *Aureos Capital Fund* which supports primarily SMEs in developing countries with or without partners in developed countries. Also, a significant number of spin-offs have emerged from several IITs in India where venture capitalists and angel investors have made an impact. SMEs need to explore the numerous government programmes that aim to support new and existing ventures financially, for instance, in India the initiatives by Technology Information, Forecasting and Assessment Council, Technology Development Board, and Technopreneur Promotion Programme, while organizations such as the National Research Development Corporation facilitate technology transfers. Similarly, in the Philippines, the SME Unified Lending Opportunities for National Growth (SULONG) is geared towards expanding the enterprise base by providing access to capital (Leano, 2004).

Intellectual Property Management and Legal Support

The Centre, or a new patent management set-up managed as a public-private partnership, could provide practical strategic and basic IP advice to firms, especially SMEs and grassroots innovators, in optimizing their patent strategies for innovations. This would include analyses of patenting benefits in relation to expenses as well as suggestions on timing and location of patent filings, alternatives to patenting, etc.

The case study from Japan cited in the final benchmarking report (SME-IIP Report, 2007) records that the skills required for an ideal IPR expert involve technical, legal, and business know-how. It is hardly conceivable that the majority of SMEs will be able to marshal staff that will measure up either in quality or in the required numbers. A similar problem is elucidated in the case of China's Zhongguancun Science Park (ZGC) where, due to the lack of institutional mechanisms for IPR protection, firms have not been actively engaged in patenting and technology transactions (Zhou, 2004).[26] It is hoped, as far as the SME dimension is concerned, that through appropriating the IP of academic research, the start-up activities (spin-offs) as well as out-licensing to existing SMEs will increase.

The SME-IIP Report (2007) states that, in terms of support aimed directly at SMEs in Japan, a number of institutions have been pegged for implementing the national IP strategy. Noteworthy examples are a national centre for IP training and the Japanese Patent Office's large portfolio of services. This report also suggests that the scale of efforts for establishing IP and IPR knowledge in the Japanese economy – and especially with SMEs – seems to eclipse that of other countries scrutinized. The report further claims that IPR is not tackled by a limited set of single support services but by a plethora of measures from different institutions,

[26] ZGC Science Park is the largest Science Park among the 53 National Science Parks in China where the vast majority of members are SMEs (Zhou, 2004).

coordinated by a country-wide IPR strategy. If measures targeting the educational sector or the general public are also added to this scenario, evidence of a strong driving force behind the fostering of an IP culture becomes apparent.

The other lesson that needs to be learnt is that when SMEs need to commercialize, they would require the support of large companies with substantial resources and marketing capabilities. The possession of IP would enable the SMEs to license their inventions on commercial terms to large corporations and thereby earn significant returns (Nair, 2006).

Supporting Agencies and Government Linkages

SMEs must explore their association with academic institutions, research laboratories, and large private firms to help ensure that the knowledge provided to them and in clusters is constantly updated, that it reflects international best practices, and is as market-driven as possible. This can be possible through public-private partnerships. In their association with academia, joint training programmes, which may include courses such as small business administration programmes for SMEs, would help in ensuring that curricula in academia reflect market needs.

The government needs to be approached by SMEs to provide matching grants for technology absorption as well as addressing constraints to other financial factors such as improving credit information on SMEs, strengthening collateral registries, and facilitating leasing. SMEs and individual entrepreneurs may urge the government to consider reducing domestic filing fees by subsidizing them on a need basis.

McNamara (2005) also elucidates that by recognizing the problem of weak local ties among SMEs, Japanese and Korean trade promotion organizations have initiated various new efforts to foster better local roots in East Asia. The study by Mephokee (2006) indicates that the government needs to build a nurturing environment for the development of SMEs, such that they are able to secure governmental procurement opportunities and are ensured that their legal rights are protected. The action plan could include the selection of SME attorneys to ensure fair treatment under a legal system.

In the context of foreign investments, the study by Tambunnan (2007) draws attention to the importance of FDI companies, as their presence gives more opportunities of backward linkages through subcontracting to local companies, thereby helping the locals to upgrade their technological capabilities and ultimately improve their performance.

The services of agencies, particularly those involved in technology transfer and innovation activities (for instance, APCTT, chambers of commerce, industry associations) need to be availed of by SMEs. This would

benefit the SMEs not only in saving on resources, but also because such association leads to collaborative activities and knowledge advancement which is extremely useful for progress in a competitive world. The study by Kotelnikov (2008) shows that SMEs seek advice and also obtain price quotes from supporting agencies in trying to find out the exact costs and the benefits of implementing ICT.

6. CONCLUDING REMARKS AND RECOMMENDATIONS

That the SME contribution to the development of a nation's economy is significant is evident in terms of SMEs being the largest constituent sector in the production system in their capacity for generating employment and building and sustaining an entrepreneurial environment. SMEs also have an aptitude for innovation, creativity, and flexibility, enabling them to respond with more alacrity to structural changes and to adapt quickly to the dynamic demand patterns of consumers and customers.

The future of technology transfer depends on suitable capacity being created and institutional arrangements being established for the successful implementation of beneficial policies. For such a positive outcome, SMEs need to understand and value the integral place they occupy in the systems of innovation by taking appropriate measures to establish healthy linkages with other constituents of the national innovation system (see section 3). Among the constituents of the NSI, SMEs play a critical role since national competitiveness depends heavily on industrial competitiveness. To know how these constituents influence the network dynamism and innovation trajectory, one may use the narrow definition of innovation, which includes organizations and institutions directly related to searching and exploring technological innovations, and the web of related policies focusing on a country's macro-economic and industrial policies, international regulations, market governance, and socio-cultural institutions related to SMEs.

A crucial measure in capacity-building for SMEs is the nurturing of their technological capability. Given the resource constraints, SMEs need to specifically look at sources to meet their technological needs, and continuously be innovative so as to sustain themselves in the current competitive environment. The learning process can be enriched by considering the strengths, weaknesses, opportunities, and threats associated with SMEs and the process of technology transfer (see Case Studies in the Appendix: Case 1 considers the factors that lead to failure while Case 2 elucidates the pointers to success). However, these small firms encounter several barriers in the technology acquisition process, some of which can be erased by taking remedial measures within the organization whereas others need to be overcome externally. While we have discussed the typical problems that SMEs face, based on an extensive review of literature which focuses on the numerous constraints involved in technology transfer and how to overcome them (see section 4.and Table 4.1), we have also described (in section 5) the measures that need to be taken to make the technology transfer process more effective.

The barriers to technology transfer are dissimilar in different member countries in the Asian and Pacific region. An immediate and useful way to know and assess the specific barriers to technology transfer that SMEs face is to conduct a survey that can be administered by the APCTT focal points in the member countries. The assistance of chambers of commerce and other industry associations may help in expediting the process. This survey could take the form of a questionnaire (see Appendix), which may be given to select SMEs in the respective member countries, using the sampling procedure. The questionnaire has been designed to learn more about the SMEs in the member countries, their knowledge base, their interaction with supporting agencies, and the typical barriers to technology transfers. The survey is also formulated to map knowledge transfer in SMEs, which would review the existing practices in knowledge transfer, both vertically with larger firms, academic research institutions, and public research organizations and horizontally among networks of SMEs. Here, training and relevant education systems and strategies would also be reviewed, as well as practices of knowledge transfer in different sectors.

The responses may help to clarify the complexities in the technology transfer process as well as facilitate a comprehensive analysis of the barriers to technology transfer as these affect SMEs. This crucial exercise would give a valuable basis for taking policy decisions by the government and supporting agencies as well as by the SME management in dealing with the existing problems they face during the technology transfer process.

By listing the typical barriers to technology transfer at all levels, this paper provides a valuable research reference and basic documentary support to policy-makers interested in the development of knowledge infrastructure in countries/clusters, and thereby facilitates understanding of the creation of suitable conditions for the progress of SMEs in the transfer of technology. The paper also suggests that the place of SMEs as an integral constituent of NSI needs to be emphasized and looked upon as a significant contributor to overall economic and social development.

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APPENDIX

CASE STUDIES

The two cases discussed here relate the effects of the barriers in the technology transfer process to their success and/or their failure. The first case lists the problems that could not be resolved or adequately addressed, resulting in the ultimate failure of the technologies commercially. In the second case, the technology transfer process benefitted the recipient, as most of the problematic aspects were adequately addressed by both the source and the sink. In each case study, the section on the inferences drawn and the lessons learnt attempts to link the barriers (those listed in Table 4.1) with the problems encountered – though not comprehensively.

CASE 1: Medicine Storage Devices: FITT office at IIT-Delhi[27]

Technologies for the following five products were developed at the Centre for Biomedical and Engineering (CBME) at the IIT-Delhi:

(1) Vaccine carrier: capacity 1-1.5 litres
(2) Portable refrigerator; capacity 7-10 litres
(3) Blood storage unit; capacity 40 litres
(4) Deep freeze; capacity 7-10 litres.
(5) Water cooler : cooling chamber capacity 40 litres

The firm to which these technologies were assigned specializes in air-conditioning, including the making of moulds and dyes for various applications – air-conditioners, speedometers, fans, etc. The company manufactures and sells its own air-conditioning equipment in the commercial market all over India, especially in the north, and has offices in different parts of the country, including Delhi, Maharashtra, Tamil Nadu, Punjab, and Rajasthan. The entrepreneur, although not a technical graduate, has 35 years of experience in the air-conditioning business, and heads a group of small companies, which also manufactures security systems. The group's annual turnover has been Rs. 150-200 million in the last few years.

Of the five technologies under consideration, the one for the water cooler was on non-exclusive terms. Two technologies, namely, those for the vaccine carrier and the portable refrigerator, were transferred to the firm on an exclusive basis for a period of five years, and also had a royalty clause specifying payment to the Technology Transfer Office (TTO) at 3% of the sales, post-commercialization of the products. However, the

[27] Adapted from Chandra (2003).

outcome was that none of the technologies under consideration was fully commercialized; and the two technologies that were transferred were not developed beyond the prototype stage.

Case Background

After the entrepreneur had visited IIT-Delhi informally for first-hand information on the institute's technological research, he was approached by a TTO executive for initial inquiries. Their one-on-one discussions developed favourably, culminating in a mutually satisfactory technology transfer agreement for the licensing of a complete package of technology for the five above-mentioned products. The signed agreement stated that, for each of the products manufactured, specifications of individual components/items would be provided with a schematic plan, a circuit diagram, and two prototypes. The successful functioning of the prototypes was meant to ensure the maintenance/control of the temperature in the cooling chamber (of the vaccine carrier, portable refrigerator, deep freeze, and blood bag storage unit) at a given range, with slight variations, for the storage of polio vaccines or a selected load of eatables or blood bags, as the case may be. Such functioning was required to be demonstrated at the premises of IIT-Delhi to the firm's representatives, for a given period, as specified in the agreement.

The firm had agreed to manufacture certain components such as the outer casing, cooling chamber, water cabinet, and insulation chamber, as deemed fit by the inventor, and also to meet the cost of development of two units of each product. The development of technology at CBME, IIT-Delhi, also required an imported component, which was acquired and, finally, the prototypes of both the products (1 and 2) were developed. The demonstration was conducted, and the technology was transferred. Progress in the development of prototypes for the remaining three products[28] was fraught with problems due to defaults in payments.

A similar technology, based on a thermoelectric device, was transferred to another Delhi- based firm at a higher price, but was also not commercially successful. According to the entrepreneur and CEO of this firm, the product – a water cooler – required an imported thermoelectric device, which could not be procured after the sanctions imposed in 1998 (subsequent to the nuclear tests conducted at Pokharan) restricted imports on the grounds of these components being used for National Defence Applications.[29] The prototype demonstration, according to the entrepreneur, was an eye-wash as he had no details of the technology, and the sample shown was not delivered. The designs and the specification details of the components were also not satisfactorily given/explained.

[28] The prototype for the water cooler had been developed and a demonstration given.

[29] Although the component was later available in India, the firm had not probed this aspect.

Firm's Opinion

Technology 1 for the vaccine carrier and technology 2 for the portable refrigerator

- Both the technologies were widely known and both the products were available on the commercial market as against claims to the contrary made by TTO executive(s) and the inventor.
- The products on the market were superior, be it in terms of performance, design, aesthetics, and affordable price.
- The prototype that was developed and delivered was unsuitable for mass production for the following reasons:
  * It was too heavy to qualify as a portable device.
  * The design itself was not aesthetically appealing to attract the customer market.
  * The vaccine carrier box, which would ultimately hold the vaccines, was too small.
  * The prototype developed had a separate tank for water (for cooling purposes) which made it even heavier (approximately 20 kg).
  * The prototype for the portable refrigerator had an aluminium chamber inside, making the storage compartment unattractive as compared with the competitor's products which were made of light fibre material.

The entrepreneur's major concern was that even if the technology could be satisfactorily developed, it lacked a market for its sale, as similar and better imported products, mostly from Taiwan, were available on the market. The temperature range of these superior products was higher (from -5° to 60°) as against IIT's technology which could attain only -5° to 30°; and their design was such that it attracted the customer at first sight, as claimed by the entrepreneur. The inventor had already filed the patent for all the technologies, but this did not count with the entrepreneur, who regarded the entire technology transfer agreement as a breach of trust. The entrepreneur alleged that he had not raised objections at the time of transfer as he had no reason to disbelieve the claims of the TTO and IIT-Delhi and their commitments in respect of the technologies.

TTO's Opinion

Two technologies were transferred, and the prototype of the third technology (the water cooler) was demonstrated only after a long period of time. The TTO was dissatisfied on several grounds: lack of interaction between the two entities despite constant correspondence from the TTO; failure to build the prototype as per the inventor's specifications, as mentioned in the agreement; and the entrepreneur's limited knowledge about the technologies that were transferred. The TTO also claimed that had the entrepreneur the will to develop the technologies further, nothing could have deterred the commercial success of their transfer

or the products thereof; and that if the entrepreneur had encountered problems with any aspect, including the design, he could have approached the inventor and/or TTO, but failed to do so.

The fact that all the five technologies earmarked for transfer were based on the same principle of incorporating a thermoelectric device as a necessary component, it might just be possible that since the firm already had the technological know-how of two technologies, the remaining three technologies elicited no special interest, as the products could be developed based on the know-how already transferred.

Inventor's Opinion

"The firm did not move ahead." This was the inventor's first response. It was his contention that, although the complete technological know-how had been given to the firm in question and the prototype satisfactorily demonstrated, the entrepreneur failed to develop the technology further. He alleged that the problems encountered could have been resolved in consultation with IIT-Delhi, as the firm itself had the requisite facilities for the project. The prototype was developed entirely at the CBME laboratory, and the Instrument Design and Development Centre (IDDC) had not been involved.

The inventor traced the main problem to industry's unreal expectations of smooth functioning and operations of a new technology immediately after its transfer, which is not the case – except in a few instances. In his opinion, the onus after the transfer lies more with the entrepreneur, and the development of the new technology depends largely on the firm's competence and involvement rather than on the inventor, as academic research institutes have their limitations.

Inferences Drawn and Lessons Learnt

Though the technology at the time of transfer was novel in India, and the products had a ready market, the prototype that was developed presented problems – not with the technology per se, but rather with the prototype design and the development skills. The specifications were such that the portability feature was defeated. The dimensions of both the portable refrigerator and the vaccine carrier could have been modified to make the device more handy and appealing. These modifications could have been carried out before the demonstration – an exercise in which the expertise of IDDC at IIT would have been an asset. The TTO also should have made efforts to coordinate with IDDC and the inventor when it became apparent that the feasibility study and the need assessment were not up to par, and that the quantification of the transfer objectives – that is, the results expected at different phases of the project – had not been carried out. (In Table 4.1, the barriers in the post-acquisition stage reflect the stated problem.)

At the same time, if the entrepreneur had found the prototype imperfect, he could have expressed his dissatisfaction at the time of demonstration; and for any deficiencies in its design and functioning, he could have contacted the inventor or the TTO to resolve the difficulty. Even though the novelty of the technology, the large market potential as assessed by the TTO executive, and the unrivalled functional aspects are all subject to official inquiry, a series of problems were encountered. The absence of mutual trust had been a major reason for the ultimate failure; and an even more important contributing factor to the dismal end was the neglect of a system of regular communication. As noted in Table 4.1, a crucial constraint is the omission of well-ordered, regular meetings to discuss and address problems at every stage of the transfer process.

In this particular case, the firm was seriously impeded in the normal process of scaling up from prototype to mass scale production when its progress came to a standstill after demonstration at the laboratory scale. Although the firm had the capability to scale up in terms of further designing, it got wedged between the complexities of technology development and the spate of similar imported products at a cheaper price. Further, the failure to file the IPR for the technology rendered implementation ineffectual, as no claim was made by either the source or the sink.

Based on the record of the technology's commercialization process, it is evident that the problem was rooted at the project's very inception when the assessment of crucial parameters, which should have been thorough, was just cursory (see Table 4.1: problems pertaining to strategic factors). This might have been the outcome of inadequate research on the assessment of the market potential, the threat of competitors entering the market, the possible product design, and related issues. Of the many shortcomings, the design and the development emerged as the most deficient, necessitating a reassessment after the demonstration of the prototype underscored the fact that important parameters had fallen short of expectations. With the entrepreneur opting for centralized decision-making rather than a result-oriented, dedicated team, job assessment had been sketchy. Moreover, the work portfolio of five technologies needed to be separated into smaller units, specifying the expected technical and functional benchmarks (see post-acquisition barriers in Table 4.1). Finally, but not the least disadvantageous, was the technology obsolescence which was the inevitable outcome of long delays in taking decisions.

CASE 2: The Glass Industry in Firozabad: From the MSME Report [30]

The dusty town of Firozabad in the northern state of Uttar Pradesh is famous for its bangles. It has the world's largest concentration of workers in the glass industry: almost a hundred thousand people. But the industry faces several handicaps: a high percentage of wastage through breakage and/or rejections; gross misuse of resources; and sub-standard working conditions.

[30] MSME: Micro, Small and Medium Enterprises. The case study has been adapted from: Clustering for Progress: The Road Travelled and the Way Ahead, pp.32-33. Source: http://www.msmefoundation.org/ folder/Publication/47.pdf

Traditional technology reigns supreme, and the occupants of these clusters are reluctant to change their age-old ways. However, progressive thinkers who aimed for improvement worked to transform the status quo. The UPTECH team who studied the region found the pollution levels way beyond the permissible limits prescribed within the Taj Trapezium, a geographical area with special environment pollution limits.[31] Moreover, air pollution, both inside and outside the area, was aggravated by the extreme temperatures prevalent in the workplace. High fuel costs and the melting pot's limited and uncertain life were the other drawbacks. These several constraints kept the product quality well below international standards.

The three most pressing problems that had to be addressed were:

- The pots used in the coal-fired furnaces had an uncertain life, varying from a couple of days to a month, causing wastage of material, time, and funds. External technical assistance was sought, the problem was analyzed, and the causes were ascertained. An improved pot mix was then developed, and new systems for drying pots, under controlled conditions and pre-heating the pot in a scientific manner, were introduced. The result was that the average life of the pots increased by 35-40 melting cycles per pot.

- Coal-fired pot furnaces, the most favoured for glass melting, were highly inefficient, utilizing only 6.3% of the available energy, while the remaining energy was wasted. To achieve more efficiency, it was recommended that an open-pot furnace, with a specially designed three-layer insulated crown, comprising Slimnite, insulated bricks, and ceramic wool insulation, be used instead of the old single crown. This brought about a reduction in fuel consumption by about 17-20%.

- The coal-fired tank furnaces were highly polluting and inefficient. New, oil-fired tank furnaces were introduced with better refraction and fuel-efficient burners, which led to an increase in glass draw per day by approximately 30%; reduction in fuel costs by approximately Rs. 5000 per day or about Rs.15 lakh per annum; and substantial reduction in the emission levels of air pollution which helped to bring the pollution level within permissible limits. This, in turn, improved the workers' environment.

The project led to a threefold development in the clusters. One, technology upgradation in terms of conversion of coal-fired *bhattis* or furnaces into oil-fired ones provided oil-fired pre-heaters for pots and production aids, and low-cost automation for improving productivity. Second, visible improvement in terms of quality were the modification of production processes; shop-floor training for better work culture and practices; and appropriate raw material mix in terms of both quality and quantity. Third, technology and

[31] The State Bank of India (SBI) Project UPTECH is one of the schemes meant to support small-scale industries and help them upgrade their technologies so that they are able to "…survive forces that would be unleashed by liberalization and globalization…" (MSME Foundation: http://www.msmefoundation.org/ folder/Publication/47.pdf, p.31)

quality development automatically led to cost control, as the number of rejections plummeted after the effective utilization of inputs, the search for better inputs, and proper input mix in the cluster became customary practice.

Now, some firm-level challenges had to be addressed: the challenges were varied; their dimension and complexity were dependent on factors such as size of the unit, products, processes, prevalent practices, installed equipment, etc. Solutions had to consider not only the economic feasibility of investment, but also improved working conditions, pollution abatement, quality enhancement, cost reduction, and long-term gains through higher productivity and increased profitability. .

Inferences Drawn and Lessons Learnt

The problem was well identified and understood, and a proper need assessment was carried out. The first step was the formation of a specialized team of UPTECH to study the problem. The team's main task was to interact with the client's/recipient's personnel on a regular basis such that, over a period of time, the personnel on both sides would function as one team. The initial bottlenecks were listed primarily in terms of productivity, which, they found, could be higher if the current loss were minimized by adopting a technology from outside. (These shortcomings can be correlated to the barriers specific to analyzing and assessing the sink's technological needs, as listed in Table 4.1.) Thus the issues pertaining to capacity utilization; the need for equipment; employee training; and skills development were adequately addressed. As discussed in Table 4.1 under the constraint related to the lack of mutual trust, in this case the perception of mutual benefit did not mitigate the issues in technology adoption. The commercial interests of both entities, coupled with the complexities of the transfer process, were resolved at every stage because of constant and clear communication. This was also possible as the negotiations that were conducted took into account the transferor's reputational interest and the recipient's clearly stated needs. In the feasibility study and risk analysis, the transferor's adequacy of expertise and resources to execute the project were examined. Here other barriers to a successful technology transfer were also given due attention. The environmental concerns, working conditions, and cultural barriers involved in modifying the production process were looked into, and the management was involved at almost every stage of the technology transfer process. The performance of new technology was monitored and measured, and the final results were assessed for their conformity with the established objectives of the technology adoption/adaptation project. The communication and relationship between the source and the sink appeared to be very effective, as the technical and the business aspects of the deal were clearly specified.

Q U E S T I O N N A I R E

This questionnaire is intended for SMEs and is structured as follows:

I. QUESTIONS ON GENERAL PROFILE AND INTRA-ORGANIZATIONAL ACTIVITIES OF THE SME

II. QUESTIONS ON LINKAGES AND SUPPORT STRUCTURES OF THE SME

III. 2QUESTIONS ON BARRIERS TO TECHNOLOGY TRANSFER IN SMEs

I. a GENERAL PROFILE

1. What is the area/sector of your operation?
   _____

2. The estimated assets of your enterprise are in the range of:

   ___ Less than US $1000
   ___ US $1000-10000
   ___ US $10000-100000
   ___ US $100000-500000
   ___ More than US $500000

3. Specify the number of employees in your SME
   _____

   Percentage of employees in labour: _____(%)
   Percentage of employees in supervisory cadre: _____ (%)
   Percentage of employees in management: _____(%)

4. What is your role in the technology transfer process?
   Chief executive
   Executive in firm
   Technology transfer administrator
   R&D personnel
   Other (please specify)_____

5. How often have you been involved in technology transfer?
   _____Once
   _____2-3 times
   _____3-5 times
   _____More than 5 times

6. How often has your firm (SME) been involved in technology transfer?
   _____Once
   _____2-3 times
   _____3-5 times
   _____More than 5 times

I. b. INTRA-ORGANIZATIONAL ACTIVITIES OF THE SME

(a) Knowledge Acquisition

How do you acquire knowledge? (Mark each head below individually on a scale of 0 to 10: 0 for absence and 10 for high importance. For example, if knowledge acquisition through publications is constantly prevalent in your organization, mark 10.)

Publications	Internet Sources	Peer Learning	Seminars/Conferences	Customer/Supplier Feedback Mechanism

Experts from inside the Firm (Mentoring)	Incorporation of New Workers	Gains from On-the-Job Experience	Training Programmes/Courses	Any Other

(b) Problem Solving in Technology Transfer

What positive measures do you find at work in your firm and how important are they? (Mark each head below individually on a scale of 0 to 10: 0 for absence and 10 for high importance. For example, if your firm does not have a system for rewards, the score is 0.)

Crisis Management Mechanism	Problem Solving Teams	Handle Problems Individually	Mechanisms for Self-development Opportunity	System for Rewarding People Involved in Technology Transfer	Use Expert/ Mentor Advice from Outside	Recruit Professionals Dedicated to Technology Transfer

(c) Continuous Improvement/Quality Control

What measures do you consider important in your SME? (Give a score individually on a scale of 0 to 10: 0 for absence and 10 for high importance.)

Total Quality Management (TQM) Process	Steering Committee for Quality Process	Action Learning/Quality Circles	Benchmarking Exercise	IT Systems for Info Exchange and Feedback	Any Other

(d) Competence, Consolidation, and Growth

Based on your employee/staff strength and their qualifications, assess the importance of the following tools of learning. (Please give a score against each item: 10 for high importance; 0 for its absence.)

Formal Learning

_____ Technical education
_____ Post-graduate specialization
_____ Continuous training

Informal Learning

_____ Family mentorship
_____ On-the-job learning
_____ Informal relations with businesses

II. LINKAGES AND SUPPORT STRUCTURES OF SME

(a) Whom do you generally approach for know-how and know-why (assessing your mobility initiatives involving external entities). (Multiple selections are possible using √)

FOR KNOW-HOW	FOR KNOW-WHY	
____	____	Large firms known to you (include collaborations)
____	____	Academia (include collaborations)
____	____	Government laboratories/Institutes
____	____	External consultants
____	____	Agencies supporting organizational R&D
____	____	Expertise from within local milieu (clusters)
____	____	International agencies in your field
____	____	Professional/Industry Associations/Chambers of Commerce
____	____	Cluster association management
____	____	Technology transfer institutions
____	____	Action-learning catalysts
____	____	Trade fairs/Exhibitions
____	____	On-line databases
____	____	Friends and acquaintances
____	____	Any other (please specify)

(b) What methods have you adopted for technology transfer/knowledge exchange? (Please give a score against each item: 10 for high importance, 0 for its absence.) Base your response on technology transfers in the recent past

Industry Liaison Office/ Technology Transfer Office	Seek On-Site Technical Assistance from Source	Directly Signing Transfer Agreement on Your Own	Outsourcing to Professional Commercial Firm	Opt for start-up Firms through Formal/ Informal incubation Units	Trade Shows
Network Meetings	Site Visits	Training Events	Seminars/ Conferences	Customer/Supplier Meets	Informal Exchange
Job Secondments	Newsletters/Reports	E-mails/Other ICT	Joint Research/ Intelligence Gathering	Cooperative Research/Co-publication or Such Activity	Any Other

III. BARRIERS TO TECHNOLOGY TRANSFER IN SMEs

STRATEGIC FOCUS

1. What are the most serious barriers your firm has encountered in the transfer of technology? (Kindly identify the type of technology transfer involved and enter a score against the below-mentioned barriers according to the importance in your firm: 10 for the most important, 1 for the least important, and 0 for its absence)

_____ Lack of developed organizational and institutional (policies) structures and support mechanism
_____ Technical assistance from source
_____ Informal discussions of techniques or research results between source and sink
_____ Formal dissemination of outputs
_____ Licensing procedures
_____ Personnel exchange
_____ Formal exchange instruments (agreements, patenting procedures)
_____ Dealing with start-up firms, using government support
_____ Technology screening
_____ High price of technology
_____ Negotiations in deciding royalty
_____ Commercialization aspect, especially in securing sales channels, markets
_____ Preparation for mass scale production (facility investment)
_____ Lack of technical follow-up, particularly on-site

2. What is your opinion on barriers to technology transfer (TT)?

	Strongly Agree	Somewhat Agree	Indifferent	Somewhat Disagree	Strongly Disagree
Marketability and profitability of technology is insufficient					
Technology valuation is difficult					
Cash flow/budget for TT process is restricted					
Budget for seeking appropriate technology is inadequate					
Lack of qualified personnel for TT					
Information on demand for technology is limited (insufficient awareness of value of technology as a strategic business tool)					
Delivery of technology and systems is a complex process					
Technology transfer and implementation is highly centralized					
Incentives for TT by the government are insufficient					
Incentives for TT at the firm level for employees are inadequate					
Often excessive royalty is determined					
Inadequate experience in TT process results in failure					
Focus on production is short-term					

Patenting facilitates technology transfer					
ICT infrastructure enables removing barriers to TT					
Government interference leads to problems in TT					
Infrasructure for learning is necessary to address the problems in TT					

Typical Obstacles

1. In your opinion, what is one of the most crucial barriers in successful technology transfer?

   _____

2. What, according to you, are the problems faced in your day-to-day business? (Kindly give a score on a scale of 1 to 10, 10 being extremely important, and 1 being the least important reason)

   ____ No/limited access to local labour
   ____ Inadequate subsidies and incentives (monetary, fiscal)
   ____ Poor transport connections
   ____ Lacking proximity to markets
   ____ Weak links with local community
   ____ Poor quality of life
   ____ Weak ties with other firms
   ____ Inadequate support services (telecommunications, internet, photocopy…)

3. Apart from financial risk, what are the major sources of risk/uncertainty in technology transfer?
   ____ Technical risks
   ____ Commercial competition
   ____ Management risks
   ____ Any other (please specify)

TECHNOLOGY SPECIFIC

1. What are the typical barriers to technology selection?
   (Kindly give your estimate alongside the below-mentioned barriers, according to the importance in your firm: 10 for the most important, 1 for the least important, and 0 for its absence)

   ____ Lack of accepted standards
   ____ Opposition by employees
   ____ Extra-fast changes in technology
   ____ High investment cost
   ____ Management problems
   ____ Time pressure
   ____ Lack of information
   ____ Inadequate number of trained personnel

2. Has the technology been assessed to be offering the new/improved products or services for a short, medium, or long term? Yes/No

3. For what purpose has your firm negotiated the acquisition of technology?
   ____ Increase sales and thus profitability

____ Minimize cost to add to profitability
____ Any other reason (please specify)

FINANCIAL ASPECTS

1. What are the typical difficulties that technology transfer professionals face in financial negotiation?
   ____ Disagreeing on a value of the negotiated technology
   ____ Lack of a generally accepted method of technology valuation
   ____ Indecisiveness about the method of royalty determination (income approach, cost-based approach, grant-based approach, market-based approach)
   ____ Lack of expertise in technology valuation and in deciding on issues of implementation costs
   ____ Limited investment for contracting the new technology
   ____ Lack of negotiation skills in deciding on royalty payments

INTELLECTUAL PROPERTY PROTECTION

1. What is your assessment of technological quality and marketability prior to the filing of the IP application?
   _____

1.a. Do you assess the concerned technology prior to IP filing? Yes/No

1.b. Do you assess the market potential of the concerned technology prior to IP filing? Yes/No

2. Are you aware of any legal process or protection for SMEs suffering from unfair competition, predatory activity, etc from large firms? Yes/No
   If yes, please specify:_____

3. Do you observe a dearth of experts in patent licensing? Yes/No

LOCATIONAL ASPECT

1. Are you located in any of the clusters/S&T/entrepreneurs parks? Yes/No

2. What, according to you, are the advantages in operating in technology clusters/research parks? (Rank them on a scale of 1 to 10, 10 being extremely important, 1 being the least important reason.)

   ____ Collaboration among firms
   ____ Innovations
   ____ Knowledge flow
   ____ Personnel recruitment
   ____ Image boosting

3. How much stability do you observe in the local business environment where you are located?

GOVERNMENT SUPPORT

1. Do you believe that the government gives adequate support in respect of concessional or favourable tax rates to your SME (for example, special exemptions on certain taxes, reduced company tax rates, etc)? Yes/No
2. Is there government support (financial support, infrastructure, etc) for databases to allow large firms and subcontractors to exchange information and opportunities? If yes, please specify the ones you know about. _____

3. Does the government provide any programmes to encourage the adoption of more efficient technology (e.g. pollution control, manufacturing processes, etc)? If yes, please specify the ones you are making use of: _____
4. Does the government provide any programmes to assist SMEs to adopt information technology and better management systems? If yes, please specify the ones you are making use of.

_____

INCENTIVES

1. Does your organization offer monetary rewards for the submission of patent claims or the granting of patents? Yes/No

1.a If yes, how effective do you believe these rewards to be?

2. Does your organization provide recognition and/or rewards for time and effort spent on technology transfer? Yes/No

2a. If yes, how effective do you believe these rewards to be?

3. Do you support the grant of incentives to licensing professionals in case technology transfer is channelled through a TLO? Yes/No

4. What factors do you consider influence your individual willingness to contribute time and effort for technology transfer?

COMMUNICATION AND ICT-ENABLING ENVIRONMENT

1. Do you find a general lack of information on technology transfer? Yes/No
1.a If yes, is it:
   - ____ Lack of appropriate resources to obtain information
   - ____ Lack of resources to explore opportunities for technology transfer
   - ____ Lack of resources for up-to-date information on technology target markets about SMEs

2. Do you observe lack of communication, and absence of infrastructure and a similar business network? Yes/No

3. Do you observe that SMEs lack confidence in e-commerce and e-trading? Yes/No

4. Do you consider that the understanding of SMEs' needs is limited? Yes/No

5. Do you believe that too much emphasis is placed on hardware and too little on soft skills? Yes/No

POST-ACQUISITION STAGE

1. What were the deliverable and implementation support and means that were lacking in your most recent technology transfer project?

   - ____ Operational guidelines
   - ____ User's guide
   - ____ Explanations, citing cases and examples
   - ____ On-site expert assistance
   - ____ On-line assistance
   - ____ Any other (please specify)_____

2. What problems did you face during validation of the acquired technology?
Prototype

_____ not applicable in your case
_____ not developed
_____ not working as desired/tested in a few cases, but not representative of all potential situations
_____ not yet tested
_____ already in use in a wide range of situations
_____ non-compliant with regulatory norms
_____ any other (please specify)_____

2a. Transferability Issues

_____ Lack of information (printed document, electronic version)
_____ Lack of adequate skills in adapting/adopting technology
_____ Problem of integration of new technology with existing one
_____ Ownership of IP
_____ Any other (please specify)_____

2b.Other Barriers

_____ Language
_____ Work culture
_____ Safety consideration
_____ Any other (please specify)_____

MEASURING EFFECTIVENESS OF TECHNOLOGY TRANSFER

1. Are you aware of any metrics to assess success or effectiveness of technology transfer?
Yes/No If yes, please describe them:_____

2. Where do you look for relevant best practices in the transfer of technology?
_____

3. Do you think any economic restructuring at the regional level has impacted on the stability of SMEs?
_____

FACILITATING TECHNOLOGY TRANSFER

1. What mode of transfer do you think would facilitate technology transfer?

_____ Granting of exclusive licences to SMEs
_____ Granting of non-exclusive licences to SMEs
_____ Depends on case-to-case basis

2. What are the most important elements that you, as practitioner of technology transfer, consider would facilitate such transfers?

_____ Putting pressure on the government to increase the R&D budget for and investment in technology transfer to SMEs
_____ Providing incentives and benefits to SMEs as licensee
_____ Providing marketing channels to SMEs
_____ Subsidizing technology transfer and commercialization
_____ Providing on-site technical assistance
_____ Organizing trade shows for on-the-shelf technologies

3. What, according to you, is one of the most important factors for successful technology transfer?

_____