

Strategic Risks in Planning and Implementing Technology Transfer Projects

This paper was prepared by Prof. Sushil, Department of Management Studies, Indian Institute of Technology (IIT), New Delhi under a consultancy assignment given by the Asian and Pacific Centre for Transfer of Technology (APCTT).

Disclaimer

This paper has not been formally edited.

The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of the United Nations Economic and Social Commission for Asia and the Pacific.

The description and classification of countries and territories used, and the arrangements of the material, do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country, territory, city or area, of its authorities, concerning the delineation of its frontiers or boundaries, or regarding its economic system or degree of development.

Designations such as '*developed*', '*industrialised*' and '*developing*' are intended for convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process. Mention of firm names, commercial products and/or technologies does not imply the endorsement of the United Nations Economic and Social Commission for Asia and the Pacific.

CHAPTER 1. INTRODUCTION

1.1 Background

The project, “Promotion of the Technology Transfer Network for Small and Medium Scale Enterprises in the Asia-Pacific Region” is aimed at the development of a self-sustainable information technology (IT)-powered technology transfer network of intermediaries in Asia and the Pacific to promote regional cooperation. The main purpose of this project is to enhance the capacity of institutions/intermediaries in member countries to deliver technology transfer services in the overall effort to improve the competitiveness of SMEs and to accelerate the adoption of environmentally sound technologies.

1.2 Objectives of the Study

In order to enhance the capacity of institutions/intermediaries to deliver technology transfer services, this study sets out to examine the strategic risks that firms face in planning and implementing technology transfer projects which could be incorporated into the risk and financial appraisal framework of financial institutions.

This study can also be usefully applied by APCTT in the delivery of UNDAF’s proposal, “Innovative mechanisms for risk transfer (including financial) and adoption of environmentally safe technologies institutionalized”.*.This work assignment would entail:

*United Nations Development Assistance Framework (UNDAF) 2008-2012.

- i. A study to examine and summarize the strategic risks that firms face in planning and implementing technology transfer projects which could be incorporated into the risk and financial framework of financial institutions.
- ii. Using this study as the basis for developing technology valuation models that may be utilized by financial institutions to manage the risk in funding technology transfer projects. The models would also be supported by a description of possible strategies to hedge the risk in technology acquisition.

1.3 Methodology of the Study

The study focuses on organizations in the manufacturing industry, particularly the automobile manufacturers, in the Indian context. The vehicle manufacturers, which are large enterprises, are supported by a network of

vendors which are Small and Medium Enterprises (SMEs) whose role in technology transfer is vital. The study follows the plan outlined below:

- a. A review of literature on related aspects of the study and the identification of key issues and strategic risks in technology transfer.
- b. An empirical appraisal of vendors to identify clusters in technology acquisition.
- c. An assessment of the links in technology absorption capabilities with success in technology transfer.
- d. Case studies on technology transfer which illustrate strategies for hedging risks.
- e. Development of technology valuation models.
- f. Case study illustrating the valuation models developed.
- g. Recommendations for financial institutions and SMEs.

1.4 Technology Management: Relevance and Phases

The management of technology is acquiring a distinctive character and increasingly being recognized as an activity that complements other managerial functions in providing the necessary inputs to the decision-making process. The manufacturing scenario has undergone a rapid change in the last decade, more so in the last few years. The arrival of new materials and products, customers' changing needs, and such other factors have revolutionized the area of manufacturing of goods: product life cycles have been shortened; the variety of products for manufacture in a single production unit has considerably increased; and existing/new products have to be constantly modified to remain competitive. Consequently, more flexible machines, equipment, and systems are being acquired to fulfil these needs.. In other words, the manufacturing units are continuously trying to update their profile by acquiring or developing new technologies.

Notwithstanding the fact that new technology is needed today for surviving in the market and that wide-ranging benefits accrue to firms with the competitive edge, a cautious approach that is geared to a systematic and scientific procedure for acquiring new technology proves rewarding. This need is dictated by economic, social, technical, and environmental effects which may be imbued in the new technologies. New technologies are generally associated with higher initial investments. In addition, the workers, staff, and managers have to be professionally trained in the efficient usage of the new techniques. Although initial expenditure may be set off by consequent benefits, yet a decision with regard to the acquisition of new technology calls for a thorough cost assessment. The major societal effects of new technologies are apprehensions or fears of redundancy, general resistance to change, hostility from the unions, and such other hindrances. Such pressures make the acquisition of new technology a very sensitive exercise, requiring considerable care, caution, and flexibility. On the technical side, the acquisition of new technology may introduce the need for changes in the related equipment, minor modifications in the parts/products, and training of the personnel in the new techniques, and may also

instil a fear of losing the customary parity in the production area. The leading environmental effects are the inevitable pollution and the impacts on the workforce, e.g. the workers' morale. Another major concern in respect of the acquisition of new technology is its phasing out in the event of the product's decline in the market or project abandonment.

In the modern age, technology is perhaps every nation's most important resource. Technology and its management are today matters of global primacy. Technology is being developed, improved, combined, refined, bought, sold, and traded around the world at unprecedented levels. To maintain their competitive edge, companies are increasingly looking beyond their immediate sphere of activity. They adopt and assimilate new technology, improve and refine existing technology, and combine both in their quest for success in world markets. The management of such an important resource, both at national and enterprise levels, is vital; it has to be properly planned, cultivated, and developed. This calls for an effective technology management for sustained growth of the enterprise and for greater competitiveness.

Managing new technology entails using this new technology to create competitive advantages. Technology management is the capacity of a firm, a group, or a society to master the management of the factors that condition technical change with the purpose of improving its economic, social, and cultural environment and increasing its wealth quotient. The successful management of technology requires the capacity to orchestrate and integrate functional and specialist groups for the implementation of innovations, continuous questioning of the appropriateness of exploitation of existing technology, and a willingness to take a long-term view of technological accumulation within the firm. The overall process of technology management can be divided into the following eight phases (Khamba, Singh, and Sushil, 2001):

- Forecasting and Assessment
- Planning and Strategy
- Acquisition and Development
- Transfer
- Adoption and Adaptation
- Diffusion and Substitution
- Utilization
- Phasing-out.

1.4.1 Technology Forecasting and Assessment

Technological forecast is a prediction of the future characteristics of useful machines, products, processes, procedures, and techniques. Also defined as 'the seeking of or anticipation of technological innovation', it is an

important management function, serving as an input to the planning-cum-decision-making process for future expansion, or new business, or even for remaining competitive in the market. A related function is the assessment of technology in terms of its impact on society and the environment.

1.4.2 Technology Planning and Strategy

Planning is crucial for quick and timely commercialization of technologies. If technology planning is not up to par, then no amount of investment in technology can yield results. Technology strategy is to be aligned with the firm's corporate and business strategies, and supports the concepts of core competence and competitive advantage. It covers the issues of technology portfolio analysis for taking investment/divestment decisions, and timing of technology in terms of offensive/defensive strategies.

1.4.3 Development/Acquisition of Technology

Technology development entails translating R&D efforts into marketable products, processes, and services. An effective management of technologies and an appropriate choice of technology development approaches are important for the success of the technological efforts. In R&D laboratories, new ideas are generated by 'need pull' and 'knowledge push' factors. The process of innovation occurs in the following stages:

- The invention phase, i.e. finding the idea.
- The implementation phase, i.e. translating the idea.
- The market penetration phase.

Technology acquisition can be viewed as a means of supplementing the firm's internal innovative processes, allowing an organization to circumvent various phases of the technology life cycle. By externally acquiring a technology, the organization may be able to access technology within the mature phase without striving through the earlier developmental phases. The key issues here are sourcing, pricing, and negotiations for technology acquisition.

1.4.4 Transfer of Technology

Transfer of technology means the transfer of knowledge, generally through the purchase of technology for gainful application. In other words, technology transfer is defined as the process by which the embodied as well as the disembodied knowledge contained within an organization are acquired by another.

This transfer can take place via publications, patent disclosures, personnel interaction, joint ventures, turnkey projects, R&D companies, consultants, and research companies. Transfer, unlike its common one-way movement of relocation, often represents a two-way, multilateral learning process. Technology transfer can

serve as a tool for strengthening the local production system; providing information and training; serving as a stimulant for further development; facilitating a more competitive position in the international marketplace; and assisting in closing the gap between developed and developing nations. Technology transfer can take place within the organization, within a group, within an industry, between industries, between governments, between industry and government, or between industry and university.

Based on the above transfer levels, the transfer of technology may be classified into two main streams: horizontal and vertical. Horizontal technology transfer implies the transfer of technology from one firm to another, generally located in different countries, mainly due to reasons of competition or near-maturity of technologies. Vertical technology transfer entails the transfer of technology from an R&D organization to a firm. Such transfers are mostly within the country, and the technologies are new, and may often require further efforts in terms of establishing commercial viability.

Steps in Technology Transfer

Technology transfer spans the gamut of technological knowledge - from the sharing of a precise component of information to in-depth corporate know-how. The terminology defined below describes the progression from the transfer of minimal information to that of core details.

Show-how: The recipient at this stage is a sub-contractor with limited technical assistance, allowing only the most meagre transfer of technology.

Know-how: The transfer of technology accelerates, as there is full technical aid with scientific assistance, adaptation, use of materials, and transmission of results and formulas. At the same time, the attendant risks also increase.

Know-why: In this step, existing research is shared, with the supplier of technology transmitting concepts and explaining formulas.

Know-everything: Here the core technology (or secrets referred to as the *tour de main*) is transmitted, intensifying the risks, with a boomerang effect perhaps already in place.

Phases of Technology Transfer

Technology transfer progresses through the following five phases.

Incubation: In this initial phase of technology transfer, companies evaluate their technological capabilities and life cycles, human abilities, and know-how. This phase also includes the major issue of competitor evaluation, which is addressed by competitive intelligence and technology watch to understand the buyer's intents, thereby avoiding the boomerang effect.

Anticipation: During this phase, companies focus on anticipating the price of technology, mode of transfer, choice of potential partners and clients, and typical agreements such as protecting intellectual property.

Confrontation: This phase is a period of aggressive negotiation, risk management, and cross-cultural concerns.

Implementation: This includes financing, project management, the adaptation of technologies to specific local requirements, and the transmission of know-how, training, and technical aid.

Follow-up: This final phase involves the collection of royalties, a review of the partner's technological expertise, and the technological and external diffusion, and assessing the feedback on the buyer's technological improvements.

1.4.5 Technology Adoption and Adaptation

Adoption and adaptation of technology are concerned with putting to use the new technology and its smooth acceptance and utilization. Adoption calls for the appropriation of competitive technology at the right time. In this case, factors such as customers' needs, the time of adoption, similarity of new technology with the existing system, and changes for establishing the new production programme are all critical for accurate decision-making.

Adaptation is in the nature of technology transplantation,,starting after a technology has been adopted and put to use in production activities or facilities. During this stage, a number of alterations are made to suit indigenous conditions; these modifications may relate to the use of raw materials/components manufactured; practical difficulties of scaling up or scaling down operations; adjustments in design from ergonomic and economic viewpoints; manufacturing systematization; etc. Such replication of improved prototypes and indigenization of tooling are intended to improve the quality; alter the physical properties; increase the reliability; integrate with the firm's existing products; meet the desired production capacities; and other related aspects, as planned. The adaptation exercise covers both product modifications and production technology changes, using indigenous skills and facilities as well as local materials. Government policies, manpower planning, production processes, and required changes are important influences throughout the period of adaptation.

1.4.6 Technology Diffusion and Substitution

Diffusion refers to the process by which technology is extended to other parts of the organization or across organizations. As new technology spreads throughout the organization, a social environment is created for the emergence of normative and value consensus. The widespread introduction of a new technology within an organization signals the technology's legitimacy and helps institutionalize the technology in the social environment.

Technology substitution in the life span of technology represents the decline in the use and eventual extension of a technology due to replacement by another technology. Many technical and non-technical factors influence the rate of substitution. The time taken in the substitution stage depends on the market dynamics.

1.4.7 Technology Utilization

Though the acquisition of new technology is a common industrial trend all over the world, in some cases expensive machinery and equipment are not put to use in the manner originally planned. It is only when newly-acquired technology is fully utilized to improve the production facilities that it meets the growing demand for higher quality, less cost, extensive variety, and customer-oriented products and services. Such wide-ranging accomplishment includes the issues of productivity, manufacturability, maintainability, and related areas

1.4.8 Technology Phasing-Out

When technology reaches the point of virtual universal applicability, its continued use has little commercial value, and licence agreements have probably expired, it is said to be in the obsolescence stage. Depending upon the industry's traits and nature of competition, the recommended strategies at this stage vary from an immediate exit to increased investment. In this phase, new technology displaces the declined technology, and the firm survives only by pricing itself substantially below the new technology. However, some old technologies may still have a market value in the Third World nations that wish to employ surplus labour in the substitution projects.

1.5 Issues in Planning and Implementing Technology Transfer Projects

In planning and implementing technology transfer projects, the core issues are linked with the firm's technological and people capabilities..

1.5.1 Technological Capabilities

An organization's technological capabilities are composed of a variety of sources of knowledge and experiences. Some of the capabilities are disembodied, such as new ideas and inventions. Others are embodied in equipment, machinery, and infrastructure, while still others are embodied in human skills. The extent of technology capabilities acquired by a firm depends on its learning culture (Putranto et al, 2003). The technology capability accumulation can be accelerated if deliberate and effective efforts are made to acquire knowledge, which is then converted into processes within the firm. A firm's learning processes influence technological capabilities accumulation (Figueiredo, 2002).

Technological capabilities are accumulated and embodied both in individuals, in the form of skills, knowledge, and experience, and in organizational systems. Internal capabilities are important in that they help an enterprise in understanding and assimilating its imported technologies. In order to deploy new technology effectively in an economic or operational sense, recipients need to cultivate an in-house capacity to undertake R&D and training programmes. Organizationally, firms must have the ability to set up, for their technological activities, effective organization structures which are appropriate to the firm's size and growth; facilitate effective communications across different departments; develop technology scanning or evaluation services; and promote learning within the organization. Technological capability implies the existence of the requisite skills for applying knowledge towards achieving the goal of excellence in performance.

Research and Development

Research and development (R&D) is an important input for building technological capability. Providing support in absorbing new technology within a given framework, R&D serves an important purpose in the manufacture of automobile components as customers are constantly demanding their preferred choices. Organizations that have an impressive in-house R&D record are more comfortable and successful in enhancing their abilities to ensure that technology absorption is smooth and fruitful.

Information Technology Infrastructure

Information technology has become an integral part of today's business. Easy and rapid flow of knowledge between organizations engaged in the technology transfer process is critical to its success. During the technology absorption process, the flow of information is vital for timely exchange of information and its completion. An information and communication technology (ICT) infrastructure provides a broad platform for exchanging data, coordinating activities, and sharing information. A vibrant IT infrastructure offers powerful information processing and sharing abilities which are vital ingredients in the technology absorption process.

Scientific Knowledge Base

An organization's past experience with technology, in terms of exposure and organizational learning, ultimately affects its future choices in adopting technology. This past experience can be captured through notions such as the time since the first acquisition, the number and type of technologies or applications adopted, the percentage of different classes of personnel familiar with the technologies, and the current level of assimilation and integration of the technologies.

1.5.2 People Capabilities

People can contribute more to business success if they are given relevant training in and exposure to the specific expertise. The increasing emphasis in academic literature on the need to "compete from the inside out" has made

organizations search for ways to harness the power of their employees to build and sustain the competitive advantage in order to outperform competitors. People capabilities are more about the way employees act and what they know, and less about an organization's tangible assets. Workers' education, technical aid, and technical training improve a firm's performance. Whether firms can extract an optimum from the managerial, technical, and other support provided by suppliers depends on the extent to which local personnel are involved in the transfer process. The more local employees are involved, the more 'know-how' capabilities are likely to accrue to organizations. An organization's knowledge resource is undoubtedly an important predictor of technological capabilities.

Training provides the opportunities to learn the new expertise for the new technology set-up. Training is considered to be a most significant process within the strategic management of human resources (Delaney and Huselid, 1996). It, first, plays a critical role in maintaining and developing capabilities, both individual and organizational, and also substantially contributes towards the process of organizational change (Valle et al, 2000). Second, it improves the retention capacity of qualified employees, thus reducing the involuntary rotation of personnel (Shaw et al, 1998). Third, it implies the organization's long-term commitment to its employees and reinforces the individuals' motivation (Pfeffer, 1994). All these aspects lead to a greater level of competitiveness (Youndt et al, 1996) and to an improvement in productivity and organizational results (Bartel, 1994; Delery and Doty, 1996). The significance of training in the organizational learning process is pointed out in several studies (e.g. Nonaka and Takeuchi, 1995; DiBella et al, 1996).

Training programmes are also seen as a fundamental tool for creating a climate of constant learning within the organization. These programmes favour the acquisition and constant generation of new knowledge and skills, improving the level of receptiveness to new ideas (DiBella et al, 1996; Lei et al, 1996). Thus, training promotes flexibility, contributing towards the improvement in the necessary critical skills for effective response to competitive challenges. Technology absorption requires the existence of relevant organizational skills and capabilities in the user organization.

Learning

Learning, which plays an important role in technology absorption, is an essential component in the development, cultivation, and accumulation of technological resources. Several studies suggest that organizational learning has a positive impact on technology absorption.

The need for a culture of learning in an organization to facilitate organizational learning in general, and knowledge transfer in particular, has been emphasized by many researchers. To remain competitive,

organizations should advocate constant learning, as encouragement to its people to continually learn new skills helps them to be innovative in trying out new processes and work methods to achieve the required goal. An ongoing-learning organization is one that constantly encourages its people to gain new knowledge, try fresh approaches to solve problems, and obtain feedback and adopt innovative behaviour patterns as a result of the experimentation. Organizational learning is the collective outcome of its people and group learning applied to achieve the organization's vision and objectives (Swee C. Goh, 2003).

Skills

To succeed in the global, knowledge-based economy, where a qualified and highly skilled workforce is a key strength in the competitive market, an organization must produce, attract, and retain a critical mass of well-educated and well-trained people. The demand for high-level skills will continue to increase in all sectors, constantly upgrading the skill requirements in the labour market. Firms are always on the lookout for more highly qualified research personnel, technicians, specialists, and managers to strengthen their innovative capacity and maintain their competitive advantage. Organizations are acutely aware that competent human resources are essential to drive the innovation process and apply innovations, including new technologies absorption.

1.6 Organization of the Report

The report is organized into five chapters:

Chapter 1 deals with the study's background and objectives. It provides a brief introduction to technology management and technology transfer. It also outlines the broad issues in planning and implementing technology transfer projects in terms of technological and people capabilities.

Chapter 2 presents a review of the literature, which leads to the identification of the strategic risks in planning and implementing technology transfer projects. This chapter also gives the findings of an empirical study in terms of clusters of vendors in the manufacture of automobile components in technology acquisition, the purpose being to evolve strategies for hedging risks in various clusters.

Chapter 3 deals with the strategies for hedging risk in technology transfer. It first gives the findings of an empirical analysis, relating technological and people capabilities with the success of technology transfer, and illustrates various strategies with the help of case studies.

Chapter 4 discusses the technology valuation models based on the strategies presented in chapter 3. Some of these models are illustrated with the help of a practical case study.

Chapter 5 summarizes the study's findings in terms of the strategies and valuation models, and suggests measures for financial institutions and SMEs for the effective incorporation of strategic risks in their financial appraisal framework for technology acquisition.

CHAPTER 2. STRATEGIC RISKS IN TECHNOLOGY TRANSFER PROJECTS

2.1 Introduction

This chapter initially introduces the issues and concerns in international technology transfer. First, the implications of technology transfer for institutions, governments, and firms are outlined. Next, the hurdles and barriers encountered in technology transfer projects are enumerated, giving an insight into the strategic risks involved in such undertakings. Finally, the results of an empirical study are discussed to identify clusters of SMEs in the context of technology acquisition. This, in turn, leads to the development of strategies for hedging risk in technology transfer which is covered in chapter 3.

2.2 International Technology Transfer

That international technology transfer played an important role in the industrial development of those countries that successfully achieved industrial development during the second half of the 20th century is acknowledged worldwide. An appropriate technology transfer policy, assisted by a viable political framework and sound business conditions, contributed to competitiveness in domestic and international markets while also contributing to the attainment of a global sustainable industrial development (UNIDO, 2002).

Increasing complexities of technology management and competitiveness need fresh policies and strategies, based on new perspectives and paradigm shifts. Kumar (2007) has drawn attention to major changes that are taking place in the technology transfer domain in the globalizing economies in a market-driven policy environment. These are:

- Liberalization in technology import policies.
- Acquisition of technology associated with Foreign Direct Investment (FDI).
- Difficulty in procurement of state-of-the-art technology.
- Emphasis on R&D for better and quicker absorption of technology and incremental improvements over the acquired technology.
- Higher rate of technology obsolescence, particularly in certain sectors necessitating faster commercialization by technology acquirers.
- Encouragement for globalization of R&D for internationalization of products as against the earlier policy of indigenization and self-reliance.
- Increase in interaction and networking of R&D organizations and academic institutes with industry with a view to development and acquisition of technology.

- Transfer of technologies and associated capabilities through global outsourcing of manufacturing.
- Indications of increased trends in acquisitions and mergers for access to modern and sophisticated technologies for international competitiveness.
- Increased emphasis on the development and transfer of globally competitive technologies rather than self-reliance, import substitution, or reverse engineering.
- Technology transfer no longer limited one way - from advanced countries to developing countries - but likely to be both ways, depending upon the needs and strengths in the area of interest.
- More widespread use of ICT in effective and faster technology transfer process.
- More focus on Intellectual Property Rights issues.

Slow technology capability-building and related processes in the competitiveness of firms at the micro level and the country at the macro level have important implications. Despite significant achievements in select technological fields, such as space, missiles, and software, the technological capabilities of average firms, organizations, and individuals in the Indian market remain far below relevant international benchmarks. Poor technological capability is often a basic reason for poor performance. The low level of appreciation for technology and innovation has made some firms take a defensive posture. After being grounded in the follower strategy in technology management for decades, these firms cannot easily change their mindset to update their outmoded pattern of activity.

Nurturing the private sector with capabilities to contribute actively in S&T-driven emerging industries may be a paradigm shift that competitive countries leveraged. For instance, 80% of investment in S&T in Japan is from the private sector and only 20% from the government sector, of which the former is relatively high as compared with countries of Europe and North America (Kuniya, 2007). Japan's meteoric rise to the technological forefront and the trade and economic leadership could never have been achieved without such contributions from the private sector and industry-academia-government domain.

The national system of innovation in most developing countries tends to be weak and unstructured. The efforts to strengthen the system, besides supporting the development of firms, should focus on human resources, institutions, technology management at the plant or cluster level, and information systems (UNIDO, 1996). Key research can help draw implications for decisions related to technology management and international technology transfer. Findings can be richer, if we can synthesize them from multiple sources and perspectives. Apart from research projects, interactions with industry experts, visits to factories, courses in consulting and teaching technology management have provided new insights (Sushil, 2007).

2.2.1 Implications for Institutions

Technology transfer, in a broad sense, has relevance for institutions and universities, as such institutes of excellence can play a crucial role in international technology transfer through their programmes in education, training, and research. Aspiring institutes should carefully evolve their mission, vision, and mechanisms and periodically review their overall performance, including their fulfilment of criteria of international technology transfer, such as knowledge creation and the development of human capital.

- In the light of the changing geo-political scenario, leading institutes should realign their capabilities.
- Since important resources are, to a large extent, created by human resources, nurturing capable human resources is a necessity across stakeholders: firms, organizations, and institutions.
- International technology transfer is a complex concept, demanding multi-faceted learning. Institutions can develop mechanisms for imparting learning to enrolled members as well as for education programmes for senior management in industry and government.
- Efforts should be made to evolve better mechanisms for industry-academia-government interaction that facilitate significant contributions.

2.2.2 Implications for Governments

The government plays a crucial role in facilitating international technology transfer. The following are a few of the important implications for governments.

- The extremely high levels of concentration of technology trade at country as well as industry and firm levels render it difficult for firms from the developing countries to contribute to trade. Even some of the most competitive countries such as Japan, Korea, and China have thoughtfully implemented strategies of cooperation across all levels to enhance their chances of success. The governments in the developing countries must therefore be proactive in supporting capable firms and industries in their efforts to benefit from new technologies, and must make critical choices cautiously.

Governments at different levels can play a distinctive role in nurturing industry clusters, institutions, and firms that contribute to the technological competitiveness of their country by leveraging international technology transfer. For instance, the departments of the central government that are concerned with technology in India (e.g. Department of Scientific and Industrial Research, Department of Science and Technology) have consistently endeavoured to evolve specific strategies to keep up with the changing needs of the time and taken several advantageous measures (Bhat, 2001)..

2.2.3 Implications for Firms

Since commercial firms are the biggest beneficiaries of liberalization; they must shoulder greater responsibilities in the transfer of international technology. Here are some specific implications for firms.

- Many progressive firms in the emerging economies and the developing countries have successfully leveraged technologies for competitiveness by rapidly building relevant technological capabilities. Hence, success is possible for aspiring firms with capable leadership.
- Strong technology absorption capabilities (particularly in recipient firms) have been found to greatly influence the success of any technology transfer. For instance, the rapid technological capability-building in several industries in Japan, Korea, and Taiwan is attributed partly to their extremely strong technological absorption processes. The relative spend on absorption/acquisition is much higher in these countries. This may not be the case in India.
- Technology absorption is a major area of weakness for many firms focusing on technology transfer. Substantial funds are often spent on technology acquisition, leaving only a meagre sum for absorption activities. Firms must clearly understand the significance of all the interrelated processes and practices.
- The rapidly rising share of trade between East Asian countries and India, which has eclipsed the trade levels of these same countries with USA, may soon be reflected in the area of technology trade too.. The impact and market share of East Asian countries in India in several important industries, such as automobiles and electronics, far exceeds what is reflected in financial statistics. Progressive firms in India have already benefited from distinctive technology transfer in manufacturing and gone on to win the coveted Deming Award. Such unqualified success should spur the management of more firms to seriously consider the opportunities and challenges of technology transfer from East Asian countries for recognition in the competitive market.
- Capable human resources play the most crucial role in technology transfer. Personnel at all levels therefore need access to high quality education/training in technology management to take informed decisions.

2.2.4 Small and Medium Enterprises and Technology Acquisition

Research has shown that small and medium sized enterprises (SMEs) play an important role in the economic development of countries worldwide (Jones and Jain, 2002). However, in order that SMEs survive for more than a few years in markets monopolized by large competitors, they must nullify the disadvantages arising from their limited size either by forming alliances with similar firms to increase the rate of their market penetration and reduce financial risk, or by utilizing technology to overcome diseconomies of scale and produce innovations that carry their own stamp in the competitive market. Because of the SMEs' limited resources and relative inability to absorb the costs and risks associated with in-house technology development, they must often utilize the process of technology transfer to take advantage of the benefits gained by technology and innovation. In view of the fact that SMEs have the potential to contribute positively to a country's economic development and that their ability to innovate has an impact on their capacity for survival in the long run, it is important to identify the

primary obstacles they face with regard to new technology development and acquisition and to create tools and policies designed to help them meet these specific challenges.

2.3 Hurdles/Barriers during Technology Acquisition

A review of literature (Bhardwaj, Sushil, and Sharma, 2005) has highlighted the key hurdles/barriers encountered by SMEs in the process of technology acquisition. Some of these key hurdles/barriers are discussed in the subsequent sections.

2.3.1 Lack of in-house Technological Capabilities

Contrary to common wisdom, technology can seldom be packed, easily moved, and ready for use in any new location. Actually, a technology developed in one country can only be partially transferred to another country. A recipient country needs to learn the functioning of the transferable part as well as the parts that cannot be transferred. The importation of technology does not imply full understanding and mastery of that particular technology. In spite of massive flow of foreign technology, most developing countries have yet to develop a strong indigenous technological capability (Rosenberg and Frischtak, 1985). A major difficulty noted in several studies has been the lack of technological capabilities to absorb the imported technology by LDCs. The multinationals which have dominated the economics of developing countries usually conduct their research in the advanced countries. According to one study, the successful use of imported technology largely depends on the recipient's own technological competence.

2.3.2 High Cost of Technology

Pack (2002) analyzes the role of technology licensing in the industrial development of impoverished countries and assesses whether the prices negotiated in their technology agreements are excessive and if so, to what degree. It is argued that in the early stages of industrial development, licence agreements in industrially advanced sectors were not apt for the bulk of poor countries because of the possibility of exploitation by the donor company.

According to Huseth (1988), the availability of high-quality technology concepts does not guarantee the effective transfer of a technology into new tools or methods and thereby into actual practice. Two types of barriers hinder a successful transition: the high cost in resources of integrating an existing well-developed tool or methodology into the project life cycle; and the stifling of the technology as a result of inflexible licensing practices. Both these obstacles are described, and some perspectives on minimizing them are offered.

2.3.3 Organizational Resistance and Communication Barriers

The basic elements for successful technology transfer include reliable sources of useful information, commitment of information disseminators, and flexible conduits for information transfer. Ansoff (1987) stresses the need for transition from single-function focus to multi-function focus. Transition to multi-function orientation requires a radical transformation of the firm's management: changes in the mindset, personality, and skills of key managers; adjustments in the organizational culture and power structure; and revision in the information system, rewards, and incentives, and in decision-making systems and organizational structures. Typically, the transition to multi-function orientation is resisted by both the firm's leaders and the rest of the organization. That it is essential for the developing countries to cultivate their own technological capabilities and technology management during the process of technology transfer has unfortunately been poorly understood (Katz, 1985).

2.3.4 Lack of Infrastructure and Technical Professionals

In his assessment of technology transfer to developing countries, Pau (1988) identified the lack of a well-established industrial infrastructure as the most serious problem. He also noted that the second most important requirement was the need for an adequate number of local technical professionals to tailor the newly introduced technology to local applications. Finally, he concluded that a carefully plotted national strategy, meticulous training programmes, and the correct implementation policy from the local government of the developing nations are essential elements for assuring the success of technology transfer.

2.3.5 Hurdles in New Technology Commercialization

New technology during its up-scaling, proving, and commercialization is encumbered with inherent risks, and demands considerable inputs in terms of time and money (Kumar and Jain, 2002). Notwithstanding these constraints, the benefits that may accrue from a new technology generally outweigh the costs/investments. However, most financial institutions as well as business people are deterred from financing/undertaking new technology commercialization ventures because of the higher risks entailed. Further, the majority of lower-order financial institutions, industries, and other stakeholders do not have separate mechanisms to evaluate and assess new technology projects. The commercialization of new technologies has started emerging as an important activity in India where special focus and thrust has been provided for the last two decades.

2.4 Types of Strategic Risks

In view of the hurdles/barriers in technology acquisition which have been well-researched in published literature on the subject, the important types of strategic risks in technology transfer projects have been identified: technological risk, business risk, country risk, and organizational risk. Such risks which threaten the

success of technology transfer projects may arise from various sources: newness and inappropriateness of a technology in a given context; the lack of infrastructure and legal framework; inadequate technological and people capabilities to absorb and effectively implement the acquired technology; and changes in the business parameters during implementation of the technology, such as fluctuations in demand, interest rates, and exchange rates.

2.4.1 Technological Risk

The technological risk is associated with the newness and inappropriateness of the acquired technology in a given context. MNCs are highly motivated to transfer technology to LDCs. However, what they transfer does not always meet the needs and objectives of LDCs (Doz and Prahalad, 1980). Also legal bindings on receptors reduce the willingness to innovate and produce indigenous technology (Coughlin, 1983). The technology transfer process requires that the LDC and MNC managers be suitably trained to manage the process of change itself. This needs an understanding of the interaction between a country's regional and global environments (Mytelka, 1979). Capital-intensive rather than labour-intensive technologies are often transferred to LDCs (Prasad, 1986).

Strong indications of LDCs generally being passive recipients of technologies developed in DCs are evidence of a situation fraught with risk. When decision makers in LDCs are often uncertain of their technological requirements, they leave the door open for the transfer of inappropriate technology. The inappropriateness of some industrial technologies is due to factors such as:

- inadequate response to market requirements;
- failure to use and/or adapt to the local supply of materials;
- failure to adapt to a smaller scale of production;
- insufficient use of labour due to price distortions and other restrictions;
- import of unsuitable machinery; and
- selection of unsuitable technology due to restrictions on the acquisition of technology (Teitel, 1978).

A disturbing offshoot of technological risk is environmental risk. If the technology to be acquired poses serious threats to the environment -- for instance, nuclear technologies--, it is environmentally risky to acquire and implement such a technology. This risk becomes far more significant in the context of SMEs, as these organizations are committed to abiding by the given environmental regulations. The technological risk therefore needs to be assessed while evaluating the transfer proposal's technical feasibility and environmental viability. .

2.4.2 Business Risk

The business risk, which arises from the ever-changing shifts in the business context, is of multiple types such as cost risk, demand risk, exchange rate risk, and interest risk. The cost risk may be due to the high cost of technology which renders it commercially untenable. The other three risks are attributed to the fluctuations in business parameters in the time span between the technology's acquisition and its implementation. If the estimated demand of the item earmarked for production with use of the proposed new technology goes down, this decline would jeopardize the technology's viability. Similarly, fluctuations in the foreign exchange rates imperil the agreed terms of payment of the royalty of the new technology: the variation in the interest rates may enhance the interest burden for the firm. The funding institution should take all such strategic business risks into account while assessing the commercial and financial viability of the proposed technology transfer project.

The profitability of a new technology is rarely a guarantee at the time of its announcement. To reduce the degree of uncertainty associated with the technology's profitability, a sound solution is to collect up-to-date estimates of its prior record of profitability in the Bayesian manner. It has been shown that it is imperative for the firm to continue to collect information until its estimate of profitability crosses the threshold, after which time it is safe to adopt the technology. The firm can reject the technology if the threshold is not crossed. The model predicts that even the manager who behaves optimally may occasionally adopt an unprofitable technology (McCardle, 1985).

2.4.3 Country Risk

Country risks are associated with the profile of the country acquiring the new technology. Of the various types of country risks, the most prominent are linked with the social, political, and legal framework and the availability of the required infrastructure. These risks may arise from the non-acceptability of the technology in the social set-up, difficulties in political approvals, and barriers due to legal regulations for technology transfer. The country risk should form part of the consideration of the social viability of the technology transfer proposal.

The implementation of the acquired technology may face roadblocks owing to the lack of required infrastructure such as power, transport, communication, and complementary technologies in place. Meleka (1985) argues that MNCs must adapt their behavioural strategies to changing environments. The emphasis on the socio-political and cultural value systems of recipient countries shows that the structural factor can influence the success or failure of technology transfer. Gee (1981) endorses a gradual implementation of new technology over a long period of time in order to effectively plan and manage the change in the transfer process. LDCs often enter into

licensing agreements with MNCs. Restrictions on these agreements tend to limit the extent of technology transfer.

Madu (1988) advocates identification of the right type of technology for achieving successful technology transfer. At times, the different types of technology may not be mutually exclusive. This requires grading the different technologies for a particular country. The priority ranking will help developing countries determine how to allocate their limited resources to achieve their overall goal of successful technology transfer. The analytic hierarchy process (AHP) is suggested as a method to determine the appropriate technology. AHP requires the development of priorities for the different technologies, based on the decision-maker's judgment. Selection of the appropriate technology is based on a quantitative solution to these rankings (Saaty, 1980).

2.4.4 Organizational Risk

Ascertaining that the acquired technology is appropriate to the requirements of the recipient company limits organizational risk. The primary aim of acquiring technology in any organization is to enhance technological capabilities through efficient and effective production processes. The organizational risk in technology transfer may be predominantly because of the lack of organizational capabilities to absorb and implement the acquired technology. These capabilities are of two types, i.e. technological capabilities and people capabilities. Evaluation of the technology transfer project should include the assessment of in-house technical feasibility and managerial competence vis-a-vis the parallel project parameters throughout the whole process. In view of the lack or absence of any crucial capability, the technology transfer project may turn out to be a failure. The organizational risks therefore need to be incorporated while assessing the technical feasibility and managerial competence.

2.5 Identifying Clusters in Technology Acquisition

In order to evolve the strategies to hedge the strategic risks, as discussed in the previous section, it would be helpful to identify the characteristics of SMEs and cluster them suitably. Different strategies for different clusters may prove to be effective depending upon their organizational characteristics.

A questionnaire was developed, which included questions relating to organizational capabilities for adapting technology, involvement in product design for the customer, sincerity of the donor company, technological strength acquired through the tie-up, organizational resistance to change, customer support, and innovation culture (Bhardwaj, Sushil, and Sharma, 2008). The questionnaire was administered to 84 respondents, in 44 supplier organizations in the auto-component industry in the Indian context, with an average experience of 16.8 years. A Lickert five-point scale varying from very high, to high to medium to low to very low was used for the

analysis. The respondents and the organizations to which they belonged were grouped with the help of a hierarchical cluster yardstick, common characteristics of the different clusters of suppliers being worked out by analyzing the mean values of different variables for different clusters.

Initially, all the respondents were considered to be separate clusters, which were next joined step-wise depending upon their similarities. Clusters were identified step by step and joined together to produce the final partition. In the final partition, four clusters were identified. Table 2.1 gives the number of respondents as also the number of organizations in each cluster. The common characteristics of the organizations grouped in each cluster are presented in Table 2.2.

Table 2.1: Organizations in Each Cluster

Cluster No.	No. of Respondents	No. of Organizations in each Cluster
1	37	17
2	24	14
3	11	7
4	12	6

An analysis of the clusters revealed that in cluster 1, 33 out of 37 respondents belonged to organizations of the joint venture (JV)-type. These organizations acquired technology by partnering with other organizations through equity participation. All these vendors are OEMs (Original Equipment Manufacturers) to various vehicle manufacturers and are Tier-1 suppliers, i.e. direct suppliers. They have in-house world-class technology and sufficient technological capabilities to supply not only components but even complete sub-assemblies to the vehicle manufacturers.

Table 2.2: Identification and Description of Clusters

Cluster No.	Description
<i>Cluster 1</i>	JV organizations having world class technology, OEMs to vehicle manufacturers (Tier-1 status) have capabilities for manufacturing sub-assemblies.
<i>Cluster 2</i>	Technology acquisition mostly through licence arrangements and in certain

	cases through joint ventures. Did not acquire technology under any compulsion from customer company; largely benefited from active technology transfer through enhancement of technical capabilities. These organizations have high capability for developing and adapting manufacturing processes but not for designing components, and they have very low involvement in product design for their customer company.
<i>Cluster 3</i>	Technology acquisition through licence arrangements, but acquired technology only to satisfy their customer company to fulfil the condition for entering into licence arrangement for supplying components. These organizations did not benefit much from technology acquisition, as the partnership was mostly passive in nature.
<i>Cluster 4</i>	FDI-type organizations having world class technology and manufacturing proprietary items. Have high capabilities for product design and involve them in designing components/products after getting broad guidelines from the vehicle manufacturers.

In cluster 2, 21 out of 24 respondents belonged to the vendor/supplier organizations, which acquired technology mostly through licence arrangements (TAAs). These organizations are forward-looking and have average technological capabilities. They entered into technical agreements with the sole purpose of enhancing their technological capabilities and not under pressure from their customer company. Having taken full advantage of the technology acquisition, they derived benefits from it. They even diversified their products by getting the latest know-how because of technical tie-ups. However, they were unable to get sufficient know-why about the engineering designs of the components. In-house capabilities are sufficient for developing and adapting manufacturing processes but not for designing components as the workforce has minimal involvement in product design for their customer company.

The respondents in cluster 3 belonged to organizations that have also acquired technology through licence arrangements (TAAs), but only for the purpose of satisfying the condition laid down by the customer company. These suppliers entered into licence agreements with the original supplier of the JV partner of their customer company. All these suppliers supply components to 100% FDI-type vehicle manufacturers. As a part of their policy, these FDI-type of vehicle manufacturers enter into an agreement with their vendors to pay royalties to their original vendor who held the patent/rights of the designs of the components. Discussions with most of these organizations revealed that they have sufficient technical expertise, especially in manufacturing

technology, but they are not making practical use of the technical tie-ups, which are merely paper documents to satisfy the customer company and pay royalties to the donor company.

The fourth cluster of respondents belonged to proprietary organizations that are mostly JV-type or FDI-type (100% ownership) and are manufacturing components, e.g. spark plugs, tyres, air-conditioners, oil filters, etc. These organizations are very similar to those of the first cluster with the difference that they have superior capabilities for designing their own components and they engage in the designing of products for the vehicle manufacturers. They are also more involved in product design for their customer company.

Clusters 2 and 3 are similar because the organizations in both these clusters are small/medium scale and have acquired technology through licence arrangements. The organizations in clusters 1 and 4 are similar because they have world-class technology available with them. The organizations in cluster 1 have acquired technology through joint ventures whereas the organizations in cluster 4 are mostly of the FDI-type.

2.5.1 Comparison of Clusters 2 and 3

It was observed that the suppliers belonging to clusters 2 and 3 shared the following common characteristics:

- capability for developing/adapting process technology;
- involvement by customers in product development;
- receptiveness of donor for providing information and help;
- encouragement for acquiring technology by customer;
- capabilities of R&D department in developing/adapting technology.

Clusters 2 and 3 showed a marked difference in their grading under the following variables:

- overall sincerity of donor company;
- gaining technological strength by opting for tie-up;
- frequency of enrolling employees in training programmes.

It was observed that the capabilities of the vendors in cluster 2 are a little higher than those of the vendors in cluster 3. In fact, the vendors belonging to cluster 2 entered into technical agreements of their own choice with the purpose of enhancing their technological capabilities, whereas the vendors in cluster 3 entered into technical agreements only to satisfy the condition of their customer company. Hence the tie-ups of the suppliers belonging to cluster 3 are passive in nature with minimal interaction between the technology partners. In such cases, customer companies urge their suppliers to opt for a tie-up with their worldwide suppliers who hold the rights of design of these components..Such suppliers as those belonging to cluster 3 otherwise have enough technical

capabilities to manufacture their own components. Customer companies in such cases play a mediator role in developing this relationship and also in helping the vendors during negotiations.

2.5.2 Comparison of Clusters 1 and 4

Clusters 1 and 4 are quite similar to each other because the organizations of cluster 1 predominantly acquired technology by entering into joint ventures and those belonging to cluster 4, being FDI-type organizations, have the technology of their own parent organization. Both types of organizations have similar characteristics in certain fields whereas they diverge in other respects. The following are some of the common characteristics for the suppliers belonging to clusters 1 and 4;

- capability for developing/adapting process technology;
- receptiveness of donor for providing information and help;
- gaining technological strength by tie-up;
- higher costs involved in transferring technology;
- encouragement for acquiring technology by customer;
- flexibility of machinery.

The suppliers belonging to clusters 1 and 4 diverge in the following respects:

- FDI-type companies have much higher capabilities for product design as per requirements of the customer company as compared with JV-type companies belonging to cluster 1.
- Involvement in new product design for the customer company is much higher for FDI-type companies as compared with JV-type companies.
- Transfer of know-why part of technology is higher for FDI-type companies than for JV-type companies.
- Organizational resistance to change is higher for JV-type companies than for FDI-type companies.
- Flexibility of workforce for adapting to changing conditions is higher for FDI-type companies than for JV-type companies.

2.6 Concluding Remarks

Technology is a key strength for industrial competitiveness, a robust trade, and sound economic development. Developing countries with aspirations for overall growth can choose to participate and gain from the challenges of competing in the international arena. Glimpses of trends in international technology transfer hint that technology transfer often follows economic development. Building strong technological capabilities for enhancing competitiveness through inward technology flow is a positive measure, if the choices are made wisely

to achieve the requisite balance. International technology transfer is a highly concentrated and complex process in the context of international commercialization..

Several hurdles/barriers in the process of technology acquisition occasion a number of strategic risks in technology transfer projects. Hedging these risks in the planning and implementation of the technology transfer projects calls for suitable strategies which are discussed in the next chapter.

CHAPTER 3. STRATEGIES TO HEDGE RISKS IN TECHNOLOGY ACQUISITION

3.1 Introduction

From a delineation of the risks and clusters of vendors in technology acquisition in chapter 2, we move on in this chapter to a discussion of the strategies to hedge the risks in technology acquisition. Our deliberations here are based on an empirical study, a review of literature on the subject, and select case studies of SMEs in the Indian context.

3.3 Strategies to Hedge Risk

The predominant strategic risks in technology transfer are: technological risk, business risk, country risk, and organizational risk. The proposed strategies for hedging such risks in technology transfer projects are accordingly identified as (Bhardwaj, Sushil, and Sharma, 2005):

- Developing Capabilities
- Training Employees
- Developing Partnerships
- Extending Strategic Scope
- Choosing Appropriate Technology Valuation Model
- Choosing Right Mode of Technology Transfer
- Adaptation of Acquired Technology.

3.3.1 *Developing Capabilities*

A conceptual model has been developed relating the technological and people capabilities with the manufacturing process and, ultimately, the performance. The data is obtained through a tested instrument from 102 respondents (representing 85 automobile component manufacturing organizations in the Indian context). The Pearson correlation and step-wise regression analysis techniques have been used for testing the model (Khan, Sushil, and Haleem, 2008).

The correlation technique is used to measure the degree of association between two sets of quantitative data and it also helps in understanding the strength of the linear relationship between the two quantitative variables. In the present study, a correlation analysis has been carried out of all the four variables, viz. technological capabilities (TechCap), people capabilities (PeoCap), manufacturing processes (MfgPro), and performance (Perform) (see Table 3.1).

Table 3.1: Correlation of Key Variables

	TechCap	PeoCap	MfgPro	Perform
TechCap	1			
PeoCap	0.486**	1		
MfgPro	0.479**	0.572**	1	
Perform	0.382**	0.473**	0.622**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

From the data in Table 3.1, it is evident that performance has a significant correlation with technological capabilities (0.382**), people capabilities (0.473**), and manufacturing processes (0.622**) at 99% confidence level; And manufacturing processes have a significant relationship with technological capabilities (0.479**) and people capabilities (0.572**) at 99% confidence level. This shows that technology absorption is strongly dependent on an organization’s technological and people capabilities. Technology absorption leads to the enhancement of manufacturing processes in terms of innovation, flexibility, and improvement.

The step-wise regression of multivariate technique has been used to test the conceptual model as it has the advantage of presenting the large amount of complex data in a simplified and meaningful form. The analysis has enabled prediction of the variability in the dependent variables, based on its co-variance with all the independent variables. The purpose of performing the step-wise regression analysis is to examine the model’s statistical significance, showing the relationships of key variables presented in the conceptual model.

Performance as Dependent Variable

The coefficient of determination (R-Square) indicates that 38.7% variation in performance is explained by ‘manufacturing processes’. The beta value, which indicates a regression coefficient, gives the degree of association between performance and manufacturing processes as 0.622 (beta value). The ‘t’ statistic (7.939) tests the significance of the slope, which is equivalent to testing the significance of the correlation between dependent and independent variables (Table 3.2).

Table 3.2(a): Model Summary for Performance as Dependent Variable

	R	R-Square	Adjusted R Square	Std. Error of Estimate
Model				
1	0.622	0.387	0.380	0.3997

a Predictors: (Constant), MfgPro

Table 3.2(b): ANOVA for Performance as Dependent Variable

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	10.068	1	10.068	63.021	0.000
	Residual	15.975	100	0.160		
	Total	26.043	101			

a Predictors: (Constant), MfgPro

b Dependent Variable: Perform

Table 3.2(c): Coefficients for Performance as Dependent Variable

		Non-standardized Coefficients		Standardized Coefficients	T	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.165	0.304		3.826	0.000
	MfgPro	0.687	0.087	0.622	7.939	0.000

a Dependent Variable: Perform

Manufacturing Processes as Dependent Variable

The model summary, ANOVA, and coefficient summary, in terms of manufacturing processes as the dependent variable, are shown in Table 3.3 Two steps have been taken to compute the step-wise regression analysis for manufacturing processes as the dependent variable. The change in manufacturing processes due to people and technological capabilities can be explained by the R-Square (0.380). The higher the value of R-Square, the more accurate the prediction. The standard coefficient beta shows that the people capabilities (0.444) have more impact than the technological capabilities (0.263). The F-value (30.330) is statistically significant where technological capabilities and people capabilities are independent variables.

Table 3.3(a): Model Summary for Manufacturing Processes as Dependent Variable

	R	R-Square	Adjusted R Square	Std. Error of Estimate
Model				
1	0.572	0.327	0.320	0.3787
2	0.616	0.380	0.367	0.3654

a Predictors: (Constant), PeoCap

b Predictors: (Constant), PeoCap, TechCap

Table 3.3(b): ANOVA for Manufacturing Processes as Dependent Variable

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.969	1	6.969	48.586	0.000
	Residual	14.344	100	0.143		
	Total	21.313	101			
2	Regression	8.097	2	4.049	30.330	0.000
	Residual	13.216	99	0.133		
	Total	21.313	101			

a Predictors: (Constant), PeoCap

b Predictors: (Constant), PeoCap, TechCap

c Dependent Variable: MfgPro

Table 3.3(c): Coefficients for Manufacturing Processes as Dependent Variable

		Non- standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.612	0.272		5.937	0.000
	PeoCap	0.531	0.076	0.572	6.970	0.000
2	(Constant)	1.108	0.314		3.526	0.001
	PeoCap	0.412	0.084	0.444	4.905	0.000
	TechCap	0.277	0.095	0.263	2.907	0.005

a Dependent Variable: MfgPro

Technological Capabilities as Dependent Variable

Technological capabilities are affected by people capabilities. The variation of 23.6% (R-Square value) in technological capabilities is explained by people capabilities. The degree of association (beta value) with the dependent variable of technological capabilities is 0.486. The independent variable reduces the sum of squared errors by 22.8%. The F-value 30.843 (with 1100° of freedom) shows the highly significant relation of technological capabilities with people capabilities and explains the variation in technological capabilities. The model summary, ANOVA, and coefficient summary, in terms of technological capabilities as the dependent variable, are shown in Table 3.4.

Table 3.4(a): Model Summary for Technological Capabilities as Dependent Variable

	R	R-Square	Adjusted R Square	Std. Error of Estimate
Model				
1	0.486	0.236	0.228	0.3831

a Predictors: (Constant), PeoCap

Table 3.4(b): ANOVA for Technological Capabilities as Dependent Variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.527	1	4.527	30.843	0.000
	Residual	14.676	100	0.147		
	Total	19.203	101			

a Predictors: (Constant), PeoCap

b Dependent Variable: TechCap

Table 3.4(c): Coefficients for Technological Capabilities as Dependent Variable

		Non-standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.819	0.275		6.622	0.000
	PeoCap	0.428	0.077	0.486	5.554	0.000

a Dependent Variable: TechCap

Validated Model

The validated model of technology transfer for vendor organizations is shown in Figure 3.1. According to this model, people capabilities are the main driving force affecting technological capabilities and, in turn, manufacturing processes and performance. Thus, a valid strategy for hedging risk in technology transfer is to develop people and technological capabilities in the organization aspiring for the technology acquisition. This strategy will hedge the organizational risk and help in ensuring the technical feasibility of the technology transfer project. This strategy is evident in clusters 1, 2, and 4, as analyzed in chapter 2.

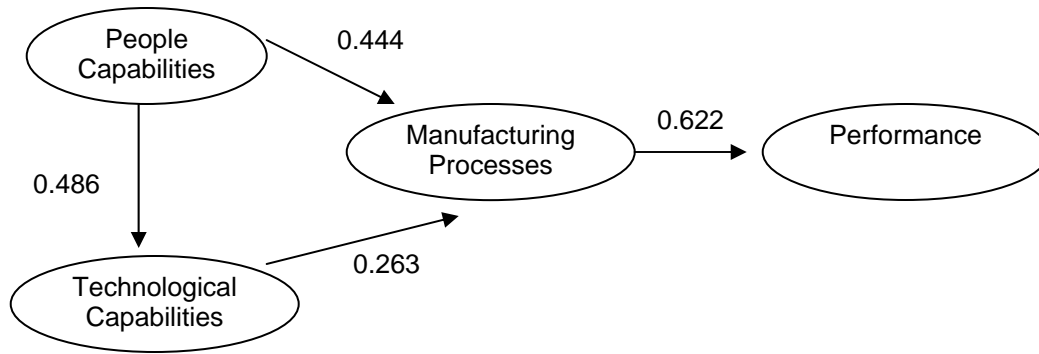


Figure 3.1: Validated Model for Relationship of Key Variables

3.3.2 Training of Employees

As is evident from the validated model in section 3.3.1, people capabilities are the major driver of performance. The training of employees acts as a cushion to absorb the shocks of technology transfer. In this fast-moving environment, the major objective should be to keep people abreast of change, increase productivity, and find new ways of offering a competitive advantage. As the world economy is getting more global and technologies more complex, cooperation between donors and recipients has become increasingly critical to successful technology transfers. Training employees is an investment for quality improvement, product innovation, and client service. From an employee's point of view, tailored training for high-tech jobs is appealing, because it directly promotes career development and her/his value to the firm.

Training for Technology Transfer

According to Gunnerson (1991), effective transfer of technology requires:

- Insistence by the host-country government that the transfer of technology takes place.
- Appointment of the most competent professionals as counterparts.
- Training resources amounting to an additional 15–20% in time and money during project identification and preparation.
- Due regard by expatriate engineering firms for the possibility that host country staff training is likely to be in the best strategic interest of the firms.

Katrien (2000), in his work on training and technology transfer in the field of information technology, reports that China will transfer state-of-the-art technologies from foreign companies, thereby reaching the level of industrialized nations. Such technology transfers always involve rigorous training and the passing on of all the requisite expertise. A key factor in a successful industry is the development of human resources. Investing today to create highly skilled teams for tomorrow is a vital exercise in the development of new products with a short

marketing time. China's major asset is the availability of highly educated people. The country's practice of training their highly skilled people in advanced design methodologies has been a critical factor in obtaining a competitive edge..

Training promotes growth as it generates increasing returns in production through the transference of knowledge, skills, and technology (de Mello and Luiz, 1997). The provision of training and the acquisition of skills have a positive effect on human capital accumulation and the diffusion for workers in recipient countries. Such healthy practices are also expected to be a potential source of productivity gains via spillovers to domestic firms.

Job Rotation for Enhancing Effectiveness of Training

How do human resource practices differ across Asian countries and how does this influence the innovation process? LeBlanc, Nash, and Gallagher (1997), while addressing the effects of job rotation of scientists and engineers in a large Japanese company, found evidence that frequent inter-functional transfers facilitate inter-functional knowledge. Do other Asian countries have a similar level of flexibility in job boundaries? Are some Asian countries more bureaucratic in their job descriptions, relying on narrower and more specialized tasks? Such relevant questions spurred them to probe another hallmark characteristic of Japanese companies; the use of inter-functional transfer as a way of providing broadbased training for employees. This practice allows employees to experience familiarity with the whole enterprise, breaking down the narrow functional myopia that has characterized bureaucratic organizations in the West. The study, which focuses on a large Japanese chemical company, provides a detailed pattern of such inter-functional transfers of 213 engineers.

Training and technology transfer projects require multidisciplinary consulting and advisory support, which may include courses and on-the-job training, but may also require twinning and other linkages between institutions for a more substantial transfer of skills over a longer period (Miles, 1999). The analysis offers several general lessons for engineers involved in international technology transfer, including:

- The importance of assessing local administrative, social, cultural, and regulatory instruments.
- Environments at the project design stage.
- The need for an open-minded approach to the choice of technology.
- The scope for working with and through the local private sector.
- Deciding on an appropriate mix of technical and management training.
- Applying the principle of sustainability through recognition of recipient autonomy and maintenance of contact between provider and recipient institutions to build confidence through collaboration.

3.3.3 Developing Partnerships

As was evident in clusters 1 and 4, the vendor organizations are involved as partners in the technology implementation, leading to the success of technology transfer. In the case of cluster 3, where the technology transfer took place through a passive licence agreement, the benefit was negligible.

Vendors depend heavily on the vehicle manufacturers for locating, acquiring, adapting, and implementing the technology acquired for manufacturing the components as per the customer's specifications. Here, the customer company plays a crucial role in facilitating the acquisition of technology whereas the vendors play an important role in the process of technology transfer. In fact, the vehicle manufacturers have a practice of outsourcing the components to the extent of 85–90%. Therefore, a large percentage of the technology is transferred at the organization's vendor level. Vehicle manufacturers in the developing countries, therefore, have to carefully monitor and help their own vendors in acquiring technology from the partnering organization's vendors. Technology transfer, therefore, can never be completely successful unless it is transferred effectively at the level of vendors also.

Sharing Design Work with Vendors

Wasti and Liker (1999) report that an increasing number of buyers share their design work with their suppliers. However, the outsourcing of design work has been relatively neglected in literature. Based on a survey of 174 US and 122 Japanese automotive component suppliers with product design capabilities, the study investigates the degree of supplier involvement in design and the factors leading to supplier involvement. The two strongest predictors of the extent of early supplier involvement in both US and Japan are the degree of technological uncertainty and supplier technical capabilities. Automotive companies are more likely to outsource design of high uncertainty and, to this end, select suppliers of high technical capability for design outsourcing.

Bidault and Despres (1998) report the results of an empirical study that probed the adoption of early supplier involvement (ESI) in the product development process. ESI is defined as a form of vertical cooperation in which manufacturers involve suppliers at an early stage in the product development/innovation process. Previous research has shown that Western automobile manufacturers obtained significant benefits by emulating the ESI practices of their Japanese competitors. A model of ESI adoption was developed and tested, and an ESI index was created to determine the degree to which this practice was applied. The results reveal that the level of ESI practice is strongly related to a higher number of supplier-based initiatives, lower product integration, broader supplier scope, and a higher proportion of parts purchased.

Involvement of Suppliers in New Product Development

Handfield and Ragatz (1999), in their study of suppliers' involvement in new product development, have given various supplier integration timings and supplier integration approaches. A process model for reaching a consensus of suppliers to integrate into a new product development project was suggested, as was identification of desired supplier capabilities and potential suppliers. Results of their survey show that the responding companies achieved a significant improvement in project results when the suppliers participated, whereas similar new product development projects in which suppliers were not involved did not fare as well.

A study on supplier development in the Malaysian automotive industry focuses on the organization Proton and its suppliers. The facts elicited that Proton and its vendor development programme play a crucial role in developing and extending comprehensive support to its supplier firms, such as contract R&D, financing, and marketing, and in promoting continuous performance improvement programmes. The relationship is cooperative and long-term in nature. The lack of technical capability, the reliance on bought-in technology, the protected environment, and limited volume for economies of scale are some of the factors that restrained the industry's competitiveness at the international level.

An important opportunity exists to proactively integrate suppliers from the inception stage right through the exploration and definition stages of product development (Bozdogan et al, 1998). Research suggests that the concept of architectural innovation can be so extended as to match a product feature with the associated specialized technical skills of partners in the development teams. In addition to the establishment of integrated product teams, key enablers include: long-term commitment to suppliers; co-location; joint responsibility for design; seamless information flow; and retaining flexibility in the definition of system configuration. Bates and Twigg (1997) focused on the approach of Western automotive companies to the management of their design chain that assesses the supplier's role as a source of component design expertise.

Long-term Relationship between Suppliers and Customers

Helper and Sako (1995) point out that long-term relationships between auto-makers and their suppliers have performance advantages in both the US and Japan. Although such high performance relationships with customers are still more prevalent in Japan than in the US, the nature of supplier relations in the two countries is converging in some respects. The survey includes more than 600 automotive suppliers in the US and almost 500 suppliers in Japan. Magretta (1998), in his study on the supplier's involvement, reports that in the 1980s the focus was on supplier's partnerships to improve cost and quality. In today's faster-paced markets, the focus has shifted to innovation, flexibility, and speed. Handfield et al (2000), in their study on supplier development, suggest that, for an integrated supply chain, it is best to view supplier development as a long-term business

strategy. Further, it is estimated that 20% of the suppliers are responsible for 80% of the poor performance. A road map for supplier development is identified. Specific supplier pitfalls are identified as the lack of supplier commitment and insufficient supplier resources. Specific buyer pitfalls are also presented. Treleven (1987), in his study, emphasizes that buyers understand the factors that are likely to motivate a vendor to enter into a long-term relationship.

MacDuffie and Helper (1997), in their paper, address questions such as ‘Should a customer try to create a lean supplier? Should suppliers agree to work with those customers pursuing this goal?’ Both suppliers and customers can benefit from entering into the kind of knowledge transfer agreements described in the Honda case in the study. However, the specific mechanism chosen by Honda is far from the only way in which such a knowledge transfer can take place. Where knowledge transfer mechanisms require highly customer-specific investments of time and capital without a long-term commitment from the customer, the risk for suppliers may be unacceptably high.

3.3.4 Enlarge Strategic Scope

It would be risky to restrict the application of technology to a narrow product–market combination. In the event of reduction of demand in that segment, the business risk will be very high. A sound strategy would be to enlarge the strategic scope to a number of potential product–market combinations as a possible future extension of the technology application. This might require a premium for enlarging the strategic scope, but will hedge the business risk substantially.

3.3.5 Choosing Appropriate Technology Valuation Model

For hedging the risk in technology transfer, appropriate technology valuation models should be chosen. A discussion on this is provided in section 4.4 while discussing the technology valuation models which take care of various types of business risks such as foreign exchange risk and interest risk.

3.3.6 Choosing Right Mode of Technology Transfer

An important issue in international technology transfer research centres on reasoning why firms choose a particular mode of technology transfer. The factors advanced in the literature focus on a firm’s resource dependencies and transaction costs (Kumar and Cray, 2002). Researchers believe that the mode of technology transfer is embedded in managerial, political, social, and national contexts. The objective of the study was to identify factors considered for different modes and explain the contingencies under which either set of factors would drive a particular choice. Specifically, the study evaluated the factors affecting international licensing agreements and joint ventures in India and Turkey. Results from the study indicate that licensing was the

popular mode of transfer. The contingent factors were government policies and the donor's resolution influence. The joint ventures were established when the recipient's resources were weak (resource dependency high), when top management was committed to faster growth, and when donors had invested significantly in R&D. An important factor underlying joint ventures, especially for a related technology of technical complexity, was that these technologies were coalesced with the participants having past experience of sharing common technology with a recipient.

In the case of cluster 1, the technology transfer was conducted by joint ventures, whereas clusters 2 and 3 resorted to technology licensing agreements. In cluster 4, the technology transfer took place through FDI. Thus, the adoption of the most appropriate mode of technology transfer depends on the characteristics of the organizations in the cluster.

The term *technology transfer* implies the movement of technology from the technology-owning entity (the transferor) to another; and if the transfer is successful, it results in the proper understanding and effective use of the technology by the receiving entity (transferee) (Ramanathan, 1995). This paper deals with the elaboration of a procedure that could be used by buyers or transferees of technology in the manufacturing sector of developing country firms, in the formulation of effective TTAs. The procedure prescribes the undertaking of three stages: the motivation scrutiny stage; the technology component specification stage; and the transfer mechanism selection stage. It is argued that, once a particular technology and potential transferors for its supply have been identified, the adoption of the proposed approach could enable the transferee to generate valuable information for increasing its power at the negotiation stage..

The risks in technology transfer are always very high and the failure rate is also substantial, but a management committed to viable technology transfer must be tolerant of failures. The organization and human resource aspect of technology acquisition must be planned and executed with great care. Technology transfer should become part of the organizational culture for progressive firms. All technologies are subject to refinement and have scope for further innovation. The decision in respect of technology acquisition needs to be made at the propitious time; else one may lose the opportunity to gain from the technology to its fullest extent. The top management who has an important role to play in technology acquisition decision-making must establish the need and suitability for a particular technology within the organization (Husain and Sushil, 1997, 2000; Husain, Sushil, and Pathak, 2002).

Joint venture provides an effective mode of technology transfer when the technology is to be transferred from a single source. This also hedges the financial risk as the technology provider becomes an integral part of the new

venture, and some funding may also be provided along with the technology. Since the technology provider has an equity stake, it jointly works to cover up various types of strategic risks such as technology risk, business risk, and organizational risk.

On the other hand, in cases of technology acquisition from multiple sources, the major mode of transfer is that of technology licensing. In the case of vendor organizations supplying the components to the product manufacturers, the partnering of the customer organization is helpful in hedging the technology and business risk.

3.3.7 Adaptation of Acquired Technology

A technology that is acquired from a different milieu may not necessarily be a complete fit in the new setting. Thus, a good strategy to counter the technology and business risks is to suitably adapt the acquired technology. This increases the chances of success of the acquired technology.

Adaptation of technology is a phase that starts after the technology has been adopted and put to use in production activities or facilities. During this stage, a number of alterations and modifications have to be made to suit the indigenous conditions, and these changes may relate to the use of raw materials/components manufactured, practical difficulties of scaling up or scaling down operations, modification of design from the ergonomic and economic viewpoint, manufacturing systematization, etc. In so doing, the firms aim at improving the quality, changing the physical properties, increasing the reliability, integrating their products, meeting the desired production capacities, and other related aspects as planned. The adaptation exercise covers both product modifications and production technology changes, using indigenous skills and facilities as well as local materials.

Internal Capabilities of the Technology Recipient

In the absence of industrial technological capabilities, technology development cannot flourish (Rosenberg and Frischtak, 1985). Companies with successful experience in technology acquisition have come to realize that a minimum level of technological competence is required, not only to modify and adapt foreign technology to local needs, but also to provide the basis of an intelligent selection from the wide range of suppliers. The proper selection of alternative technologies available from abroad requires a considerable amount of technical knowledge, which is difficult to acquire in the absence of any domestic experience. Proactive technology management can accelerate the acquisition, absorption, and diffusion of imported technology; improve the firm's bargaining power; enhance their ability to make independent technological choices; enable them to improve and innovate upon chosen techniques; and eventually generate new in-house technology.

Sen and Rubenstein (1990) draw attention in their study to the many possible roles that in-house R&D can play to alleviate problems associated with a firm's external acquisition of technology.. Involving in-house R&D in the external technology acquisition process can increase the effectiveness of the process. Bowonder (1998) presented a case study of TELCO (Tata Engineering & Locomotive Company, India, now known as Tata Motors), which has become the largest commercial motor vehicle manufacturer in India, using a long-term competitive and technology management strategy. The author identifies the major focus of technology management at TELCO as intensive R&D, stating that other influencing factors are concurrent engineering, standardization, and integration of manufacturing and design.

In-house Development and External Acquisition

External technology acquisition has two qualitative different goals; to shorten development time, and thereby reap short-term profits (short-term strategy), and to maximize long-term profits over the life of the innovation (long-term strategy). The analysis suggests the dominance of the former strategy (Kurukawa, 1997).

Further upgrading of an existing technology is basically an indigenous task. There is little evidence to show that any firm has achieved a significant success in the long run depending solely upon foreign technology. Japanese companies have frequently been recognized as the most outstanding procurer of foreign technology. The positive gains they achieved from such acquisition may be attributed to the sizeable funds they spent on domestic R&D and their highly absorptive capacity for mastery of the functioning of the imported technology. According to Ozawa (1985), Japan is well known, since the late 1960s, as a country extremely capable of further developing, adapting, and commercializing foreign technology.

Import and Adapt Strategy

Katrak (1985) considers the strategy of importing a technology and then adapting it to suit local conditions as 'import and adapt' technology (IAT) strategy. His paper examines the following two questions: First, does the IAT strategy stimulate local R&D? And second, does the expenditure on adaptive R&D differ between large and small, indigenous and foreign-owned, private and public sector enterprises? He considered the import of capital goods and royalty payments as variables representing technology imports. His main conclusions were, first, that the import of technology did stimulate in-house R&D but its magnitude was limited, and the effect was weaker for more complex technologies. Second, larger enterprises undertook proportionately less R&D than smaller ones.

3.4 Case Studies on Technology Transfer

Three different case studies of suppliers belonging to three important clusters were conducted to verify the findings of the study reported in chapter 2 and to further compare the actual characteristics of these organizations with the strategies to hedge the risks in technology transfer (Bhardwaj, Sushil, and Sharma, 2007).

3.4.1 Case Study I

This case study is of a leading automotive supplier Subros Limited, which was established in the year 1985 in technical and financial collaboration with Denso Corporation, Japan, to manufacture automotive air-conditioning systems. Subros' first customer was Maruti Udyog Limited (MUL), a leading Indian vehicle manufacturer, which continues to be Subros' largest customer even today. Subros has grown physically in terms of turnover, number of plants, and units produced. The company has grown and matured also in terms of technology absorption, widening of the customer base, and creation of world-class systems.

Ever since its operation in India from 1986, Subros has been continuously upgrading its technology with assistance from Denso, Japan, to meet all performance requirements of the Indian automotive car industry. Denso provided Subros with all the know-how on designs, production processes, quality procedures, inspection methods, and Denso standards. However, Subros' efforts in getting state-of-the-art technology from Denso met with resistance. For instance, Denso has not transferred the technology for the air-conditioners fitted in the Baleno car being manufactured by MUL. Perhaps Denso's intentions of setting up its own plant in India are behind its reluctance to part with this technology.

Although the production volumes of Subros are sufficiently high to meet the ever-increasing requirements of its principal customer MUL, yet these are lower than the global standards and the volumes of its technology provider, Denso Corporation, Japan. However, the primary importance Subros gives to R&D and engineering have refined its skills for developing and manufacturing its own products for its customers.

For specific product development for customers like MUL, the collaborator's facilities are being extensively used. Subros is closely involved with its customers in the product design for developing their products and gives complete solutions to its customers as per their requirements. The customer company provides the broad framework and layout of the space where the parts are to be fitted, but the remaining design parameters are chosen by Subros in consultation with its collaborators. Subros gets a fair level of help from the customer company's R&D department also for this activity, but the major design work is undertaken by Subros and its collaborators (Figure 3.2).

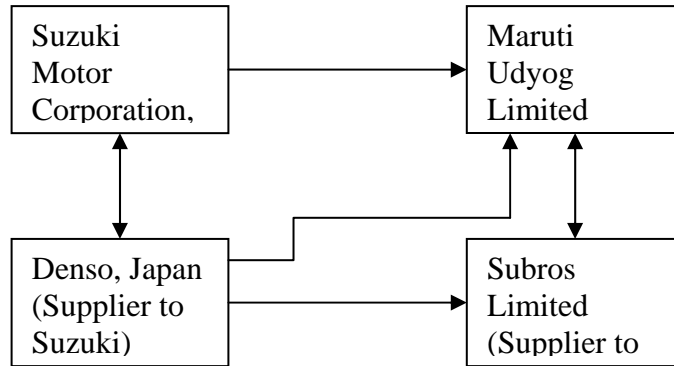


Figure 3.2: Flow of Technology

Support from Customer Company

Subros' customer base has expanded over the last two decades: from supplying components for only 800 cc cars in 1985 (the year of its inception) to complying with the requirements of all models of Maruti and TELCO as well as other OEM's such as Hindustan Motors and Bajaj Trax. Subros received extraordinary and ongoing encouragement from MUL in acquiring the new technology and also unstinting help in adapting the technology to local conditions, which has encouraged Subros to invest more in plant, machinery, and R&D activities for Maruti's products. However for any change in the design, the company has to get approval from its collaborator.

Subros also received support from MUL for locating the technology provider, Denso of Japan, which is a reputed supplier to the Suzuki Motor Corporation. Maruti Udyog Limited not only identified this technical collaborator for Subros, but also extended all help for the tie-up between the two companies, which turned out to be a win-win situation for all the players concerned, as discussed below:

- i) Maruti Udyog Limited started receiving regular supplies of high quality products from Subros at a time when there was no well-developed vendor with capabilities for the manufacture of world-class air-conditioners. This need was answered with the technical and financial tie-up between Subros and Denso. MUL's proximity to the Subros plant, which is set up at Noida, was another advantage as it helped Maruti Udyog to reduce its inventories with high-quality consistent supplies. Maruti therefore has benefited from its commitment to Subros of a long-term relationship.
- ii) This tie-up benefited Subros as it received world-class technology from Denso Corporation of Japan. "Had this tie-up not been there, Subros would not have been at the level where it is today," admits Subros' General Manager (R&D)..Subros gained the following long-term advantages because of this tie-up:
 - State-of-the-art technology from Denso.
 - A reputation in the market for developing high quality air-conditioners for automobiles.

- Expanding its customer base: from MUL to several other vehicle manufacturers.
 - A big boost for its R&D department which also gained experience for developing new products for other customers.
 - Tie-up between Subros and Denso proved to be a launching pad for Subros' speedy growth: over the last 20 years its turnover has multiplied many times.
- iii) Denso Corporation, Japan, benefited from this tie-up in the following ways:
- Denso gained financially by virtue of its financial partnership with Subros and received extra royalties for transferring its technology to Subros, as per the TAA signed by the two companies.
 - By way of this tie-up, Denso had exposure to the Indian market and discovered the potential of their product under Indian conditions.
 - Denso expanded its business in India by entering into another collaboration in India -- with the 'Kirloskar' group, located at Bangalore, for catering to the needs of Toyota's unit in India and also for exporting their products to other countries. Denso was able to engage in yet another collaboration with the 'Sanden' group at Faridabad for manufacturing air-conditioners.
- iv) Suzuki Motor Corporation also benefited as it had a financial stake in the tie-up. Also, Suzuki was pleased that Denso, its leading supplier, was growing in India alongside itself.

Today, Subros' customers, apart from MUL, include Tata Motors, Hindustan Motors, Bajaj Tempo, Honda Siel, and other leading vehicle manufacturers.

3.4.2 Case Study II

This case study deals with JCBL Ltd., which was incorporated as a company in the year 1989 for the manufacture of high-quality Japanese technology coaches for Swaraj Mazda's buses, ambulances, and load carriers. Swaraj Mazda, an LCV manufacturing Indo-Japanese JV company and JCBL's major customer, has entrusted the manufacture of 95% of their buses to JCBL. By diversifying into the manufacture of several high quality luxury coaches, motor homes, trailers, special utility vehicles, and cargo boxes, JCBL has today evolved into a successful automobile company. Its automotive parts are widely considered at par with the finest in the industry and have the advantages of superior quality and efficient performance.

JCBL's Technical Tie-Ups

JCBL entered into TAAs with the following companies in order to upgrade its technology by diversification and launching of new products:

1. Auto Parts Manufacturers (APM) of Malaysia
2. King Long United Automotive Industry Co. Ltd of China
3. Tantri Pvt. Ltd. of Sri Lanka

In May 2001, JCBL entered into a TAA with Auto Parts Manufacturers (APM), Malaysia, for the design and manufacture of luxury coach seats. Regarded as one of the world's best manufacturers of luxury coach seats, APM has recently been honoured with Ford's world excellence award for quality and delivery.

Another technology partner of JCBL, Tantri of Sri Lanka has experience in the manufacture of a wide range of high quality trailers. Tantri's expertise in this field has helped JCBL consolidate its trailer manufacturing facilities. Established in 1982, Tantri Pvt. Ltd. is a pioneer in this specialized field and commands considerable respect in the Sri Lankan automobile industry.

King Long United Automotive Industry Co. Ltd. has proved to be an able partner in the manufacture of integral coaches. Ranked the leader among over 160 bus manufacturers of China w.r.t. turnover and per capita output, King Long has shared its know-how and technical expertise with JCBL. Through various training programmes and a healthy exchange of information, JCBL has expanded its knowledge base and grown from strength to strength.

Customer's Role in Building JCBL's Technological Capabilities

Swaraj Mazda, the customer company of JCBL, played a vital role in providing and continuously upgrading technology. From the beginning, a team of experts from Swaraj Mazda worked at JCBL for a few months until the vendors of JCBL grasped the new expertise, and the production line was set up in every respect. Swaraj Mazda provided JCBL with details of designs, drawings, materials, processes, and machinery, and had the advantage of close proximity to this supplier.

Within three to four years, JCBL started producing the coaches for all the existing models of Swaraj Mazda. Until then,, only the conventional type of coaches had been available. JCBL made further progress by acquiring capabilities for developing tailor-made coaches to produce interiors as per the requirements of Swaraj Mazda's customers. The development of mobile vans, police stations, railway electrification vans, ambulances, mobile offices, etc. is testimony to the flexibility this company gives to its customers. JCBL's success story would never have been written without the active support of different departments of Swaraj Mazda, especially the R&D wing, which helped in reducing costs and making vehicle fuel-efficient by substituting the metallic front and rear with FRP. The substitution of the former metallic sheet with the more flexible FRP reduced costs for the customers as the earlier expenses on the costly tooling/dies were eliminated and the flexible FRP sheet could take any chosen shape, thereby enhancing the aesthetic appeal and reducing the weight.

In-House Efforts for Development of Suspension System

In the year 1999, JCBL entered into a TAA with Chalmers Suspensions, of Canada for the acquisition of their Pneumatic Suspensions Technology. Technological know-how for pneumatic suspensions was transferred by passing on drawings, process designs, information about raw materials, etc. JCBL engineers were sent to Chalmers, Canada, for training which focused on the production process for suspensions and familiarity with the design standards. But this tie-up between JCBL and Chalmers was shortlived as the Canadian pneumatic suspensions did not work well under Indian conditions due to technical snags. Later,, JCBL engineers worked diligently to develop the pneumatic suspension indigenously by circumventing the problems in the Chalmers design. Their renewed efforts to independently launch the improved product in the market met with success. Today JCBL has the capability to design suspension for any type/make of chassis. Apart from Wheels India (of the TVS group), JCBL is today the only other company in India to manufacture pneumatic suspension..

Acquisition of Technology for Luxury Seat Manufacturing

In May 2001, JCBL entered into a TAA with APM, Malaysia, for acquiring state-of-the-art technology for the design and manufacture of luxury coach seats. The top management of APM and JCBL had already been closely associated, and these bonds paved the way for their TAA. For this technology acquisition. experts from JCBL went to Malaysia to select a few models of APM's luxury seats, which would suit the anthropometric data of the Indian population. Engineers from JCBL were then sent to APM for training in designing these models as per the APM design standards. The DGM of the plant says, "We have found APM to be a very cooperative and sincere partner. Design capabilities for designing the seats on specially designed APM software were also transferred to JCBL. Our engineers gained capabilities for designing and analyzing the seats in the virtual environment." This tie-up differed from others in that the know-why of the design was also transferred. The major benefits to JCBL have been: (i) association with the world-renowned seat manufacturing company APM; (ii) acquiring design and testing capabilities for luxury seats; and (iii) an enhanced customer base. JCBL is paying royalty to APM at 2% per annum of the sales value.

Testing equipment for checking the functioning of the seats under different conditions is also developed at JCBL. Experts from APM were deputed to set up the testing facility. The complete process design for these seats, including drawings, bill of materials, production processes, and special tooling, was also transferred. However, the proposed manufacturing processes were adapted to suit local conditions, focusing largely on cutting down the cycle time and the cost of tooling/dies involved. Tool design concepts were also acquired from APM as a part of the technology acquisition process. This licence agreement was renewed in the year 2003. Since then, it has been a practice for a group of JCBL employees above the engineer grade to visit APM every year for a 2-3 week training course. On their return to India, these employees, in turn, pass on their new skills to

their colleagues at different levels, including workers. Initially, a team of experts from APM had visited JCBL to personally set up the production process and hold discussions with suppliers for ensuring that products met APM's specifications. The company acquired TS 16949 certification in the year 2003, which helped streamlining the production and other documentation involved and put the quality system in place. APM has always been prompt in providing JCBL with information and assistance whenever required.

Importing Chinese Technology for Manufacturing Integral Luxury Coaches

In the year 2002, JCBL entered into a TAA with King Long United Automotive Industry Co. Ltd. of China for acquiring technology for the manufacture of integral coaches (Model 6113). King Long has designed these integral coaches by incorporating innovations in the body design, engine, chassis, and body manufacturing technology, offering low maintenance costs and superior fuel efficiency. It is the first bus in India to gain full approval from the Automotive Research Association of India (ARAI) for the entire vehicle. Equipped with a Cummins C245 HP UK-made diesel engine, a Holland Neway (U.S.A.) air suspension system, and a host of other distinguishing features, the integral coach 6113 provides luxury, performance, and reliability. Through various training programmes and a healthy exchange of information, JCBL has been able to expand its knowledge base as an outcome of this agreement, and King Long has proved to be its valued partner.. JCBL is currently importing the kits comprising complete chassis parts, including engine, transmission, suspension, and other spare parts, which are being assembled here. Coaches for the vehicles, including seats. are being fabricated at JCBL. A series of vehicles comprising the initial production has been supplied to the State Road Transport of Andhra Pradesh and of Tamil Nadu, and customers have so far been satisfied with their performance and quality..

As a part of the technology transfer exercise, a team of experts from King Long visited the plant at the outset, to set up the assembly and body fabrication line, and personally supervise production of the first few vehicles. This exercise helped the local engineers, technicians, and workers to learn the assembly and production features. Complete drawings of the vehicle body, along with assembly and fabrication processes as also operation manuals, were transferred to JCBL which is currently producing only 1-2 vehicles per month due to the vehicle's steep cost.. However, once the product's quality and reliability are established in the market, sales are expected to soar and provide the impetus to higher production.

Some of the problems JCBL is facing in this tie-up are mentioned below.

- i) Since most of the drawings and operation/assembly manuals supplied by King Long are in Chinese,,the JCBL engineers had difficulty in reading the drawings. However, employing Chinese interpreters could solve this problem.

- ii) Sometimes some of the components, which are a part of the kit supplied by King Long, are defective. JCBL replaces these components with Indian substitutes, if these are available in India. Otherwise, the company has to await the arrival of fresh components from China, wasting time and resources due to delay in shipments.
- iii) Sometimes some of the parts supplied by King Long are found to have crossed the expiry date. These parts may meet all other specifications and may therefore be in perfect working order, but JCBL prefers to request King Long for fresh parts so as to maintain the vehicle's high standards, although company time gets wasted in this exercise.
- iv) On a few occasions, JCBL encounters some snags during the vehicle's final inspection, which may require only minor adjustments. But if its experts are unable to rectify these problems, the King Long experts who are immediately alerted provide the solution. If the problem still persists, then qualified personnel from King Long visit JCBL to settle the issue in person. The same procedure is followed if JCBL mechanics face problems while providing maintenance/service to the customers.

3.4.3 Case Study III

This case study deals with the company XYZ, which was incorporated in the year 1989 in the state of Punjab. The name of the company has been kept confidential as requested by its top management, keeping in view the nature of the issues covered. The business involves the manufacture and assembly of mainly sheet metal pressings and turning components, etc. for several industries, including automobiles (two and three wheelers, passenger cars, LCVs, trucks, and tractors, etc.), and electrical, electronics, and consumer appliances. XYZ entered into a licence agreement in the year 1999 for the transfer of technical know-how for manufacturing jacks and pedal assemblies for the different models of one of its customers, ABC. The licence agreement partners in this case are leading component-manufacturing companies of U.K. and Spain, which are worldwide suppliers for the customer company, ABC. These tie-ups were negotiated, as ABC insists that its suppliers have a TAA with its worldwide suppliers for access to world-class technology. The company is OE supplier to Ford Motor Company (India), General Motors India Ltd, Maruti Udyog Ltd., Honda Sael Cars India Ltd, Mahindra & Mahindra Ltd., and Swaraj Mazda.

Customer's Interest in the Tie-Up

It may be concluded that of the three parties involved in this contract, i.e. licensor, licensee, and customer company, it is the customer, i.e. ABC, that was responsible for wrapping up this agreement. The customer in this case has the following interests:

- Keeping quality and standardization of the components on a par with worldwide standards.

- Helping their original worldwide suppliers financially in terms of royalty payments, since those suppliers have the sole rights over the designs of the components.
- Since the labour costs in India are much lower than in developed nations, the overall production costs in India remain quite competitive. Even their worldwide suppliers may not supply the components at the costs quoted by their Indian counterparts.

Customer's Support

It was in the mid-80s that XYZ started growing technologically by being appointed supplier to vehicle manufacturers like Maruti Udyog and Swaraj Mazda. Being Japanese collaborations, Maruti Udyog and Swaraj Mazda were much ahead of traditional customers in their requirements and expectations. Accordingly, representatives of customers like Maruti Udyog and Swaraj Mazda made it a practice to visit XYZ's plant to assist in developing their products to meet the desired quality levels. After attaining a certain level of technological competence, the organization's growth remained steady. In the late 90s, XYZ upgraded its tool room facility with the addition of CNC lathe and milling machines, CNC wire cut, and CNC machining centre, etc. This helped in providing flexibility and boosting productivity of the tool room for developing tools such as dies, jigs, fixtures, and gauges. XYZ further enhanced its productivity and streamlined/developed systems by adopting ISO-9000 certification. Another landmark in XYZ's history was when it became supplier for ABC.. It was ABC's insistence on a licence agreement with their worldwide suppliers that helped to upgrade XYZ's services. After these tie-ups, the next step that further strengthened the internal system was getting QS 9000 certification. Recently, the company has got TS 16949 certification also.

Most of today's vehicle manufacturers expect their Tier-1 suppliers to get TS 16949 certification. Even the sub-suppliers of XYZ need approval by ABC. XYZ is now preparing to get Q1 certification, which is given by ABC to only those suppliers that maintain the minimum prescribed limits for meeting quality standards and supply deadlines. When a supplier conforms to these prescribed limits continuously for a minimum period of six months, then Q1 certification is granted for an initial period of three months only. If, in this testing period, the supplier fails to meet these conditions even once, then certification is withdrawn and the supplier has to qualify again for certification..

Whenever XYZ has faced any problem, ABC has been ready to help. Also, whenever XYZ received no response to urgent requests for information from the licensor,,then ABC intervened to get that information without delay. Another area where ABC provided valuable help to XYZ was when representatives of the licensor company visited XYZ for audit of the processes for the new pedal set under development. After scrutiny of the processes, the licensor team listed 72 significant characteristics of the product that required to be incorporated by XYZ into

their record of data. After ABC's discussion with the licensor team, about 30 of the less important characteristics were eliminated from the original list of 72. This is because, under Indian conditions where production volumes are far lower than international standards, the exorbitant expenses that XYZ would have to incur to keep track of these 30 characteristics in the form of sensors or other instrumentation would increase the product cost which, as they pointed out, was unwarranted in the light of the relative insignificance of these characteristics. ABC's convincing presentation of the requirements facilitated XYZ's acquisition of technology and thereby clinched the licensing agreement for them.

3.4.4 Comparison of Case Studies

A comparative analysis of the three case studies reported in the previous sections is given in Table 3.5. These cases belong to clusters 1, 2, and 3 respectively, as presented in chapter 2. In the case of technology transfer from one source only, joint venture is used as the mode of technology transfer, whereas in cases 2 and 3 the technology acquisition is conducted from multiple sources and thus licensing is used as the mode of technology transfer.

Table 3.5: Comparative Study of Characteristics for Different Case Studies

	Subros Limited	JCBL Limited	XYZ Company
Type of Tie-up for Technology Acquisition	Joint Venture	Licensing	Licensing
Cluster	1	2	3
No. of Tie-Ups	01	03 (currently)	02
Major Customers	Maruti Udyog	Swaraj Mazda	Maruti Udyog, Ford (India)
Whether Tie-Up was Suggested by Customer Company	Yes	No	Yes
Whether Tie-ups Resulted in Significant Technology Upgradation	Yes (Very high)	Yes (Medium)	Yes (Low)
Major External Sources for Technology Upgradation	Joint Venture Partner, Customer	Customer	Customer
Whether Tie-Up Done for Manufacturing Components for Customer Company	Yes	No (Open market)	Yes
Whether Know-Why was Transferred	No	Yes (In one tie-up and to very limited extent)	No
Whether Donor Company Entered or has Plans to Enter the Indian Market Independently	Yes	Yes (Planning)	No
Donor Company's Interest	Very high	Medium	Low

in Tie-Up			
Primary Driving Force for Tie-Up	Technology upgradation	Diversification for different products	To fulfil one customer's requirement for becoming supplier
Whether Company Fears Threat from Donor Company in Form of Competitor	Yes	Yes (In one tie-up)	No
Whether Company had Experience Prior to Tie-up	No (Company started as joint venture)	Yes (8 Years)	Yes (More than 15 years)

3.5 Conclusions

The following conclusions have been drawn from this study:

- People capabilities are the main driving force in the development of technological capabilities, manufacturing processes, and ultimately the performance.
- The important strategies to hedge risk in technology transfer are:
 - Developing Capabilities
 - Training Employees
 - Developing Partnerships
 - Enlarging Strategic Scope
 - Choosing Appropriate Technology Valuation Model
 - Choosing Right Mode of Technology Transfer
 - Adaptation of Acquired Technology
- Vehicle manufacturers, who launched their products in the early 1980s, played a vital role in giving an initial thrust in the upgrading of the technological capabilities of the Indian suppliers. In fact, these vehicle manufacturers focused on developing the skills of these suppliers indigenously, and in a few cases the suppliers were asked to engage in joint ventures with their worldwide supplier. The manufacturers took a personal interest in the development of the suppliers by sending their expert teams to the suppliers from time to time, and today those suppliers are big names in the Indian automotive supplier industry.
- Most of the suppliers, who were earlier nurtured by vehicle manufacturers like Maruti Udyog, Hero Honda, and Swaraj Mazda, tried to expand their customer base in the mid-1990s and gain access to the latest technology by entering into TAAs with the worldwide suppliers of the customers like Ford Motors, General Motors, and Toyota.
- Most of these new players entered the market independently and had the option of sourcing the components either directly from their worldwide suppliers or through only those local suppliers that have TAAs with their worldwide suppliers. Hence, a number of forward-looking suppliers entered into TAAs.

- Most of the Indian suppliers have adapted their production processes to suit the low production volumes prevailing in India. International standards that require hi-tech instrumentation in the process control and integration of different processes in a single stage are not economically feasible. Also, the production processes employed under Indian conditions are manual in nature rather than the highly automated ones being employed by worldwide suppliers.
- The involvement of donor companies and their commitment towards transferring technology and the level of their subsequent help for problem solving is much higher in the case of joint ventures as compared with TAAs. Therefore, any supplier acquiring technology through TAAs must weigh its internal capabilities before entering into an agreement. In fact, the success of TAAs depends upon how the recipient company judiciously adapts the technology before implementation.
- Certifications like QS 9000 and TS 16949 have also played a role in establishing the systems and streamlining the suppliers' documentation and have reduced the earlier communication gap between suppliers and vehicle manufacturers.
- Sending employees for training and upgradation of their skills is a regular feature of the suppliers belonging to clusters 1 and 4, i.e. JVs and FDI-type suppliers, whereas its level is much lower for suppliers belonging to cluster 2, i.e. those that have entered into TAAs on their own initiative, and it is lowest for suppliers belonging to cluster 3, i.e. those that entered into TAAs in order to fulfil their customer's conditions.
- The extent of suppliers' involvement in the new product development and the vendors' capabilities to adapt and absorb the technology is very low, especially for suppliers belonging to clusters 2 and 3. Only a few vendors belonging to cluster 3 are involved in the product design work, and a majority of vendors with these capabilities belong to cluster 4.
- Most often, donor companies are reluctant to divulge the details of the engineering designs of the product/components. What they transfer is only the process design of the product/components along with drawings of the components/assemblies and empirical standards for functions such as Production, Quality, and Design and Testing. All this forms a part of the know-how for technology, but the important know-why of these aspects is not transferred.

,

CHAPTER 4. TECHNOLOGY VALUATION MODELS

4.1 Introduction

In view of the strategic risks in technology transfer and the strategies to hedge these risks, technology valuation models are proposed in this chapter. These models should prove useful to technology providers, technology acquirers, and financial institutions in assessing the strategic risks in technology transfer. First,, issues related to selling and acquiring technology are outlined to serve as a backdrop to the evolution of the technology valuation models. Next, a case study on technology valuation is provided as a guideline for the implementation of these models. Finally, a framework is provided as an overview of the appraisal process undertaken to value the technology.

4.2 Selling/Acquiring Technology

The selling and acquiring of technology are complementary processes. In order to capture the intricacies of technology transfer, it would be appropriate to first deliberate the issues linked with the selling of technology and then critically examine the process of technology acquisition.

4.2.1 Why Sell Technology?

In order to plan and implement technology transfer effectively, it would be appropriate to understand why an organization would be interested to sell its technology for the benefit of others. The reasons for this could be reactive or proactive. Some of the reasons for reactive selling of technology could be:

- The technology may be spare, i.e. it isn't needed for one's own business. Technologies peripheral to the core business, whether as a result of a refocused strategy or of accidental development, are typical candidates for sale.
- Even with a tight and consistent focus, mainstream R&D can still produce unwanted technology.
- A better option may be to hand over a critical technology to someone more able to develop it.
- It may reduce commitment to supporting the technology's development, financially or otherwise.
- The realization that technology is valuable, and that its sale can bring in worthwhile income, particularly if revenues are tied to royalty payments, is another inducement.

Some of the important reasons for proactive selling of technology could be:

- For financial gain..
- To support the core business.

- To gain strategic leverage.

4.2.2 Managing Sale of Technology

Strategic Guidelines: some don't's

- Don't sell technologies that are not fully proven.
- Don't develop technologies just for commercial sale.
- Don't attempt to broaden the scope of the sale by getting involved in equipment manufacture or procurement.

Implementation Guidelines

- The seller needs to encourage sound customer relations and generate adequate information feedback without being drawn into providing excessive support and help.
- Payment for technology know-how is often in two instalments. The first instalment is a combination of fixed fee and ongoing royalty payment, dependent on the product or process technology sold. The second instalment is a per diem fee for additional technical support and consultancy services.
- Seller and buyer establish a user club to maximize the exchange of technology information and to set objectives and provide the resources needed for further technology development.
- To keep the risks low, contracts are structured to transfer liability to the contractors, and care is taken to select and work with reputable contractors.

4.2.3 Matching Technologies to Strategic Objectives

- Ensure key and pacing technologies that provide scope for differentiation. These should not be sold lightly.
- Include base technologies that are essential for the business but provide little scope for differentiation. These can be sold readily, but there is less market demand for them.
- The design know-how of engineers, designers, and draughtsmen is really a key technology, but it merits separate attention here because it cannot be readily parcelled for sale.

4.2.4 Acquiring Technology

Some of the critical questions pertaining to effective technology transfer for an acquirer of technology are:

- Why should one consider acquiring technology at all?
- What might one consider acquiring under different circumstances?
- From whom might one acquire the technology and with what objectives in mind?

- How can one organize and manage the acquisition process?
- How does one put a price on technology?
- How does one hedge the risks in the acquisition process?

4.2.5 Factors Critical to Successful Acquisition

- Creating an innovative climate in which reward systems, management style, and cultural factors promote innovative behaviour and persuade innovative individuals to join and stay with the company.
- Encouraging team working, so that acquisition staff share their skills and resources across disciplines and national boundaries to deliver results and exploit corporate synergies.
- Breaking down the barriers between technologies and non-technologies.
- Creating technological capabilities for technology absorption and adaptation.

4.2.6 Funding Technology Acquisition

- Corporate funding, either by a levy imposed on each business or as a corporate overhead.
- Divisional budgets agreed upon annually, leaving details on the work portfolio to be settled later.
- External contracts with no pre-set budgets, and each contract negotiated on a commercial basis.
- Obtaining funding from financial institutions.

4.3 Basis of Valuation of Technology

Technology valuation is essentially an art rather than a science, thus making it an intractable task (Park and Park, 2004). At the very outset, whether the focus is embodied or disembodied technology, the task of identifying its content and scope itself is difficult. Further, with uncertainties of its success in the market and a host of other non-technical factors, the process of valuation gets more complicated and cumbersome. However, given the increase in the importance and frequency of technology transfer deals over the past few years, it is imperative to explore the basis of valuing technology (Chatterji, 1996; Escher, 2001).

Academic literature is replete with a variety of valuation models based on different criteria and procedures which may express the value of technology either in scores, index, or monetary value (Park and Park, 2004). The three basic approaches to the valuation of technology are the cost, market, and income approaches (Mard, 2001; Pavri, 1999). Chiesa et al (2005) further discuss an additional technique, namely, the real option method, which is an extension of the income approach. Baek et al (2007) suggest a web-based technology valuation system for an impartial valuation of fully developed technologies.

Given the wide array of methods, a simpler and more comprehensive set of possible bases for technology valuation may be enumerated as follows:

- *Supplier replication cost:* What would it have cost the supplier to develop the technology?
- *Customer replication cost:* What would it cost us to develop this technology in-house?
- *Market value:* What value would others in the market attribute to the subject technology? It requires comparison with a similar/comparable technology to determine the value.
- *Future value:* What will be the strategic risks associated with this technology transfer?
- *Time-dependent future value;* What will be the risk on a time scale?

4.4 Types of Technology Valuation Models

In view of the basis of valuation of technology, as outlined in the previous section, the following technology valuation models are recommended. The details of these valuation models are given in Table 4.1. The relevance of these models for different players in a technology transfer project, i.e. technology supplier, technology customer/acquirer, and intermediary or financial institution, in terms of the strategic risk and negotiation, is summarized in Table 4.2. The valuation models are separately discussed from the viewpoints of technology supplier, technology acquirer, and financial institution.

4.4.1 Supplier Replication Cost Model

- The value of the technology to the customer is equal to the supplier's full cost of developing the technology.
- The technology is valued in terms of the development cost to the supplier, including various heads such as manpower cost, infrastructure cost, utility cost, and contingencies.

Technology Supplier Viewpoint

The supplier replication cost model is more relevant to the technology provider or supplier. It helps in assessing a base price for the supplier, keeping in view the cost incurred in developing this technology. The model, which is illustrated through a case study in section 4.4, covers the supplier's technology development risk.

Technology Acquirer Viewpoint

The supplier replication cost model is comparatively less important for the technology acquirer. It provides an alternate valuation of the technology that can be used in the process of negotiation.

Financial Institution Viewpoint

The supplier replication cost model provides an alternate method of evaluation to the financial institution that funds the technology acquisition as it does to the acquiring organization, thereby enriching the process of negotiation.

4.4.2 Customer Replication Cost Model

- What would it cost the customer to develop the technology? In the customer replication cost model, the technology is evaluated by keeping in view all the costs of technology development as if the technology under consideration is to be developed independently by the acquiring organization.
- The customer replication cost model hedges the organizational and country risks for the acquirer.

Technology Supplier Viewpoint

For the technology supplier, the customer replication cost model is an alternate valuation method to aid in the negotiation. From the point of view of the supplier, this valuation is expected to be higher than the base cost as given by the supplier replication cost model.

Technology Acquirer Viewpoint

The customer replication cost model covers the acquirer's technology and organizational risks.. It includes the costs of developing the technological and people capabilities of the acquiring organization. But it does not allow a premium for the fact that the technology is proven.

Financial Institution Viewpoint

From the viewpoint of the financial institution also, the customer replication model gives a base value and ensures the technical feasibility and managerial competence of the proposal of technology transfer by assessing the technological and people capabilities available at the acquiring organization.

4.4.3 Market Value Model

- The value of the technology is settled by others in the marketplace. It is determined by comparing the value of a similar/comparable technology in the market.

- The market value model is largely intuitive and subject to the existence of an active market from where data required for comparison would be available.

Technology Supplier Viewpoint

While the supplier replication cost model provides the base price of the technology, the market-based valuation estimates the probable price a customer/acquirer would be ready to pay for the technology. It incorporates the risks and uncertainty related to the market.

Technology Acquirer Viewpoint

As the market value model provides an important alternate valuation, incorporating market-related uncertainties, it may be of special interest to the acquirer. Finding the comparable technology for arriving at a reliable assessment is, however, a challenge.

Financial Institution Viewpoint

For financial institutions, the market value may induce further confidence in hedging market-related uncertainty, thus providing a relevant alternate valuation of the technology under consideration.

4.4.4 Future Value Model

- Although cost-oriented models are logical, the valuation is historic rather than futuristic. Market-based valuations, too, despite being simple and intuitive, do not reflect the future wealth-generating capability of the technology. Thus, basing the valuation on the technology's future value would give a sound framework.
- Basing valuation on the value of the technology to the customer provides scope for attributing value to risk factors. It assesses the future value of the technology and the risk factors in terms of various uncertainties. The cash inflows and outflows are estimated over a period of time, for instance, 10 years. The expected value generated by the use of technology is assessed and may be converted either in terms of current value or royalty instalments or a combination of the two.
- Based on the principle of expectation, the future value model determines the wealth-creating potential of the technology being valued. The value is measured by determining the present value of the net cash flow from the technology, over a time horizon (the useful life of the technology), discounted at a rate incorporating the business risk. Such a determination of the value of the technology asset may be expressed as follows (Chiesa et al, 2005):

$$V_T = \sum_{t=1}^T \frac{NCF(t)}{(1 + k_b)^t}$$

where V_T is the technological asset value, $NCF(t)$ is the net cash flow, k_b is the actualization rate reflecting business risk, and T the time horizon.

- The future value model covers the technological and business risks that arise due to changes in various parameters in the course of time such as demand for the end product, exchange rate, etc.

Technology Supplier Viewpoint

For the technology supplier, value is added for the fact that the technology is proven. The future uncertainties in respect of suitability of technology, matching with the country framework, and business parameters are to be incorporated by the supplier in pricing the technology. A premium may be added by the technology supplier to hedge its strategic risks in technology transfer.

Technology Acquirer Viewpoint

The future value model incorporates the future uncertainties for the acquiring firm, which may add a negative premium to hedge its business risk with the new technology.

Financial Institution Viewpoint

The future value model is helpful to financial institutions in assessing the commercial viability and financial soundness of the technology transfer project. The commercial viability incorporates the demand uncertainty whereas the financial viability takes care of the exchange rate and interest risk. It hedges the business risk by incorporating a negative premium in the technology cost.

4.4.5 Time-Dependent Future Value Model

- The time-dependent future value model introduces the time dimension explicitly. The analysis is, by and large, similar to the future value model except for the fact that the future value and risk are not assessed on an average basis but rather are computed separately for different time periods. Thus, the royalty payments and risk premium would have different values in different time periods. It is difficult to implement this model.
- This model hedges the technological and business risks on a time scale in an explicit manner: it places a premium for the future uncertainties that may emerge with the passage of time.

Technology Supplier Viewpoint

For the technology supplier, the time-dependent future value model hedges the technology, country, and business risks by incorporating a premium on a time scale.

Technology Acquirer Viewpoint

For the technology acquirer, the time-dependent future value model is similar to the future value model, but the negative premium for uncertainties would vary with time.

Financial Institution Viewpoint

In the case of financial institutions also, the negative premium for business uncertainty would be time-variant in assessing the commercial and financial viability.

Table 4.1 Alternative Valuation Models

Valuation Model	Appropriate in case of	Advantages	Disadvantages
<i>Supplier replication cost</i>	Base technologies Peripheral key technologies (e.g. components)	Simple to assess	Doesn't add value for supplier expertise Doesn't include risk premium
<i>Customer replication cost</i>	Base and key technologies	Relatively simple to assess Includes costs of risk-taking and value of in-house expertise	Doesn't attribute value to knowledge that technology is proven
<i>Market value</i>	Technologies for which active market for comparable technology exists	Values the judgment of others in the marketplace	Largely intuitive, difficult to acquire data for comparable technologies
<i>Future value</i>	All technologies and particularly when customer takes risk on the technology	Values the 'comfort' factor of proven technology	Difficult to estimate
<i>Time-dependent future value</i>	All technologies when time is critical factor	Helps supplier recover a time premium	Very difficult to estimate Risk of over-pricing

Table 4.2: Relevance of Technology Valuation Models for Different Players in Technology Transfer

Valuation Model	Relevance for Technology Supplier	Relevance for Technology Acquirer	Relevance for Intermediary/Financial Institution
<i>Supplier replication cost</i>	<ul style="list-style-type: none"> • Provides base price • Hedges development risk of supplier 	<ul style="list-style-type: none"> • Provides alternate valuation for negotiation 	<ul style="list-style-type: none"> • Provides alternate valuation for negotiation
<i>Customer replication cost</i>	<ul style="list-style-type: none"> • Provides alternate valuation for negotiation 	<ul style="list-style-type: none"> • Provides a base value • Covers technology and organizational risk 	<ul style="list-style-type: none"> • Provides a base value • Ensures technical feasibility and managerial competence
<i>Market value</i>	<ul style="list-style-type: none"> • Gives an idea of probable price in market 	<ul style="list-style-type: none"> • Provides an important alternate valuation incorporating market related uncertainties 	<ul style="list-style-type: none"> • May induce further confidence hedging market related uncertainty • Ensures commercial viability
<i>Future value</i>	<ul style="list-style-type: none"> • Hedges technology, country and business risk • Add a premium for hedging risk 	<ul style="list-style-type: none"> • Hedges technology and business risk • Add a negative premium for hedging risk 	<ul style="list-style-type: none"> • Hedges technology and business risk • Ensures commercial viability and financial soundness
<i>Time-dependent future value</i>	<ul style="list-style-type: none"> • Hedges technology, country and business risk • Add a premium for hedging risk on a time scale 	<ul style="list-style-type: none"> • Hedges technology and business risk • Add a negative premium for hedging risk on a time scale 	<ul style="list-style-type: none"> • Hedges technology and business risk on a time scale • Ensures commercial viability and financial soundness

4.5 Case Study on Technology Valuation

A case study on technology valuation was carried out for the L+ Lactic acid project for transferring the technology from a research institute to an entrepreneurial firm in India. The valuation is based on the supplier replication cost model. The overall valuation is given in Table 4.3, whereas the detailed valuation, using the

supplier replication cost model in terms of development cost, infrastructure cost, and utility cost, is given in Table 4.4.

Table 4.3 Case Study on Technology Valuation

Technology Pricing for L+Lactic Acid Project with ABC Biotech		
Exclusivity in India for Selling End Product (period of 2 years)		
Time frame	Activity	Charges (INR in Millions)
At the time of agreement	Cost of microorganism	5
At the time of agreement	Cost of process development up to 10 litres	3
	Exclusivity Charges included with the above (Insitute can still give technology for production abroad or production in India but for sale abroad)	
On successful demonstration of process at 100 litres scale		1
On successful demonstration of downstream processing at lab scale		1
Year 3 onwards	Royalty basis 2% of net sales for the first 5 years, then 1.5% of net sales	

Consultancy Charges for L+Lactic acid Projects with ABC Biotech		
Time frame	Activity	Charges (INR in Millions)
Year 1 (M1-M6)	Consulting for process upgradation to 100 Liters for 3 different categories of product lines medium	1.08
Year 1 (M7-M12)	Onsite consulting basis cost of retainership INR 20,000/- per day+ cost of air travel+ accomodation cost (at a stretch max 5 working days per person 3 -4 times in 6 months)	
Year 2 (M1-M6)	Consultancy for down stream processing for concentration 9-10%	1.08
Year 2 (M7-M12)	Onsite consulting basis cost of retainership INR 20,000/- per person + cost of air travel+ accomodation cost (at a stretch max 5 working days per person 3 -4 times in 6 months)	

ASSESSMENT OF DEVELOPMENT COST					
(in INR)					
A: Manpower Cost					
MANPOWER	MONTHLY SALARY (A)	TIME GIVEN TO PROJECT (B)	NO. OF MONTHS WORK ('C)	TOTAL COST (SUM A*B*C)	
faculty-AS	100,000	25%	60	1,500,000	
faculty-PKRC	150,000	2%	60	180,000	
faculty-VS	200,000	5%	18	180,000	
Post graduate student-NN	50,000	100%	24	1,200,000	
Post graduate student-SJ	50,000	100%	6	300,000	
Post graduate student-AD	50,000	100%	6	300,000	
Post graduate student-AG	50,000	50%	9	225,000	
				3,885,000	
B: Infrastructure Cost					
Machines	Cost of Machine (A)	Economic Life Cycle of M/C in Months (B)	Time Utilized ('C)	No of Months used (D)	Total Cost (A/B*C*D)
Bioreactor 1	1,500,000	72	60%	24	300,000
Bioreactor 2	1,700,000	72	60%	6	85,000
Bioreactor 3	1,700,000	72	60%	6	85,000
Bioreactor 4	1,000,000	72	60%	9	75,000
Lab facility	25,000			12	300,000
Analytical eqpmts 1	2,000,000	72	10%	12	33,333
Analytical eqpmts 2	600,000	72	10%	12	10,000
Analytical eqpmts 3	100,000	72	5%	12	833
					889,167
C: Utility Cost					
	Cost of Utility (A)	Qty per Month (B)		No of Months Used (D)	Total Cost (A/B*C*D)
Power	5	600		12	36,000
Steam	5	600		12	36,000
Cooling Water	5	600		12	36,000
Reagents	1,000	80		12	960,000
					1,068,000
Total Project Cost					
A: Manpwer Cost	3,885,000				
B: Infrastructure Cost	889,167				
C: Utility Cost	1,068,000				
Total Cost	5,842,167				
Share of Institute @ 20%					

	2,142,128			
Share of Technology Transfer Agency @ 20%	2,142,128			
Share of PI/Deptt @ 60%	6,426,383	Based on 10% Mark-up on Total Cost of Project		
Total Price of Technology	10,710,639			

Table 4.4: Case Study based on Supplier Replication Cost Model

4.5 Technology Valuation Process – A Comprehensive Framework

This framework provides an overview of the appraisal process undertaken to value the subject technology (Figure 4.1). The various steps in the process are enumerated as follows:

- Selection of the subject technology for valuation: defining and describing the technology’s content, scope, and impact.
- Identification of the stakeholders, such as sellers, acquirers, and financial institutions, from whose perspective the valuation is to be done.
- Identification of strategic risks: technological, business, country, and organizational risks
- Development of strategies to hedge risks:
 - Developing Capabilities
 - Training Employees
 - Developing Partnerships
 - Enlarging Strategic Scope
 - Choosing Appropriate Technology Valuation Model
 - Choosing Right Mode of Technology Transfer
 - Adaptation of Acquired Technology
- Choice of the appropriate valuation method; supplier replication cost, customer replication cost, market value, future value or time-dependent future value model.
- Collection of data: as per the method selected
- Determination of value of the technology.

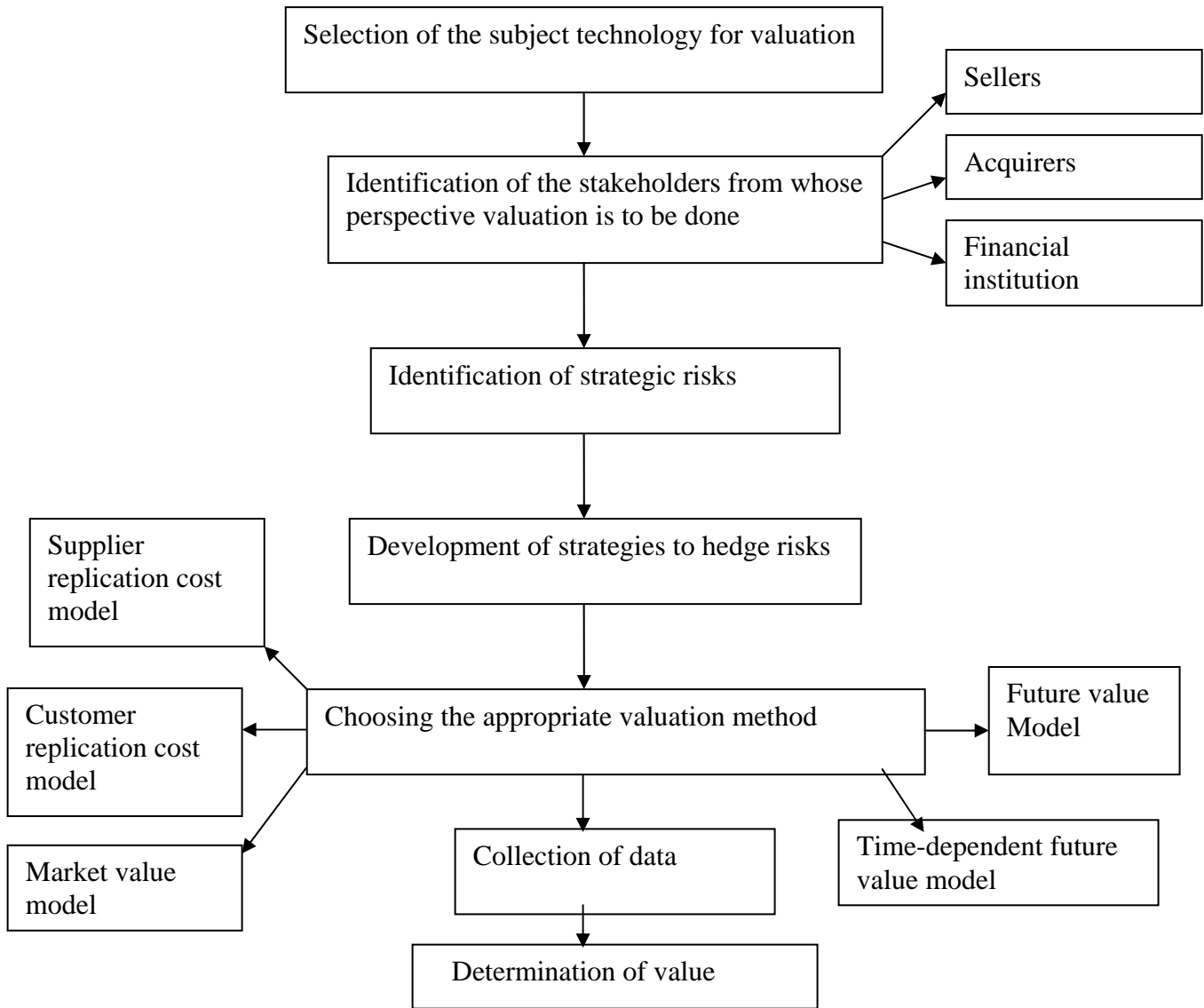


Figure 4.1 Technology Valuation Process Flowchart

4.7 Concluding Remarks

The four important technology valuation models discussed in this chapter can be adopted for different types of technologies and for different levels of risk in the acquisition of technology. The financial institutions funding the technology acquisition may include these valuation models in their financial appraisal framework to assess technical feasibility, managerial competence, commercial viability, and financial soundness, incorporating various types of strategic risks.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the study's major findings in terms of the hurdles/barriers encountered during technology acquisition, and the strategic risks in technology transfer. The strategies to hedge risk in technology transfer and the technology valuation models are also outlined. Finally, recommendations are made for incorporation in the financial appraisal framework of the financial institutions as well as SMEs engaged in technology transfer projects..

5.2 Summary of Major Findings

5.2.1 Hurdles/Barriers during Technology Acquisition

The study reflects the following issues connected with hurdles/barriers in the technology transfer process.

- Sometimes due to monopolistic conditions, the clauses of the technology transfer agreement are dictated by the technology provider company, and the recipient company has no choice but to accept all the conditions. In other words, the technology recipient at times is exploited by the technology provider.
- Technology recipients in the developing countries generally lack the facilities/know-how to adapt and absorb the acquired technology. The import of technology does not imply full understanding and mastery of the new techniques. In spite of the massive flow of foreign technology, most organizations in the developing countries have yet to develop a strong indigenous technological capability.
- Prices that technology recipients pay in accordance with the TAAs they sign are usually excessive.
- Language/communication problems and cultural differences between the technology provider's country and the recipient country pose a big problem in the process of technology transfer.
- Problems encountered during installation/implementation, and the lack of infrastructure in the recipient's milieu is another hurdle in the smooth transfer of technology.
- The lack of equipment/machinery at the recipient's plant to support the acquired technology is another major hurdle.
- During its upscaling, proving, and commercialization, new technology has inherent risks, and demands considerable inputs in terms of time and money.
- The scarcity of a skilled/expert workforce with the recipient company is a limitation in the technology acquisition process. But with the passage of time, as more advanced technology arrives in the marketplace, organizations are making a practice of sending their employees for training to the donor organizations.

5.2.2 Strategic Risks in Technology Transfer

The important issues synthesized in connection with the risk of acquired technology are:

- Literature suggests that generally technology transferred to the developing countries does not meet their needs and objectives. Capital-intensive rather than labour-intensive technologies are normally transferred. Restrictions on the licensing agreements further discourage technology recipients from further development and innovation.
- Decision-makers in the developing countries are uncertain about the type of technology they need and hence inappropriate technologies are transferred.
- The cost-effectiveness of the technology to be acquired has to be ascertained before the technology is transferred, rendering it important to investigate the relationship between the cost of technology and its justification for the recipient company. This depends on whether the technology has a proven record.
- The strategic risks deal with the possible sources of failure of technology transfer projects. The important strategic risks are technological risk, business risk, country risk, and organizational risk. These risks are based on a number of factors such as newness and inappropriateness of a technology in a given context; the lack of infrastructure and legal framework; inadequate technological and people capabilities to absorb and effectively implement the acquired technology; and changes in the business parameters during implementation of technology such as change in demand, interest rates, and exchange rates.

5.3 Summary of Strategies to Hedge Risk

The key issues in respect of the strategies to hedge risk in transferring technology are noted below.

- The involvement of suppliers in the process of new product development has yielded favourable results in the developed countries. But the extent of involvement of vendors/suppliers in new product development and the capabilities of the vendors to adapt and absorb the technology which they have acquired through a licence agreement in the developing countries are crucial for successful technology transfer.
- Considerable research work has been reported on the comparison of strategy of the vehicle manufacturers in respect of the duration and kind of relationship between customer and buyer organizations in the USA and Japan. But the kind of relationship between suppliers and customer companies in a developing country like India has yet to be studied in detail..
- A minimum level of technological competence is required for the technology recipient, not only to modify and adapt foreign technology to local needs, but also to provide the basis of an intelligent selection from the wide range of suppliers.

- Involving in-house R&D in the external technology acquisition and adaptation of the product and process technologies for tailoring them to the local conditions can increase the effectiveness of the technology transfer process.
- Ascertaining whether or not the import of foreign technology stimulates R&D activities at the recipient's base would be worthwhile.
- Vehicle manufacturers, which were established in the early 1980s, played a vital role in giving an initial thrust to the technological capabilities of Indian suppliers. In fact, these vehicle manufacturers at that time focused on developing the skills of these suppliers indigenously, even occasionally sending their expert teams to personally train the suppliers, and in a few cases asking the suppliers to enter into joint ventures with their worldwide supplier. Today those suppliers are big names in the Indian automotive supplier industry.
- People capabilities are the main driving force for developing technology capabilities, manufacturing processes, and ultimately the performance.
- Keeping in view the characteristics of the organization intending to acquire the technology, suitable strategies need to be evolved for hedging the risks in the planning and implementation of the technology transfer projects. An empirical study of vendors in the automotive sector has highlighted four clusters with different technology transfer strategies.
- Joint venture provides an effective way of technology transfer when the technology to be transferred is from a single source. This also hedges the financial risk, as the technology provider becomes an integral part of the new venture, and some funding is also provided along with the technology. In cases of technology acquisition from multiple sources, the major mode of transfer is that of technology licensing.
- The proposed strategies for hedging risk in technology transfer projects are identified as:
 - Developing Capabilities
 - Training Employees
 - Developing Partnerships
 - Enlarging Strategic Scope
 - Choosing Appropriate Technology Valuation Model
 - Choosing Right Mode of Technology Transfer
 - Adaptation of Acquired Technology

5.4 Summary of Technology Valuation Models

The following four technology valuation models are recommended for capturing different levels of strategic risk in technology acquisition:

i. Supplier Replication Cost Model

- The value of the technology to the customer is equal to the supplier's full cost of developing the technology.
- It covers the technology development risk for the technology supplier.

ii. Customer Replication Cost Model

- It covers the cost that the customer would incur in developing the technology.
- This model hedges the organizational and country risks for the acquirer.

iii. Market Value Model

- This model focuses on the value of the technology as estimated by others in the marketplace. It is determined by comparing the value of a similar/comparable technology in the market.
- This model is largely intuitive and depends on the existence of an active market from where data required for comparison would be available.

iv. Future Value Model

- Basing valuation on the value of the technology to the customer provides scope for attributing value to risk factors.
- This model covers the technological and business risks due to changes in various parameters in the course of time, for instance, demand for the end product and exchange rate.

v. Time-Dependent Future Value Model

- Here the time dimension is explicitly introduced.
- This model hedges the technological and business risks on a time scale. It places a premium on the future uncertainties with the passage of time in an explicit manner.

5.5 Recommendations for Financial Institutions

In view of the study on the strategic risks in technology transfer, the strategies to hedge such risks, and the technology valuation model, the following recommendations are made for incorporation in the financial appraisal framework of intermediaries and financial institutions:

- The financial institutions (FIs) should appraise technology transfer projects, taking care of the following aspects of the proposal:
 - Technical feasibility
 - Managerial competence
 - Commercial and financial viability
 - Economic and environmental viability

- While appraising the technology transfer project, FIs should assess the strategic risks in the technology transfer project. The important strategic risks to be examined are:
 - Technological risk
 - Business risk
 - Country risk
 - Organizational risk
- In order to prepare a sound case for negotiation and to hedge the strategic risks, multiple technology valuation models should be used. The important models recommended are mentioned below.
 - i. *Supplier Replication Cost Model*
 - Provides alternate valuation for negotiation
 - ii. *Customer Replication Cost Model*
 - Provides a base value
 - Ensures technical feasibility and managerial competence
 - iii. *Market Value Model*
 - May induce further confidence by hedging market-related uncertainty
 - Ensures commercial viability
 - iv. *Future Value Model*
 - Hedges technology and business risks
 - Ensures commercial viability and financial soundness
 - v. *Time-Dependent Future Value Model*
 - Hedges technology and business risks on a time scale
 - Ensures commercial viability and financial soundness
- Financial institutions should incorporate the technology valuation models into their scoring/rating system for financial appraisal of technology transfer projects.

5.6 Recommendations for Small and Medium Enterprises

As an outcome of the study, the following recommendations are made for Small and Medium Enterprises (SMEs):

- SMEs should evaluate the hurdles/barriers in technology transfer and try to overcome them.

- SMEs should examine their intrinsic character, assess the cluster to which they appear to be closest, and accordingly choose the mode of technology transfer best suited to their needs.
- SMEs should evaluate their technological and people capabilities with reference to the technology to be acquired and initiate action in the deficient areas.
- SMEs should assess the strategic risks, such as technological, business, country, and organizational risks, based on a number of factors: inappropriateness of a technology in a given context; lack of infrastructure and legal framework; inadequate technological and people capabilities to absorb and effectively implement the acquired technology; and possible changes in the business parameters during implementation of technology such as change in demand, interest rates, and exchange rates.
- SMEs should plan appropriate strategies to hedge the risks in technology acquisition. Some of the important strategies recommended are:
 - Developing Capabilities
 - Training Employees
 - Developing Partnerships
 - Enlarging Strategic Scope
 - Choosing Appropriate Technology Valuation Model
 - Choosing Right Mode of Technology Transfer
 - Adaptation of Acquired Technology
- SMEs should carry out technology valuation by using one or more than one models as follows:
 - i. *Supplier Replication Cost Model*
 - Provides alternate valuation for negotiation
 - ii. *Customer Replication Cost Model*
 - Provides a base value
 - Covers technology and organizational risks
 - iii. *Market Value Model*
 - Provides an important alternate valuation incorporating market-related uncertainties
 - iv. *Future Value Model*
 - Hedges technology and business risks
 - Adds a negative premium for hedging risk
 - v. *Time-Dependent Future Value Model*

- Hedges technology and business risks on a time scale
- Adds a negative premium for hedging risk on a time scale

5.7 Future Scope

The study has provided a base for SMEs and FIs to identify strategic risks in technology transfer projects and select strategies and technology valuation models to hedge these risks. In order to effectively implement the strategies to hedge the risks and the technology valuation models to assess and incorporate them in the financial appraisal framework, the following future directions are suggested:

- A significant number of case studies of technology acquisition by SMEs, including those from India, need to be conducted to examine the effectiveness of proposed strategies to hedge risks.
- The proposed technology valuation models need to be implemented in various situations.
- A comparative analysis of various models would facilitate a proper selection of valuation models for hedging the risks
- The proposed technology valuation models need to be converted into a scoring/rating system for implementation by financial institutions. The details of a financial scoring framework are provided in another study by P.K. Jain on “Appraisal, Assessing and Managing Risk by Financial Institutions Funding Technology Transfer Projects”.

REFERENCES

- Ansoff, H. (1987). Strategic management of technology, *The Journal of Business Strategy*, Winter:2–13.
- Bartel, A.P.(1994). Productivity gains from the implementation of employee training programs, *Industrial Relations*, **33**:411-25.
- Bates, H. and Twigg, D. (1997). Outsourcing of component design, *Proceedings of 30th International Symposium on Automotive Technology*, Warwick Business School, Coventry, U.K., 16th June 1997.
- Beak, D.H., Sul, W., Hong, K., and Kim, H. (2007). A technology valuation model to support technology transfer negotiations, *R&D Management*, **37**(2):123.
- Bhardwaj, A., Sushil, and Sharma, S.K. (2005). Synthesis of research issues in technology acquisition – A literature review and Indian field study, *International Journal of Technology Transfer and Commercialization*, **4**(2);206-30.
- Bhardwaj, A., Sushil, and Sharma, S.K. (2007). Analysis of technology upgradation practices followed by Indian automotive suppliers using hierarchical cluster analysis and case studies, *International Journal of Technology Transfer and Commercialization*, Forthcoming.
- Bhardwaj, A., Sushil, and Sharma, S.K. (2008). A study of Indian automotive vendors using cluster analysis, *International Journal of Business and Globalisation*, Forthcoming.
- Bhat, J.S.A. (2001). Management of Innovation and R&D. In Sushil and Momaya, K. (eds.), *Globalization, Flexibility and Competitiveness: A Technology Management Perspective*. New Delhi: Vikas Publishing House.
- Bidault, F. and Despres, C. (1998). New product development and early supplier involvement (ESI): The drivers of ESI adoption, *International Journal of Technology Management*, **15**(1–2); 49–69.
- Bowonder, B. (1998). Industrialization and economic growth of India: Interactions of indigenous and foreign technology, *International Journal of Technology Management*, **15**(6–7).
- Bozdogan, K., John, D., Hoult, D., and Locas, M. (1998). Architectural innovation in product development through early supplier integration, *R&D Management*, **28**(3):163–73.
- Chatterji. D. (1996). Accessing external sources of technology, *Research and Technology Management*, **39**(2);48-56.
- Chiesa, Vittorio, Gilardoni, E., and Manzini, R. (2005). The valuation of technology in buy-cooperate-sell decisions, *European Journal of Innovation Management*, **8**(2):157-81.
- Coughlin C.C. (1983). An economic analysis of Yugoslav joint ventures, *Journal of World Trade Law*, **1**(1):12–33.
- Delaney, J.T. and Huselid, M.A. (1996). The impact of human resource management practices on perceptions of organizational performance, *Academy of Management Journal*, **39**(4);949-69.

- Delery, J.E. and Doty, D.H. (1996). Modes of theorizing in strategic human resource management: Tests of universalistic, contingency and configurational performance predictions, *Academy of Management Journal*, **39**(4);802-35.
- de Mello and Luiz, R. (1997). Foreign direct investment in developing countries and growth: A selective survey, *Journal of Development Studies*, **34**(1):1–34.
- DiBella, A.J., Nevis, E.C., and Gould, J.M. (1996). Understanding organizational learning capability, *Journal of Management Studies*, **33**(3):361-79.
- Doz, Y.L. and Prahalad, C.K. (1980). How MNCs cope with host government intervention, *Harvard Business Review*, 149–57.
- Escher, J.P. (2001). Process of external technology exploitation as a part of technology marketing : A conceptual framework. *EHT- Center for Enterprise Science, Paper presented at the PICMET 2001 Conference*, www.tim.ethz.ch/research/conferences/picmet01/escher/picmet8.pdf.
- Figueiredo, P.N. (2002). Learning processes features and technological capability accumulation: explaining inter-firm differences, *Technovation*, **22**; 685–98
- Gee, S. (1981). *Technology Transfer Innovation and International Competitiveness*. New York: John Wiley & Sons.
- Gunnerson, C. (1991). International information and technology transfer, *Journal of Professional Issues in Engineering Education and Practice*, **117**(4):336–50.
- Handfield B., Krause, R., and Monczka, M. (2000). Avoid the pitfalls in supplier development, *Sloan Management Review*, Winter;37–49.
- Handfield, B. and Ragatz, R. (1999). Involving suppliers in new product development, *California Management Review*, **42**(1):59–81.
- Helper, S.R. and Sako, M. (1995). Supplier relations in Japan and the US: are they converging? , *Sloan Management Review*, Spring: 77–85.
- Husain, Z. and Sushil (1997). Management of technology: learning issues for seven Indian companies, *Technology Management Strategies and Applications*, **3**:109–35.
- Husain, Z. and Sushil (2000). Active transfer of technology in the automobile industry: Indian experiences, *Int. J. Services Technology and Management*, **1**(2/3):236-80.
- Husain Z., Sushil, and Pathak, R.D. (2002). A technology management perspective on collaborations in Indian automobile industry: a case study, *J. of Engineering and Technology Management*, **19**;167-201.
- Huseth, S. (1988). Cost of technology transfer, *Transferring Software Engineering Tool Technology*, CA, USA: Santa Barbara, 1987, Nov 15–16.
- Jones, M. and Jain, R. (2002). Technology transfer for SMEs: challenges and barriers, *International Journal of Technology Transfer and Commercialization*, **1**(1–2).

- Katrak, H. (1985). Imported technology, enterprise size and R&D in a newly industrializing country: The Indian experience, *Oxford Bulletin of Economics and Statistics*, **47**:213–29.
- Katrien, M. (2000). New training and technology transfer opportunities in China, *Solid State Technology*, 511–14.
- Katz, J. (1985). *Domestic Technological Innovations and Dynamic Comparative Advantages: Further Reflections on a Comparative Case-Study Program*. New York: Praeger.
- Khamba, J.S., Singh, T.P., and Sushil (2001). Application of flexible system methodology to technology management. In Sushil and K. Momaya (eds.). *Globalization, Flexibility and Competitiveness: A Technology Management Perspective*, Global Institute of Flexible Systems Management. New Delhi: Vikas Publishing House, pp. 431-40.
- Khan, F., Sushil, and Haleem, A. (2008). An Empirical Study of Technology Absorption and Innovation in Indian Small and Medium Enterprises, *Global Journal of Flexible Systems Management*, Forthcoming.
- Kumar, V. (2007). Managing Technology Transfer for Enhancing Efficiency. Paper presented at the *Workshop on Strategies to Meet Energy Security Challenges*, March 16, 2007, New Delhi, organized by The Institution of Engineers (India), Delhi State Centre.
- Kumar, V. and Cray, D. (2002). Key determinants of the mode of international technology transfer: Evidence from India and Turkey, *International Journal of Technology Transfer and Commercialization*, **1**(1–2).
- Kumar, V. and Jain, P.K. (2002). New technology commercialization in India: experiences and imperatives of an empirical study, *International Journal of Technology Transfer and Commercialization*, **1**(3).
- Kuniya, M. (2007). Development in S&T Policies over the Past 25 Years, Special Feature, *Science and Technology in Japan*, **25**(100) January/March: 8-11.
- Kurukawa, S. (1997). Make or buy decisions in R&D; Small technology-based firms in the US and Japan, *IEEE Transactions on Engineering Management*, **44**(2):124–33.
- LeBlanc, J., Nash, R., and Gallagher, D. (1997). A comparison of US and Japanese technology management and innovation, *International Journal of Technology Management*, **13**(5–6):601–14.
- Lei, D., Hitt, M.A., and Bettis, R. (1996). Dynamic core competences through meta-learning and strategic context, *Journal of Management*, **24**(4):549-69.
- MacDuffie, J. and Helper, S. (1997). Creating lean suppliers: diffusing lean production through the supply chain, *California Management Review*, **39**(4)Summer:118–51.
- Madu, C.N. (1988). An economic decision model for technology transfer, *Engineering Management International*, **5**: 53-61.
- Mard, M. (2000). Financial factors: income approach to valuing intellectual property, *Licensing Journal*, August:27-28.
- Margretta, J. (1998). Fast, global, and entrepreneurial: supply chain management, Hong Kong style, *Harvard Business Review*, Sep.–Oct.:103–17.

- McCardle, K.F. (1985). Information acquisition and the adoption of new technology, *Management Science*, **31**, (11);1372–89.
- Meleka, A.H. (1985). The changing role of multinational corporations, *Management International Review*, **25**, (4):36–45.
- Miles, D.W.J. (1999). Training and technology transfer for low-volume roads in developing countries, *Proceedings of the 7th International Conference on Low-Volume Roads*, Baton Rouge, LA, USA.
- Mytelka, L.K. (1979). *Regional Development in a Global Economy: The Multinational Corporation, Technology and Andean Integration*. New Haven, Conn.: Yale University Press.
- Nonaka, I. and Takeuchi, H. (1995). *The Knowledge-creating Organization*. New York: Oxford University Press.
- Ozawa, T. (1985). *Macroeconomic Factors Affecting Japan's Technology Inflows and Outflows: The Post War Experience*. New York: Prager.
- Pack, H. (2002). The cost of technology licensing and the transfer of technology, *International Journal of Technology Transfer and Commercialization*, **1**(1–2).
- Park, Y. and Park, G. (2004). A new method for technology valuation in monetary value: Procedure and application, *Technovation*, **24**;387-94.
- Pau, A. (1988). Technology transfer of software engineering to developing countries, *Proceedings of the Twelfth Annual International Computer Software & Applications Conference (COMPSAC 88)*, Chicago, IL, USA.
- Pavri, Z.. (1999). Valuation of intellectual property assets: the foundation for risk management and financing. *Proceedings of INSIGHT Conference*, Toronto.
- Pfeffer, J. (1994). *Competitive Advantage through People*. Boston, MA; Harvard Business School Press.
- Prasad, B.S. (1986). Technology transfer, the approach of a Dutch multinational, *Technovation*, **4**(1):3–15.
- Putranto, K., Stewart, D., and Moore, G. (2003). International technology transfer and distribution of technology capabilities: The case of railway development in Indonesia, *Technology in Society*, **25**;43–53.
- Ramanathan, K. (1995). Preparing for the formulation of effective international technology transfer arrangement, *Proceedings of the 1995 IEEE Annual International Engineering Management Conference*, Piscataway, NJ, USA.
- Rosenberg, N. and Frischtak, C. (1985). *International Technology Transfer: Concepts, Measures and Comparisons*. New York: Prager.
- Saaty, T.L. (1980). *The Analytic Hierarchy Process*. New York: McGraw Hill.
- Sen, F. and Rubenstein, A.H. (1990). An exploration of factors affecting the integration of in-house R&D with external technology acquisition strategies of a firm, *IEEE Transactions on Engineering Management*, **3** (4);246–58.

- Shaw, J.D., Delery, J.E., Jenkins, G.D., and Gupta, N. (1998). An organization-level analysis of voluntary and involuntary turnover, *Academy of Management Journal*, **41**(5):511-25.
- Sushil (2007). *Technology Transfer and National Development*, Monograph, DSIR, New Delhi.
- Swee C. Goh (2003). *The Learning Organization*, Volume 10, Number 4, pp. 216-27, MCB University Press.
- Teitel, S. (1978). On the concept of appropriate technology for less industrialized countries, *Technology Forecasting and Social Change*, **11**:349-69.
- Treleven, M. (1987). Single sourcing: a management tool for the quality supplier, *Journal of Purchasing and Materials Management*, Spring:19-24.
- UNIDO (1996). *Manual on Technology Transfer Negotiation: A Reference for Policy-makers and Practitioners on Technology Transfer*, United Nations Industrial Development Organization, General Studies Series, Vienna.
- UNIDO (2002). *Directory of Technology Transfer Organizations in Japan*, UNIDO Investment and Trade Promotion Office, Tokyo, August.
- Valle, R., Martín, F., Romero, P.M., and Dolan, S. (2000). Business strategy, work processes and human resource training: are they congruent? *Journal of Organizational Behavior*, **21**:283-97.
- Wasti, S.N. and Liker, J.K. (1999). Collaborating with suppliers in product development: A US and Japan comparative study, *IEEE Transactions on Engineering Management*, **46**(4):444-60.
- Youndt, M.A., Snell, S.A., Dean, J.W., and Lepak, D.P. (1996). Human resource management, manufacturing strategy, and firm performance, *Academy of Management Journal*, **39**(4):836-66.