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U.S.-India Technology Cooperation and Capability Building: The Role of Interfirm Alliances in Knowledge-Based Industries

by Rakesh Basant

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Economics Series
No. 2, January 2004

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This paper was prepared when the author was a Jhamandas Watumull Visiting Fellow at the East-West Center. Supported by the Jhamandas Watumull Fund, the fellowship seeks to promote economic and technology cooperation between India and United States through research on key issues in their bilateral relations in these sectors. The fellowship coordinator is Muthiah Alagappa, director of the East-West Center Washington.

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Acknowledgements

The interactions with people in the Indian IT industry have been very useful. I am particularly indebted to Pawan Kumar for his time and insights. Help from the officials of the Industrial Credit and Investment Corporation of India (ICICI), Mumbai, and the U.S. Agency for International Development (USAID) offices in Delhi and Washington, D.C. is gratefully acknowledged. The author benefited from the comments by the participants in the seminars organized by the East-West Center in Honolulu and Washington, D.C. Thanks are also due to Dieter Ernst, Rana Hasan, and the editors who provided comments on earlier drafts. The usual disclaimers apply.

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Digital Pixel Sensor	DPS
Fluidized Bed Reactor	FBR
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ABSTRACT

The paper reviews some Indo-U.S. technology cooperation initiatives and analyzes data on interfirm alliances in knowledge-based industries, especially information technology (IT). It shows that the market driven increase in alliances between Indian and U.S. enterprises has significantly enhanced the variety of linkages between Indian and U.S. entities both public and private, and that these linkages have contributed to capability building and diversification by Indian partners. A variety of spillover benefits of international technology alliances are highlighted. It is suggested that issues relevant for Indo-U.S. cooperation at different levels need to be analyzed together in order to appreciate complementarities across linkages of various types. For example, linkages between public sector entities of the two nations may enhance the potential of private sector networking initiatives. The paper argues that while the building of public institutions and policies relating to trade, technology, and investment remain important for Indo-U.S. technology cooperation, a shift in policy focus to market induced interfirm alliances may be desirable.

INTRODUCTION

Indo-U.S. technology cooperation has a long history. Most initiatives over the years have been government-to-government, but there have been market-driven efforts by Indian and U.S. firms as well. These private sector initiatives are now on the rise, supported by India's resource base of software and biotechnology skills and stimulated by new kinds of interactions across the public and private sectors. India can continue to build its technological capabilities through these interactions, but the nature of cooperation will need to change in order to meet current conditions of globalization and liberalization. The paper reviews some Indo-U.S. technology cooperation initiatives to explore the following questions:

- What is the nature of Indo-U.S. technology cooperation especially with respect to interfirm linkages in the IT sectors?
- What role do these linkages play in developing technological capabilities in participating firms?
- How do firms utilize these capabilities for growth and diversification?
- How can public policies contribute to linkages based on the capability building process?

The paper shows that the market-driven increase in alliances between Indian and U.S. enterprises has significantly enhanced the variety of linkages between Indian and U.S. entities both public and private, and that these linkages have contributed to capability building and diversification by Indian partners. A variety of spillover benefits of international technology alliances are highlighted. It is suggested that issues relevant for Indo-U.S. cooperation at different levels need to be analyzed together in order to appreciate complementarities across linkages of various types. For example, linkages between public sector entities of the two nations may enhance the potential of private sector networking initiatives. The paper argues that while the building of public institutions and policies relating to trade, technology, and investment remain important for Indo-U.S. technology cooperation, a shift in policy focus to market induced interfirm alliances may be desirable.

The body of the paper is divided into six sections. The first section briefly reviews the changing role of interfirm alliances. The second section discusses a variety of technology collaboration linkages between Indian and U.S. entities in order to identify some key elements that distinguish various types of linkages and their roles. The third section focuses on issues relating to interfirm linkages, reviewing the implications of research and development (R&D) alliances between Indian and U.S. firms under a specific international cooperation program. The fourth section uses survey and interview data to analyze how international linkages contribute to capability building among Indian IT firms. The fifth section discusses an interesting alliance between Indian and U.S. firms and an Indian educational institution. The last section explores policy options that can foster Indo-U.S. technology cooperation, especially through interfirm alliances in the knowledge-intensive sectors.

THE CHANGING ROLE OF INTERFIRM ALLIANCES

Economic policies the world over and especially in the developing world are being liberalized. Concurrently, North-South technology flows are adding to the technological capabilities of developing nations. As yet there is no consensus on what policy instruments would best enable developing nations to benefit from the ongoing liberalization, while with respect to endeavors to build technological capabilities, appropriate policy choices are more than usually difficult.* This is because of the inherent complexity of relationships among the sources of technology acquisition, that is, among innovators, purchasers, and copiers. Adding to the difficulty, research on the determinants of interfirm linkages and their impact on developing technological capabilities and competitiveness is in its infancy. This is particularly true for developing countries but also for the newly industrializing economies (NIEs).

For firms engaged in various forms of collaborative activity, two types of interfirm linkages can be distinguished: those that involve a one-way relationship leading to a flow of technology from the licensor to the licensee or from the mother unit to the subcontractors, and two-way relationships involving joint R&D or research programs to create common standards, etc. (See Table 1.) Of these, the unidirectional linkages are long-standing, while the two-way relationships are

*See Evenson and Westphall (1994) for a review and Basant (1999) and Kumar and Siddharthan (1997) for a discussion of these issues.

Table 1. A Matrix of Interfirm Linkages

Nature of Linkage	Technology Generation and Transfer	Pre-production	Production	Post-production
One Way	• Licensing • Cross-licensing		• Arms-length buy-sell contract • Subcontracting • Original equipment manufacture • Long-term sourcing • Acquisitions/joint ventures • GSO arrangements	• Franchising (licensing of brand) • Distribution • Marketing • Service provision (after sales support)
Two Way	• R&D consortia/joint R&D for technology development • Joint efforts at setting standards • Customer-supplier networks • Interfirm technology collaboration agreements • University-industry partnerships	• Joint bidding • Joint project development	• Joint production • Use of common components • Modularization • Joint ventures • New forms of subcontracting • Subsidiaries • GSO arrangements	• Joint marketing • Shared distribution/service • Joint service provision • System products • Standardization of interfaces

Source: Adapted from Mytelka (1999).

more recent and have become more prominent over the years (Mytelka, 1999; *World Investment Report* (*WIR*), 1998). Furthermore, in recent years the nature of some of the traditional relationships such as joint venture and subcontracting has changed considerably. In many joint ventures in the life sciences/biotechnology industry, the intention is less to exercise control than it is for the larger firm—usually a major pharmaceutical or chemical company—to provide the financial and marketing resources that the smaller, dedicated biotechnology firm lacks. Similarly, the emergence of subcontractors as partners engaged in a dialogue with their principals has been documented in textiles and clothing, auto components, and the electronics industries. Customer-supplier relationships have also changed considerably. Suppliers are increasingly drawn into joint research and collaboration in the design of new products for their clients. They also take on additional responsibility for the manufacture of whole modules subsequently assembled into complete products by their customers, notably in the automobile and the aircraft industries (for recent examples, see Mytelka, 1999 and *WIR*, 1998). Recent literature on global production networks highlights the changing nature and role of these customer-supplier networks and how these contribute to capability building (Ernst, 2000; Ernst and Kim, 2001). Just as subcontracting linkages have undergone significant changes, global software outsourcing (GSO), a kind of subcontracting, has also changed, with outsourcing firms now participating more actively in such relationships.

Recent data for international alliances overall in the 1980–1996 period show a marked shift away from the quasi-exclusive reliance on one-way linkages to the development of two-way collaborative relationships in the 1990s (Mytelka, 1999). Among the two-way interfirm agreements, technology cooperation agreements saw a significant rise in the 1990s. Moreover, technology cooperation agreements in knowledge-intensive sectors, for instance IT and the life sciences, have risen most rapidly and now constitute about 55 percent of all agreements. The information industry alone accounts for about 37 percent of such agreements (Mytelka, 1999; *WIR*, 1998).

Among the developing countries, participation in interfirm technology agreements is limited but has grown a bit in recent years. The share of developing countries (especially East Asian) in technology agreements increased from 4.9 percent in the 1980s to 6.2 percent in the 1990s. Among those agreements involving developing countries, IT-related agreements dominate, their share being as high as 27 percent.* Furthermore, the share of two-way relationships among the agreements involving developing countries is also on the rise, suggesting that firms in these countries are gradually becoming viable partners in joint technology generation activities (Hagedoorn and Freeman, 1994; *WIR*, 1998: 27–29). For developing country firms, the two-way linkages are an important mechanism for accessing knowledge bases abroad. The experiences of East Asia under conditions of globalization and liberalization suggest that similar opportunities for alliances are likely to emerge in the Asia Pacific region. Exploitation of such opportunities can become an important element of the development strategies of economies in the region, particularly for India.

The spurt in technology partnering and the changes in the nature of interfirm alliances have led researchers to look at such linkages with renewed interest in recent years (Basant and Chandra, 1997, 2001, 2002). Growth in product sophistication and variety has induced interfirm linkages because no single firm can develop capabilities in all aspects of product and process technology. The potential role of interfirm linkages in developing technological capabilities of partner firms, especially in developing countries, is well recognized (Bell and Pavitt, 1997). That the capability building possibilities are real is demonstrated by a case study of technology partnering in the telecom software sector (Basant, Chandra and Mytelka, 1998). In the hierarchy of linkages, agreements involving technology development typically require more technological competence among participating firms than do production and distribution-related linkages. The learning opportunities are also higher in the former.

Are firms participating in these linkages able to reap learning benefits from the alliances and, if so, under what circumstances? An understanding of any such circumstances is important for both policymakers and participating firms.

CHANGING MODES OF COOPERATION BETWEEN INDIAN AND U.S. ENTITIES

Over time the linkages between the Indian and U.S. entities, both public and private, have taken various forms. In the pre-1991 period, Indo-U.S. technology cooperation at the government level included:

- institution building (e.g., Indian Institute of Technology, Kanpur; Punjab Agricultural University, Ludhiana);

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*Using alternative estimates, Vonortas and Dodder (2000) show that the number of international interfirm alliances in the IT sectors increased significantly in the 1990s. Developing countries led by the East and Southeast Asian NIEs increased their share in such alliances from about 6 percent in 1988 to almost 13 percent in the mid 1990s. The technology content of alliances in which developing countries are involved also increased.

- collaborative research by U.S. entities and Indian public sector R&D institutions in specific areas;
- exchange of germplasm (e.g., the collaboration between Cornell University and the Indian Council of Agricultural Research);
- participation of U.S. agencies in technology-based public programs (e.g., vaccination programs); and
- organization of workshops and exchange of science and technology personnel.*

At the private level, the linkages during this period were very limited. Usually, technology flows from the United States took the form of trade in machinery and inputs, arms-length technology licensing, and limited foreign direct investment (FDI). Very few Indian firms were part of the global production networks. In general, the links were one-way: During this phase, restrictive policies relating to trade, FDI, and technology resulted in limited flows of embodied and disembodied technology.

In recent years, the nature of the linkages has changed drastically. Liberalization of trade, technology licensing, and FDI policies has enhanced knowledge flows. At the same time, Indian firms are gradually integrating into global production networks through a variety of interfirm alliances. Many of these linkages are aimed at developing, modifying, or absorbing technologies. This evolution reflects the emergence of India as an important entity in the development of certain technologies, especially in the areas of IT, pharmaceuticals, and biotechnology. However, Indian firms still have a long way to go before they will fully participate in the global knowledge networks. A significant effort is required to upgrade technological capabilities in a variety of areas so that the nation keeps pace with the knowledge revolution.

The Indian private sector is now involved in a variety of linkages with U.S. entities. Linkages between Indian and U.S. private enterprises not only increased significantly after 1991, many of these are two-way linkages. A variety of entities are involved in these linkages including educational institutions, enterprises, and research labs, both in the public and private sectors. Interestingly, new varieties of linkages between public entities have also emerged. Apart from interfirm alliances, a few initiatives in Indo-U.S. technology cooperation in recent years

*For details see, *India-U.S. Science & Technology Relations: Harnessing the Potential*, Science and Technology Wing, Embassy of India, United States, August 2000.

have been particularly interesting, alliances in which public sector entities were involved.

The Capability Maturity Model Certification Revolution

In 1998, the Department of Electronics (DOE), government of India (GOI), signed an agreement with Carnegie Mellon University (CMU), Pittsburgh for collaboration in software process improvement technologies. Under this agreement, the Center for Information Systems Engineering of CMU would work with the Indian software community to introduce software process improvement technologies in India. A capability maturity model (CMM) certification process was subsequently developed wherein CMU collaborated with the private sector (through the Appraiser program) to upgrade process quality among Indian software firms. This now three-way collaboration has contributed significantly to the quality upgrading of the Indian software industry. According to an early 2002 estimate, of the 58 CMM Level 5 firms in the world, 32 were based in India.* CMM Level 5 is the highest level of certification. Indian software firms have applied themselves to the process of getting certified under several quality-related programs, including the CMM and the International Organization of Standards program. Of the top 300 software firms in the country, 216 already had some kind of quality certification by December 2001; many more firms are in the process of being certified while many firms have multiple certifications (NASSCOM, 2002). There have been cases when a U.S. multinational has gone in for CMM quality certification in its Indian subsidiary first and later imported those high quality practices back to its U.S. development centers.** Thus, the quality-related Indo-U.S. collaboration has not only contributed to capability building among Indian software firms but there has been a reverse flow of knowledge embodied in quality-related processes and practices from India to the United States.

The Sankhya Vahini Project

In 1998, a memo of understanding was signed for a collaborative venture between the Department of Telecommunications (DOT), the DOE, the Ministry of Information Technology, some premier Indian educational institutions, and CMU to launch a high-speed data transmission backbone over 10,000 km of optical fiber

*See *http://www.ida.gov.sg/Website/IDAContent.nsf*. According to NASSCOM (2002), the number of Indian software firms with CMM Level 5 certification was 36 in December 2001 (p 108).

**The experience of Motorola is a case in point (Anthes and Vijayan, 2001, available at *www.itworld.com/Tech/2418*).

network. In the first phase of the project, it was proposed to provide a speed of 2.5 gigabits per second (Gbps), which was to be upgraded to 40 Gbps in the second phase. The project was to be executed by an Indian company, Sankhya Vahini India Ltd., in which the equity shares of the CMU and of the Indian government were not to exceed 49 percent. CMU was to participate in the venture through a firm IUNet (short for inter-university network) promoted by the university. The authorized share capital for the venture was expected to be Rs1,000 crores and the initial paid-up capital was pegged at Rs300 crores. The 45 percent equity share to be held by DOT was to be in the form of a pair of optical fibers from the existing optical fiber cables of the department, infrastructure, and cash. IUNet's equity of 49 percent was to be essentially in the form of equipment, systems, technology, and cash.* This project ran into problems and was shelved in November 2001.

An important aspect of the Sankhya Vahini project was that the GOI, having recognized the need for a significant improvement in the communications infrastructure in India, decided in favor of a joint venture with a foreign firm created by CMU instead of the conventional transfer of technology agreement. Moreover, the participation of Indian educational institutions indicated recognition that such participation facilitates the learning and technology diffusion process. While the project did not take off for political reasons, these elements of the project need to be noted. Another dimension needs to be noted: Indian educational institutions wishing to participate in an alliance on the model of CMU cannot do so because Indian laws do not permit them to promote firms and own equity although, as we shall see, an educational institution in India has found creative ways to participate in Indo-U.S. commercial ventures even though the laws do not permit its financial participation.

Media Laboratory Asia

The GOI and the Massachusetts Institute of Technology (MIT) have established a one-year exploratory project to create the Media Laboratory Asia (MLA), which is an independent nonprofit organization. The GOI has committed US$12 million seed funding for the one-year program, $1.7 million of which has been earmarked for MIT's participation. Based on the success of the first year, the two parties will enter into a 10-year agreement, during which they will collect funds worth $1 billion. Of this the GOI may contribute about $200 million, while the remaining

*Most of the details of the project are taken from Ramachandran (2001).

$800 million will be raised chiefly from Indian and foreign corporate sponsors. The broad objective of MLA is to facilitate the invention, adaptation, and deployment of innovations to benefit all sectors of Indian society, especially the poorer sectors. The idea is to disperse the benefits of technology throughout the country by making products that will enhance the quality of life. A variety of initiatives in entrepreneurship, health, disaster control, education, low-cost computation technologies, multilingual and multiliterate systems, and accessible telecommunications are being discussed.*

MLA is another effort initiated through collaboration between the GOI and an American university that is expected to expand into a collaboration involving public and private entities in both India and the United States (see Table 2). The transition from government-university collaboration to one that also involves the commercial sector will be critical for the success of the program.

Activities in which the public sector and universities are involved are more prone to market failures than those in which only private sector entities are involved. Evidently, such participation helps prevent market failure. Furthermore, collaboration to improve quality can enhance the probability of linkages among private entities in the two countries because Indian firms then make better partners. Similarly, any collaboration to improve infrastructure will, in turn, create more opportunities for alliances.

INTERFIRM R&D COOPERATION: THE PACT PROGRAM**

In August 1985, an agreement was signed between the U.S. Agency for International Development (USAID) and the GOI to initiate a Program for Advancement of Commercial Technology (PACT, USAID Program No. 386-0496). US$20 million were earmarked for this 10-year program. The International Credit and Investment Corporation of India (ICICI) was appointed as the implementing agency. The objective was to assist private sector companies in India and the United States in joint R&D projects. These projects were expected to lead to commercialization either in India or the United States. Conditional grants to both Indian and U.S. companies with a maximum of up to 50 percent of the project cost or US$500,000 (whichever was lower) were given. The terms of repayment were easy

*The project description is based on the material available on the MIT website and Joseph (2001).

**The author is thankful to officers at the ICICI, Mumbai office and the Delhi and Washington, D.C. offices of USAID for discussions and information on this project.

Table 2. Types of Collaborations in Terms of Organizations Involved

	Type of Entities	U.S. Entities: Public/University	U.S. Entities: Private	U.S. Entities: Both
Indian Entities	Public/ University	*Institution building* (Indian Institute of Technology, Kanpur, Punjab Agricultural University) *Research/action* (Cornell-ICAR germplasm exchange, vaccination) *Software Process Improvement* (CMU and Center for Information Systems and Engineering) *Media Lab*	U.S. firms' alliances with Indian educational institutions	Sankhya Vahini CMU, IUNet, Dept. of Telecom, Bharat Sanchar Nigam Limited, IIT, Mumbai and Institute of Science, Bangalore, Indian Institute of Information Technology (Hyderabad)
Indian Entities	Private	TCS links with CMU, University of California, Riverside/San Diego and University of Wisconsin	Variety of interfirm linkages	CMM certification (CMU, private entities)
Indian Entities	Both	TCS, Indian Institute of Science, Bangalore and UC, San Diego (Multimedia)	Midas, IIT (Chennai) and Analog Devices	PACT Media Lab

Source: Author's compilation.

and 2.5 times the conditional grant disbursed were to be repaid by way of royalty on sales of the product developed with the assistance of the PACT project within a span of five years. If the product was not sold, repayments were not expected. By 1995, PACT had assisted 50 projects and disbursed US$18.72 million. Project areas included IT, biotechnology, chemical process development, and general engineering (see Appendix I for details of the projects). So far, of the 50 projects, 22 projects have completed repayment obligation and have been closed, 18 are under commercialization and paying royalties to PACT and 10 are facing problems in commercialization. Total reflows received, as of March 1, 2002, were US$4.2 million and Rs34.7 million. Five of the U.S. firms assisted through PACT got listed on the Nasdaq (Appendix I). Apparently, the joint project went a long way in facilitating this transition.

PACT was a technology development program wherein USAID and the Indian government promoted the coming together of Indian and U.S. firms for joint research. Broadly, PACT promoted two ideas: joint technology development by Indian and U.S. companies and external funding of R&D by venture capitalists or others. Thirty-five of the projects financed commercial use of new technologies, mainly in the U.S. market. Through these joint R&D efforts, PACT also supported the successful expansion of a number of high-technology firms.

Nevertheless, overall PACT was not a commercial success. It did not recover its costs through royalty payments. Many problems contributed to this failure. The project found it difficult to define the specific product on which royalties were to be paid. More important, the prohibition on the use of USAID funds to acquire equity prevented PACT from benefiting from success. One firm, ERA Software, had offered stock for its PACT grant that would have yielded a US$20 million profit had PACT been able to accept it.*

Even so, the spillover benefits of PACT appear to have been significant. It is argued that the program's main contribution lay in creating an impetus for policy changes with respect to venture capital. In 1988, the GOI made regulatory changes to permit the establishment of venture capital firms that could acquire equity stock in companies without prior government approval and price setting.** Also, the success of PACT, however limited, showed that linkages to international technology through links to U.S. firms were useful and not harmful to national R&D capability development (USAID, 1994). Both firms and policymakers were able to see these advantages (USAID, 1993).

Taking these two developments together, the PACT project demonstrated the feasibility of joint R&D and the creation of an active private market for R&D financing. In fact, after participating in the PACT-supported activity, PACT firms placed a much higher value on joint R&D than did non-PACT firms. The assisted

*This view is articulated in USAID (1999). Officers at ICICI raised similar issues.

**USAID (1994) claims that this led to the establishment of at least 12 venture capital firms. By the end of 1993, venture funds established under the 1988 regulations had invested more than US$120 million in financing for 428 firms, most of them startup operations. Admittedly, PACT's impact on the venture capital sector was indirect. Very few people in new capital ventures were familiar with PACT. However, most knew about the Technology Development Investment Company of India (TDICI), a venture capital affiliate established by ICICI several years after PACT was established. Interviews carried out by USAID suggest that PACT demonstrated a need for venture capital financing. Thus, PACT stimulated TDICI, which became a model for most other venture capital institutions.

firms also performed better in export growth than unassisted firms. According to agency estimates, for about 82 percent of the PACT firms in India the project was a first joint R&D effort, and roughly two out of three considered foreign participation in joint R&D crucial. Paired firms (similar firms not receiving PACT assistance) were much less convinced, with only about 20 percent considering foreign participation crucial.

Another spillover benefit has been the learning at ICICI, the organization that implemented the PACT project. ICICI has gradually learned better selection methods, avoiding computer software firms that stake everything on a new project, reducing emphasis on examining the feasibility of the proposed R&D, and increasing attention to the grantee's capabilities and track record. ICICI officials now broadly assume that entrepreneurs with demonstrated capabilities who put half of the funding into the project are the best judges and enforcers of project success (USAID, 1994: 7).

From a larger policy perspective, the PACT project found its rationale in underutilized skilled human resources and inadequate linkages between academic research and industrial production. Both manufacturing firms and financial intermediaries may see opportunities for profits from more R&D but the market may not be mature enough to pick up these opportunities. Projects like PACT demonstrate the feasibility of such R&D, thereby stimulating manufacturing firms to do further research, especially joint research, and so create an active private market for R&D financing. The role of interfirm alliances in correcting market failures relating to financial markets is a very important spillover benefit.

INTERFIRM LINKAGES IN THE INDIAN IT SECTOR: SURVEY RESULTS*

Capability levels in the Indian software industry are widely considered to be quite high. However, there are divergent views on whether the industry is "moving toward maturity" or is trapped in a low-level equilibrium. Some earlier work (Heeks, 1996) suggested that Indian software firms predominantly participate at the low end of global outsourcing arrangements and that the movement to more complex jobs is constrained by the domestic IT market. Besides, while the global software skills shortage is likely to continue, the shortage may be more of analysts (or analysts cum programers) than of programers. Consequently, countries like India may face problems if they rely mainly on supplying programming staff.

*This section draws on Basant and Chandra (2003).

Bhatnagar and Madon (1997), on the other hand, cite evidence to suggest that Indian software firms have moved in recent years from low-end tasks ("low value added body shopping" and "offshore customized software development") to more value added jobs ("starting up offshore package development" and in some cases "total offshore product development"). They also argue that the growth of the domestic market is facilitating such growth. It is noteworthy that domestic IT has grown quite rapidly from the late 1990s into the new millennium. But unlike the IT export market, which is completely dominated and driven by the software and the services segment, the Indian IT domestic market has a strong hardware component.*

Irrespective of which of these trends is dominant, interfirm alliances, including outsourcing for product development, are likely to create significant opportunities for learning for participating firms in India. Tentative estimates from a database being compiled from secondary sources show that alliances in the IT sector are on the rise and that the bulk of foreign alliances of Indian firms are with U.S. firms. While analysis of secondary data is still underway, we can assess the role of interfirm alliances using data from a survey of 100 Indian IT firms conducted by the author and P. Chandra in the year 2000.** The survey sought to cover software as well as hardware firms. Preliminary investigation showed that often enterprises have more than one alliance and that, within each alliance, they work on multiple projects with their partners. Therefore, data on interfirm linkages has been analyzed at two levels: alliances and projects.

Nature and Objectives of Alliances

Detailed data was collected in the survey about the nature of alliances, whether the linkages involved transfer of technology, subcontracting, cross holding, marketing arrangements, and so on. Often the same alliance involved a variety of activities or dimensions, e.g., technology transfer, licensing of brand, and a subcontracting contract. To facilitate analysis the alliance activities were divided into five broad categories: technology related, production related, finance related, marketing and distribution related, and those involving a management agreement. Table 3 reports the distribution of alliances across these activities and subactivities within them. The alliances covered a variety of activities: While technology,

*The size of the Indian domestic IT market was about US$5.65 billion in 2000–01, showing a growth of 40 percent over its size in 1999–2000. The contribution of software and services was about 36 percent in 2000–01. (NASSCOM, 2002: 44-45).

**Basant and Chandra (2003) provide details of the survey and a more detailed analysis of the data.

Table 3. Extent of Participation of Foreign and Domestic Firms in Different Categories of Alliances (percentages)

Category	Distribution of Alliances by Categories		Share of Domestic and Foreign Alliances in Each Category			Alliances Reporting Category (%)
	Domestic	Foreign	Domestic	Foreign	Total	
Technology related	28.7	25.9	20.1	79.9	100 (134)	51.9
Production related (GSO)	21.3	25.2	16.1	83.9	100 (124)	48.1
Finance related	14.9	11.6	22.6	77.4	100 (62)	24.0
Marketing and distribution related	25.5	27.6	17.4	82.6	100 (138)	53.5
Management agreement	9.6	9.7	18.4	81.6	100 (49)	19.0
All	100 (94)	100 (413)	18.5	81.5	100 (507)	100 (258)

Notes: 1. Total number of sample firms was 96. 2. Total number of reported alliances was 258. 3. Figures in parentheses are the number of alliances/alliances reporting each type of linkage.

production and marketing, and distribution-related alliances were equally important (52 to 54 percent), finance and management agreement-related linkages involved only 25 percent of the linkages. Overall, the interfirm alliances among the sample IT firms focus on technology, production and marketing, and distribution activities. Unlike many alliances in recent years, linkages between IT firms do not seem involved mainly in raising financial resources.

A more detailed analysis of technology-related linkages showed that collaborations for establishing standards were dominant. Significantly, more than 26 percent of the alliances involved joint R&D agreements. Besides, many of the technology-related alliances involved joint R&D as well as collaborations for establishing standards. Thus, unlike other sectors where technology links are typically dominated by licensing arrangements, Indian firms in the IT-Telecom sector seem to be "more equal" partners in the technology development process. How "equal" these alliances are is difficult to ascertain but it is clear that most of them are two-way alliances.

Table 4. Distribution of Alliances by Objectives

Objective	Intentions (%)	Realized (%)
To reduce cost and risks	40.3	68.3
To seek financial support	17.1	61.4
To exploit technological complementarity among partners	71.3	77.2
To reduce innovation time span	28.3	56.2
To acquire larger market share	55.8	81.3
To conduct basic research	3.9	40.0
To monitor technological opportunities	53.9	74.8
Expansion of market	65.9	75.3
To access partner's technology	50.4	83.8
To monitor possible entry of potential competitors	22.1	52.6
To seek control over partner	3.5	22.2
Outsourcing of peripheral activities	6.6	41.2
To acquire world class practices	41.5	72.9
To activate subsidiary partnership	4.3	18.2
To strengthen customer-supplier partnership	36.8	62.1
To increase profitability	79.1	83.3
Others (new products, cost effective outsourcing)	3.9	50.0
Total number of valid alliances	258	

Table 3 also shows that interfirm alliances in the Indian IT sector predominantly involve foreign firms. Overall, foreign alliances constituted more than 81 percent of total alliances. In fact, for all categories of alliances, the incidence of alliances between domestic and foreign firms is significantly higher than the incidence of alliances among domestic firms. The survey data show that a large majority of these foreign partners are U.S. firms.

The fact that accessing financial resources is not the prime motive for alliances in the IT sector is also evident from Table 4, which reports the distribution of alliances by objective (multiple objectives were permitted). Here again the focus is on technology. Technology-based objectives included exploitation of technological complementarities among partners, monitoring technological opportunities, accessing partners' technology, acquisition of world class practices, reduction in innovation time span, basic research, and so on. A large proportion of sample firms reported most of these objectives.

Market expansion and monitoring were the other important objectives of reported alliances: The large majority of firms (79 percent) entered into alliances to increase profitability. A significant proportion of firms (40 percent) also established interfirm linkages to reduce costs and risks. Overall, market access and

Table 5. Some Features of Alliances and Their Evolution

Features	Percentage
Size of the projects increased over time	91.6
Number of employees devoted to alliance increased overtime	87.9
Partner helped setup factory/facilities	21.5
Partner helped improve shop-floor/programming practices	53.4
Managerial practices changed	43.9
Alliance helped to develop new products	44.8
Investment in hardware/software useable in other projects	66.8
Alliance helped in training of people other than those involved in projects	69.6
IPRs are held by (or plan to be held by):	
Partner	25.5
Firm	19.1
Both	21.7
None	33.8
Alliances in which email was used as a communication channel	77.6

Note: The number of responses varied for each question; percentages were computed for valid responses only.

technology access seem to be the dominant reasons for alliances. Table 4 and Table 5 read together suggest that accessing complementary assets (marketing, manufacturing, and distribution) is the other major reason for the formation of linkages.

Significantly, in a large proportion of cases the intended objectives were realized. Overall, realization of technological, market expansion, and profitability goals was greater than that for other objectives. In general, the estimates reported in Table 4 suggest that except for a few objectives like activating partnership with subsidiaries, controlling partners, and conducting basic research, the alliances succeeded in satisfying their objectives in more than half the cases. However, as compared to other objectives, the realization rate was significantly greater for exploiting technological opportunities, accessing and monitoring technologies, increasing market share, acquiring world-class practices, and increasing profitability. In sum, alliances seem to have a positive impact on sample firms' technological capabilities, market share, and profitability.

Learning from Interfirm Alliances: More Insights

In almost all the alliances, the size of the projects and the number of employees devoted to the alliance increased over time (see Table 5). The proportion of alliances in which the partner helped set up factory or other facilities was rather low at 22 percent, probably because not many alliances involved manufacturing linkages. However, in about 44 percent of the cases the partners helped improve managerial practices, and in about 53 percent of the cases the alliances facilitated improvements in shop floor or programming practices. While these relatively low percentages may be partly reflective of the nature of the alliances, one would have preferred a more positive impact of alliances on firm level practices. Perhaps firms are not consciously trying to exploit this potential benefit.

On the positive side, almost half the alliances, about 45 percent, facilitated development of new products. In about 41 percent of the cases, the sample firms (either jointly with the partner or alone) also held the intellectual property rights (IPRs) over the technology generated through the alliance. In about 26 percent of the cases, the partner firm owned the intellectual property (IP) developed through the alliance while in about one-third of the cases nobody owned the IPRs, presumably because the partnership did not lead to any tangible intellectual property that could be protected. Interestingly, only about 65 percent of firms considered IPRs to be important in an alliance. This may reflect the dominance of the service orientation of alliances, where proprietary technologies and products are less important. As alliances focus on more complex projects, IPRs can be expected to become critical.

Apart from direct benefits in the form of product or/and process capabilities (e.g., factory and other facilities), the sample firms seem also to be benefiting from spillover effects. About 67 percent reported that the investments in hardware/software made through the alliance are useable in other projects. In almost 70 percent of the cases, the alliance helped in training employees other than those involved in the alliance projects. Significantly, for about 78 percent of alliances, electronic mail was an important source of communication. The communications infrastructure seems to have facilitated the functioning of alliances in the IT-Telecom sector.

Some Dimensions of Projects Undertaken Within Alliances

As noted, more than one project may be undertaken within an alliance. The survey collected some information at the project level; Table 6 summarizes the key findings. On average, the sample firm made 73 percent of the total financial investment in the project. This is consistent with the earlier finding that alliances captured in the survey were not primarily geared toward raising financial resources.

Provision of design, software and hardware can be seen as important aspects of interfirm alliances. The estimates reported in Table 6 show that in a large proportion of cases the sample firms provided design, software, and hardware inputs. In fact, the proportion of cases in which sample firms (either alone or jointly with

Table 6. Profile of the Projects and the Associated Learning Potential

Characteristics of Projects	Percent
Average share of the firm in investment	73.0
Average share of the partner in investment	21.0
Percent cases in which design was provided by:	
Partner	43.2
Firm	48.9
Both	7.9
Percent cases in which software was provided by:	
Partner	40.3
Firm	32.3
Both	27.4
Percent cases in which hardware was provided by:	
Partner	41.9
Firm	33.3
Both	24.8
Percent cases where planning done jointly was significant	50.4
Percent cases where planning done jointly was moderate	30.7
Percent cases where planning done jointly was low	19.0
Percent cases where firm has access to the final product	82.9
Percent cases where number of people hired had new skills	58.2
Total number of projects	156

partners) provided these inputs was higher than the percentage of cases where the partner alone provided them. The cases in which both firm and partner provided these inputs can certainly be seen as two-way linkages, so that few projects can be characterized as one-way partnerships. The fact that in more than 81 percent of the projects the sample firm played an important role in planning strengthens this impression. And in 83 percent of the cases, the sample firms had access to the final product of the alliance.

Another important feature of the projects has been that in more than half the cases (58 percent) employees with skills not hitherto available in the firm were hired for the projects. The projects, therefore, created opportunities for firms to enhance their knowledge base through recruitment of better trained people. This advantage is over and above the benefit of training employees already on payroll through such projects.

Overall, these survey findings suggest that interfirm alliances in the IT sector have been used to access technology, complementary assets, and expanding markets. Accessing financial resources does not seem to be a key objective, although of course firms try to reduce risks and costs and improve profitability through such alliances. As is the case in most situations, some firms have gained most.

The survey data are inadequate to identify the characteristics of those firms that have benefited more than others. But the firm level case studies show that those firms that consciously try to learn from alliances and those which are willing to make investments and take risks are likely to gain more from alliances than others not so inclined. Learning from alliances is not an automatic process and requires significant effort on the part of the participating firms.*

Although there is evidence to show that more and more international alliances are catering to the domestic Indian market, external market needs are generally the focus of alliances. As noted, it has been argued that the small size of the domestic market is a factor constraining the growth of the Indian IT sector and will delay its maturity. Conversely, while the IT sector can continue to grow given growing external demand, there is no doubt that benefits would synergistically flow to the domestic economy if the IT market at home were to accelerate its growth rate. In the same vein, international alliances would also contribute more to the economy if the IT sector had significant linkages with the rest of the economy through growth in demand for IT products and services. Thus, policies that enhance the growth of the domestic market may be critical if international alliances in the IT sector are to contribute to growth of other sectors in the economy.

Scope for Learning and Diversification Through Linkages: A General Perspective

The discussion so far has highlighted a variety of ways in which Indian IT firms have benefited from alliances. What follows is a summary of key insights from interviews with some senior IT professionals in India. Table 7 shows that different IT tasks are associated with different levels of complexity, risk, profitability, investment, and infrastructure requirements. Interfirm alliances seem to have facilitated the movement of Indian firms from less to more complex, risky, investment intensive, and profitable services. In the absence of such alliances, the transitions might not have been possible. Table 8 provides examples of the variety of connections between Indian and U.S. firms in the IT sector.

Broadly, what emerges from the interviews is that benefits from international alliances for Indian IT firms include:

- diversification of service offerings and market access;
- acquisition of knowledge and implementation capabilities in the early stages of the product/package life cycle;

*See Basant, Chandra and Mytelka (1999) and Basant and Chandra (2001, 2002) for some case studies.

Table 7. Hierarchy of Software Services and Products

IT Tasks	Investment	Net Profit	Market Valuation	Complexity	Risk	Infra-structure Requirement
All Services	Medium	High	Medium	Medium	Medium	Medium
Staff Augmentation	Low	Medium	Low	Very low	Low	Very low
Application Development	Medium	Medium	High	High	Medium	Medium
Migration	Low	High	Medium	Low	Medium	Medium
Package Implementation	Low	High	Medium+	High	Medium	Medium
Remote Maintenance	Medium+	Medium	Medium	Medium+	Medium	Medium
Application Service Provision	High	Medium	Low	High	High	Very high
IT Enabled Services	High	Medium	Medium-	Low	Medium	Very high
Products	High	Medium	High	High	Very high	High

Source: Insights from interactions with Pawan Kumar, vMoksha Technologies, Bangalore, India.

- specialization in service provision through acquisition of domain knowledge and entry into specific verticals like telecom, banking, etc.; and
- transition from service firm to product firm.

The first three processes have been dominant and within each the complexity of tasks has increased. In recent times, one observes beginnings of the last process.

Given that the nature of different IT activities is different, can we say that the policy needs for alliances in different IT tasks are also different? We shall come back to this issue.

COLLABORATIONS WITH INDIAN EDUCATIONAL INSTITUTIONS: THE CASE OF INDIAN INSTITUTE OF TECHNOLOGY, CHENNAI*

In the early 1990s, the Telecommunications and Computers Network (TeNeT) group was formed by nine faculty members from the Electrical Engineering and

*This section draws on Basant and Chandra (2003).

Table 8. Variety of Alliances Entered Into by Indian IT Firms—Some Examples

Types of Alliances	Examples
Services	
Staff Augmentation	Aditi-Microsoft
Application Development	GE-Satyam (JV)
Package Implementation	TCS-SAP
Migrations	Compaq India-Persistent Systems
Remote Maintenance	TIS-Silverline Technologies
Application Service Provision	Satyam-Computer Associates (JV)
IT-enabled Services	Wipro-Spectramind (Equity)
Nonservice industries	
Computer Hardware	IBM-Wipro
Biotechnology	Satyam-CCMB
Verticals	
Engineering Services	Van Dorn Demag-Infosys
Telecom and Internetworking	Nortel Networks-Infosys
Retail	
Finance	Nordstorm-Infosys
Aviation	Swiss Air-TCS
Embedded Systems and Chip Design	DCM Datasystems-Intel
Manufacturing	Oncourse-Geometric Software
Systems Integration	Wipro-HP
Customer Relations Management	Siebel-Infosys
Technology Consulting	Answerthink-HCL
Alliance Categories	
Marketing Alliance (Access New Area)	JASDIC-Infosys (JAPAN)
Marketing Alliance (New Domain)	Wipro-Spectramind
Product Marketing Alliance	Vision Compass-Oasis
Technology Alliance (Implementation)	SAP-Infosys
Technology Alliance (Product Development)	Microsoft-Infosys (Hailstorm technology development)
Technology Alliance (New IP creation)	Synopsis-HCL Technologies
Joint Product Development Alliance	Tata Infotech Ltd-WFS
Product Technology Compatibility Alliance	Servion-Infosys
Standards	TCS (Internet Security Alliance)

Source: Author's compilation with the help of Vivek Gupta.

Computer Science departments of the Indian Institute of Technology (IIT), Chennai, with an objective of creating indigenous technological solutions for reducing the access network costs in India. Over the years, the group has developed a variety of systems.* Many entrepreneurial ventures, which in turn become

*These systems include CorDECT (a wireless in local loop solution for access networks); Digital Internet Access System (DIAS), a direct, wired, Internet access system; OPTIMA (fiber in the loop solutions, where the fiber connects the access centers while the backbone has a radio link); and CYGNET (a network management system).

part of the expanding TeNeT group, have been set up to commercialize these technologies. In the formation of two of these enterprises, links with U.S. firms have played a major role. In this section, we describe the linkages formed by these two enterprises incubated and launched by the TeNeT group at IIT, Chennai.

MIDAS Communications Technologies

To commercialize the CorDECT technology by setting up an enterprise, the TeNeT group scouted for people who could promote such a company. IIT and the new company were to jointly own the initial product based on this CorDECT technology while the company would be fully owned by the promoters. Such an organizational setup was necessary as IIT was not able to hold equity in the firm, Indian laws not allowing such financial participation by educational institutions. These institutions can, however, earn royalties so that ownership of the initial product was feasible.

The TeNet group persuaded nine of their graduates to start and provide equity for a company called MIDAS Communications Technologies that would commercialize the CorDECT technology. The TeNeT group provided technical support. IIT and MIDAS jointly owned the product, CorDECT. Early on in the project, the group realized the critical role of high-quality specially designed Integrated Circuits (IC) in the development of its product and also appreciated that such IC (especially in small volumes) could not be developed in India. The group contacted Ray Stater, chairman of Analog Devices, a premier IC manufacturer in the United States. He evaluated their technology and agreed to develop the IC designed by IIT. Analog Devices agreed to market these IC outside India and pay the group royalties. They also agreed to help the group license the IC within India. But most important, Analog Devices agreed to advance funds to the group against future royalty payments. To raise additional funds, MIDAS licensed its technology to other companies in India.

MIDAS now is a growing organization of about 250 people. Of these about 200 are R&D engineers who work in the design and development area, both in wireless and fiber applications. Others belong to the technical assistance cell that performs business development, validation and testing, installation and field support, manufacturing support, and pilot production. MIDAS has done significant work to make its technologies compatible with third generation telecom (3G) standards to enhance its range. The group is also working to modify its products so they can be used for new airwave ranges. Analog Devices has been an active partner in all these endeavors. Apart from IIT, Chennai, MIDAS considers the U.S. firm to be the major contributor to its growth.

Banyan Networks

While MIDAS was trying to address the last mile problem of telephone access by wireless in a local loop (WLL), the Internet revolution took place. The TeNeT group at IIT recognized that this would require local wired access for handling data through the Net and it once again helped start a company with its former students working on data-voice convergence. This was how Banyan Networks was founded in 1995. This time the company was formed with the help of former IIT students and external promoters. Stater of Analog Devices provided angel funding.

As the firm grew, other entities also showed interest in investing in it. Intel Pacific Corporation, a unit of Intel Corporation, became a venture capital investor in 1999. This linkage provided Banyan access to the global network of various Intel portfolio firms, apart from the formal connection with Intel itself. Princeton Global Fund, an associate fund of Sycamore Ventures (New Jersey, USA), invested in the company in March 2000. This venture capital firm has strong links in the telecommunications and computer networking industries in the United States and the Far East. In addition to the U.S. investors, two Indian firms have also invested in Banyan Networks, IL&FS Venture Corporation and the telecom service provider Himachal Futuristic Communications Limited.

During its growth phase, Banyan has come up with a number of related products. One of its earlier products, Nova Ethernet Switch, was developed jointly by Banyan, IIT, and Analog Devices (in Boston). Analog Devices started a new company to market this product in the United States. The product was a finalist in the Las Vegas IT show. This was probably the first time in the history of the Indian IT industry that a networking product developed in India was licensed to a U.S.-based firm (Agacia Networks Inc.) for manufacturing and marketing in the United States and other international markets. Over the years Banyan has come in with many products.*

*One product, DSP (Digital Switch Processing) was ahead of its time—it was licensed to Fujistar. Then came DIAS, a product that performs both data and voice transfer at the same time. It replaces the modem and helps in reducing overload at the exchange (a problem that occurs when modems are used as they lock a circuit). DIAS combines the wireless technology of WLL with wired ethernet connections and provides voice and data transfer over the Internet. Banyan licensed this technology to its manufacturers and service providers in the country: HFCL, Shyam Telecom and ARM, Hyderabad. The seed money provided by these licensees as well as U.S. earnings helped develop this product. The firm is currently developing another product, LAN Phone Set, which sends voice over LANs. Here each user on the LAN gets a private telephone number and can perform voice transfer simultaneously. This technology can bypass existing Integrated Services Digital Network (ISDN) technologies, as Voice-over-IP has now become legal in India.

These partnerships were based on derivation of mutual benefits although elements of risk taking were involved, a common feature of most technology linkages. One of the most enduring linkages of the entire IIT-MIDAS-Banyan network has been with Analog Devices, chipmakers looking for chip designers. Since they were not equipment producers, the people at Analog Devices did not foresee any competition from MIDAS. Moreover, each time MIDAS used its digital pixel sensor (DPS) general purpose chip for building its designs, it increased Analog Devices sales. MIDAS also helped the company find several chip designers in India (including some in the IIT team). In return, the IIT team benefited by securing help in producing specialized IC in small volumes, finding in the company a marketer of its IC designs and a funder of IIT projects.* In the initial stages of Banyan, a number of engineers from Analog Devices helped Banyan resolve technical problems. They also helped Banyan procure components from the United States.

Similarly, Intel's participation as the lead investor in Banyan Networks was motivated by its interest in selling its chips for new applications especially in emerging technologies. It was also a pre-emptive strategy in case the group at IIT developed a competitive technology. Banyan benefited, other than through direct funding, by networking opportunities with various other partners of Intel, which allowed it to attend various product portfolio conferences of Intel globally (and especially in Asia Pacific) and thereby track developments in chip design and new applications.

From the perspective of Indo-U.S. technology cooperation, two issues stand out from the experience of the two firms floated by IIT, Chennai:

- Formation of such entrepreneurial ventures seems to be the only way in which Indian scientific institutions can partner with foreign firms in any commercial venture.
- For telecom software firms in India, partnering with foreign hardware (including IC) may be critical for growth and diversification.

Institutions such as IIT, Chennai, have linkages with well-trained students, the ability to draw together a team of well-educated and trained people, international experience and exposure, and the credibility of academic institutions. They often possess world-class technological capabilities and the ability to translate innovations into commercial applications. Besides, groups like TeNeT in such

*Analog Devices advanced money to the group against future royalty for its designs.

institutions have the ability to quickly recognize implications of emerging trends in technology. This allows them to look for novel technological solutions to persisting problems in dynamic technological domains. These core strengths of groups like TeNeT, when coupled with the low cost of performing R&D in India, have provided a formidable combination for forming partnerships with international and domestic firms that possess other complementary assets.

A variety of linkages have now been identified. Once again, we note the inability of Indian institutions to own equity, a restriction on the growth of such linkages, in contrast to CMU's ability to form a company to participate in the Vahini project. That commercial linkages of the kind discussed above will be useful is obvious. There will be significant spillover benefits for India's educational institutions. Such research will flow to the classroom, and the faculty will be better able to train students to become better technologists. Master's-degree students can pick up precious designing skills and get trained in product development while undergraduate students can work on real projects and get paid for their work. The institutional team will also learn how to take an idea from laboratory to market.

In fact, all these benefits accrued to IIT, Chennai. Nevertheless, incentives for similar efforts elsewhere will be enhanced if educational institutions are allowed to own equity. The flexibility of these institutions will also be enhanced as will their autonomy and financial independence.* In the absence of laws that support equity participation by educational institutions, direct linkages with foreign firms can only take the form of research projects funded by foreign entities. These are surely useful, but in a liberalized environment equity participation is also perhaps desirable. Policies that facilitate this transition and that encourage linkages of Indian software firms with foreign hardware firms may therefore be useful.

SOME POLICY ISSUES

Polices Relating to Foreign Direct Investment

As noted, the significant rise in the number of interfirm alliances is in part due to liberalization of FDI-related policies. The 1990s witnessed consistent liberalization of Indian investment policies and also of policies relating to technology

*Some members from the TeNeT group have now established a nonprofit company that will hold equity in a firm floated by the group N-Logue Communications (www.n-logue.co.in).

collaborations. Most types of collaborations are now automatically approved. In most industries, multinational corporations (MNCs) can now own more than 50 percent equity.

It is well understood that entry of transnational corporations through technology transfer, investment, or alliances is significantly affected by host country policies. Typically multinationals strategically seek host countries with large market size, specialized skills, good infrastructure, or very liberal and FDI friendly policies. Most people interviewed by us felt that liberal FDI policies are critical for the growth of the Indian IT sector and the maturity of interfirm alliances. The liberalization of FDI policies so far has been generally welcomed, and it is believed that more liberalization is required in policies relating to mergers and acquisitions (M&As). Industry people argue that such deals are very cumbersome, with a lot of paper work and a high court permission requirement that leads to delays. In the case of cross-border acquisitions, currently only all cash deals are allowed. As stock swap deals are not permitted, Indian firms are not able to leverage their high valuation (Kumar, 2002).* These policies are important, especially for equity-based alliances, due to several interesting developments in recent years:

- A trajectory typical of international interfirm IT alliances has been that they start with small offshore projects that subsequently become large and more complex. With time and the building of trust, these projects take the shape of dedicated development centers and then of equity joint ventures. Often, foreign firms prefer ownership transfer. Liberal FDI and M&A policies facilitate these transitions and provide some certainty to foreign firms who have strategically decided to follow this trajectory.
- In the earlier phase of alliances in the IT sector, typically large Tier 1 U.S. firms built linkages with Tier 1 Indian firms. Many of these large Indian firms—Tata Consultancy Services (TCS), Infosys, Wipro, and others—have now started to compete with global IT firms such as IBM, Electronic Data Systems, and Computer Sciences Corporation. In this phase, when Indian collaborators of yesteryear are beginning to compete with the large U.S. multinationals, it is imminent that Tier 1 firms of each country will build linkages or acquire Tier 2 entities in the other nation. Global Tier 1 IT

*A stock swap deal involves an acquiring firm offering its equity in return for the equity of the firm being acquired. Current Indian regulations do not permit such swaps in cases of acquisitions but permit them for mergers.

firms will seek relationships with Tier 2 Indian IT services firms that can compete with Tier 1 Indian IT services firms. In response, Tier 1 Indian IT service firms will need to acquire (or ally with) Tier 2/3 firms (typically front-end marketing or consulting) in the United States or Europe.* More liberal M&A policies in India will be required for this transition.

- The transition from the onshore to the offshore model was not easy but the offshore model has now become quite stable, and Indian firms have already tapped the most accessible customers in the Western economies. Typically these customers are large U.S. corporations who are not that concerned about owning equity in order to control their alliances with the Indian firms. Now Tier 2 IT firms in the United States and Europe are facing competition and, in order to be cost competitive, need to build linkages with Indian IT firms. However, they do not feel very comfortable where equity participation and the possibility of acquisition are difficult.** Liberal FDI and cross-border M&A policies can facilitate the deepening of the linkages between the Indian and U.S. firms that are based on the offshore model.
- It has been pointed out that interfirm alliances have resulted in movement from less to more risky, complex, and investment-intensive IT activities. Ability to own or acquire equity is critical for such tasks. A more liberal policy in this regard would create potential for more learning by Indian firms through more complex alliances.

It will be recalled that the proportion of equity-based alliances among the sample IT firms was not very high. Once these policy-based uncertainties are reduced, we may see more financial collaborations.

Policies Relating to Education, Quality Upgrade, and Training

At the outset, it needs to be recognized that the successes of the Indian IT industry and the alliances have been in no small measure due to capabilities created by public policies. Investments in human capital creation by the Indian government have made this possible. Many studies have highlighted the role of these investments (see, for example, Arora and Athreye, 2002).

*Pawan Kumar of vMoksha Technologies first pointed out these tendencies to me. Subsequent developments have added empirical support. For example, the *Asian Wall Street Journal* of May 16, 2002, reported that Wipro plans to procure IT consulting firms in the United States.

**Thanks to Vinod Nair of McKenzie Consulting for pointing out this trend to me.

Policies relating to higher education provided the basis for the IT boom in India, and IT skills and quality orientation generated at the university level enabled the building of alliances and worked to prevent market failure. Private investment in higher education in IT has grown in recent years as the market failures associated with this segment have declined (Arora and Athreye, 2002). Therefore, the state can partly withdraw from this activity. However, some kind of state participation in the development and implementation of university objectives will continue to be desirable, and now it may be time for the GOI to focus more sharply than heretofore on developments in primary and secondary education. Computer training and a wider commitment to English language training in primary and secondary schools in mid-size towns will not only create a domestic market for IT but may also enlarge the skill pool available for the IT sector.

The transition from the onshore to the offshore model deepened the IT labor market in India. Expanding Indian firms could now utilize the segmentation in the labor market to their advantage. The offshore model permits Indian firms to hire nonengineers and engineers with less training to undertake less complex tasks, leaving the higher level tasks for senior and better trained employees. Economies of scale have put a downward pressure on labor costs, which were rising rapidly due to the growing demand and inadequate supply of people with multiple skills.

A focus on English and computer education in school can further deepen the IT labor market so that for different levels of IT tasks, people with different levels of training and background can be used. IT-enabled services have seen significant growth in recent years and are expected to generate a large volume of jobs in the next five years (NASSCOM, 2002). In such a scenario, a focus on computer education and English language in smaller towns will create a larger pool of human power to benefit from these opportunities. Combined with good infrastructure, availability of skills in such regions can increase cost competitiveness of Indian firms in the IT enabled services for many years. This is not to suggest that a focus on English language competency is necessary for the entire country. In many parts the primary need today is to develop basic numeracy and literacy.

The other role the state can play is to facilitate curricula upgrades. Many of India's higher educational institutions are still run by the state. If the nature of courses has to be changed, the government may need to take an active part. Several industry people have suggested that a sharper focus on microelectronics-related courses would facilitate India's participation in embedded software and would also create the potential for alliances in this area of IT activity. If telecom is seen as a major area of growth then public intervention may be required to generate the long-term supply of skilled personnel in the telecom sector. Support for IIT types of networks can go a long way in generating such a skill pool, as spillovers through training and research are very high.

A policy focus on education along with firm-level incentives for quality upgrades and on-the-job training would not only enhance the potential of alliances but also improve the absorption capacity to benefit from alliances.

Policies for Domestic Market Creation

In India external markets are large and growing and provide significant opportunities for learning, while the small domestic market limits the effects of these alliances on the domestic economy. In contrast, recent analysis has found that while the alliances of a North American MNC in India were for external markets, in China the collaboration served the local market (see Basant and Chandra, 2001). One way of creating local demand is to enhance the utility of IT in primary, secondary, and tertiary production sectors. Currently these uses in India are very limited. India does not have IC manufacturing, or manufacturing of those products that use embedded software in a significant manner. Absence of hardware manufacturing has been seen as a significant constraint on the growth of domestic IT sectors.

The survey findings as well as the case studies suggest that domestic software (hardware) firms may need to forge linkages with hardware (software) firms to reap the synergies between software and hardware skills in telecom and other sectors.

Policy vis-à-vis China

Interestingly, China has made significant overtures in recent years to enhance linkages between India and China. The Chinese have argued that capabilities in the two countries are complementary and that the combination of Indian software skills with the Chinese hardware skills can be potent. The Indian government and the corporate sector so far have been uncertain about these linkages because China is seen as an emerging competitor in the software sector. At the same time, the size of the Chinese market and the learning possibilities cannot be denied, and one may soon see strategic initiatives to more proactively participate in the Chinese market through a variety of alliances.

Evidently, Fortune 500 clients are also urging Indian vendors and partners to gain presence in China, not only to enhance the partnerships but also to help the Indians leverage in the wider Chinese market. Indian firms are also keen to enter new markets after the slowdown in the United States, which for the past decade has accounted for 70 to 90 percent of Indian software exports (*Financial*

Times, May 21, 2002).* It is not entirely clear if Indo-China cooperation would be beneficial for U.S. firms in the long run.

Policies Relating to Technology Standards

Policies that create technology standards in sectors like telecom are also important for creating domestic markets for software and hardware. In the current era, when convergence of technologies is taking place and at the same time technology development is being unbundled, linkages are critical for many software firms, especially those associated with telecom. Frequent government changes in technological trajectories and standards prevent MNCs from investing in R&D in developing countries like India; firms are unable to predict patterns of usage of equipment and services and hence are less likely to make investments and build linkages. Given the possibility of government error in a situation where technologies are changing very rapidly, it is difficult to make a case for a state-mandated long-term choice of technological trajectories that can potentially lock an economy into specific technologies. That having been said, all efforts need to be made to reduce technological uncertainties.

Software-hardware linkages may be particularly critical for the telecom industry in times to come and Indian IT firms should participate in these alliances actively. Unlike China, to date India has failed to become a large base for telecom equipment manufacturing. Nevertheless, there is still potential to attract equipment/hand set manufacturing firms to India to develop a manufacturing base. Equipment orders for the cellular industry were estimated to be worth US$10 billion for the 1995–2005 period (Singh, 1999: 186). While the roll-out has been not as rapid as expected, India by no means is a small market. Current trends do not suggest any major improvement on the manufacturing front. But if India is able to attract manufacturing-related FDI in telecom or become part of the global production networks of telecom equipment manufacturing, given technological uncertainties it does not seem desirable that all firms should get tied to specific telecom standards. It may be more useful for India to strategically keep its options open vis-à-vis telecom equipment manufacturing. A technologically diversified manufacturing base may be preferable for both hardware and software industries with Indian firms in alliances to make software (embedded and other) for telecom equipment following different standards. A policy of neutral telecom standards makes sense at this stage from the perspective of

*Significant efforts are being made by Indian software firms to build alliances in Europe and Japan as well.

broad-based learning through alliances. A large and growing telecom market in India can support such a strategy without compromising economies of scale.*

The learning of standards and getting observed in the international market are important advantages of interfirm alliances. Firms of developing countries may, however, need to worry about a trade-off. Long-term association with a single partner develops trust and facilitates technology transfer and learning. But given rapid developments in telecom technologies emanating from a variety of firms, multiplicity of linkages may be more useful to avoid locking into one firm's standards or technology. If one goes by the linkage patterns of large Indian firms (data not reported here), one notices that they have entered into a wide variety of alliances to reduce the potential for getting locked in. However, an open-access strategy of host country firms creates a potential for technology spillovers across networks, and multinational partners may be reluctant to facilitate learning in domestic firms under such conditions. This is an issue that the partnering firms have to resolve, given their strategic intentions.

Policies Relating to Intellectual Property

Until very recently, IP-related issues were not so important because Indian firms were still largely involved in low-end work. However, with the maturing of their linkages with foreign firms, Indian IT firms have started to do more complex tasks. In such tasks, IP becomes increasingly important. For example, if interfirm linkages involve application service provision, sharing of data will be required, making IP an important issue. Broadly, IP-related issues might be critical for linkages involving complex IT tasks, especially in the early part of the technology and product life cycles. Some Indian firms have argued that given India's legal system, most of IP-related issues can be sorted out through a proper contract and trust. For the multinationals, however, a more stringent IP policy would reduce contracting costs and the cost of legal remedies. Moreover, for Tier 2 U.S. and other foreign firms, a more stringent IP policy and implementation may provide the confidence to develop linkages with Indian firms. These firms may not be as confident of such linkages due their relatively small size and their lack of experience with Indian firms; Tier 1 U.S. firms have the muscle to arm twist Indian firms in case a problem arises.

IP-related issues may be equally important when public sector entities are involved on both sides. For example, the project MLA initiated by the GOI and

*Basant and Ramadesikan (2002) provide evidence to support this argument and a more detailed analysis of this issue.

MIT is expected to involve the private sector at a later date. IP-related issues have cropped up here. Private sector participation in the project is contingent on who will own the IP produced through the project. One option being considered now is that IP will be shared equally among all sponsor firms after a minimum amount is worked out to qualify a company to be a sponsor. Equal rights among all sponsors can create problems,* and the time for which the rights are defined and whether one firm is allowed to buy out the rights of the others will therefore be important determinants of the project. For the success of any such a scheme, a well-defined IP regime for software and hardware will have to be in place.

Overall, the ability of developing country entities to enter into partnerships with industrial country firms may often be contingent on the nature of the IPR regimes in place in the developing countries. If such partnerships are to facilitate the maturing of the venture capital-related institutions, the existence of an IPR regime that provides comfort to investors and inventors seems desirable.

Infrastructure-Related Policies

By all accounts, improvement of infrastructure is critical for building alliances between Indian and foreign firms. Upgrades will be particularly important for IT tasks that are infrastructure intensive, for instance, IT-enabled services and application service provision. A review of Table 3 suggests that infrastructure requirements are important for most IT tasks. Moreover, for policymakers on both sides who want participation of Tier 2 firms in global alliances, infrastructure upgrades will be critical. Tier 2 firms in India and the United States may not have the resources to spend very heavily on infrastructure on their own and therefore any project that can achieve Sankhya Vahini-like objectives will be very useful in the long run. Although it will be difficult to sell the idea politically, it may be in the strategic interest of the United States to facilitate such infrastructure creation in India as it will help both Tier 1 and Tier 2 firms in the country. Such help for infrastructure creation would reduce costs of alliances for large U.S. firms and enhance their strategic options, as they would now be able to build alliances more easily with Tier 2 Indian firms. At the same time, Tier 2 U.S. firms would also have more options. There is no doubt that infrastructure creation would enhance both competition and collaboration among Indian and U.S. firms and that may be the best situation for both countries. From the Indian perspective, good infrastructure would also be critical for the creation of the internal market and the

*See Joseph (2001) for an interesting discussion of this issue.

diffusion of IT. And since market failures in any large infrastructure project are large, the Indian government may need to take an active interest in this activity.

Policy Options to Enhance Participation of Educational Institutions in Alliances

It has already been said that proliferation of IIT-Chennai-type networks can have significant spillover benefits in terms of training and technology generation. Given such large potential advantages, liberalization of equity-holding norms for educational institutions would be very helpful in creating incentives for Indian institutions to participate in international research alliances with private entities.

Findings indicate that when the technological gap is relatively narrow, alliances of developing country firms with other entities (multinational or domestic) can play a crucial role in upgrading developing country capabilities. Thus, policy should aim at reducing the technological gap through a variety of instruments. Policies on human capital and infrastructure development and those that encourage active participation of educational institutions in international alliances should be seen from this perspective. Given the complementarities among various types of alliances, policymakers should view alliances in a comprehensive manner. In a period when many erstwhile public sector entities are being given more autonomy or are being privatized and the private sector is being unshackled, a variety of international alliances in which different entities participate can contribute significantly to the development of capabilities in the knowledge-based sectors in India. Finally, conventional policies to bolster absorptive capacity such as augmented support for formal education, private sector R&D, and linkages between formal research and business sectors would be useful as well.

APPENDIX I — SOME DETAILS OF THE PACT PROJECT

A. CLASSIFICATION OF PACT PROJECTS

No.	Partnering Companies	Collaborative Project	Assistance
A.	***Information Technology***		
1	American Hytech Corp., Pittsburgh, USA	Network management system	US$ 245,000
	Indian Organic Chemicals Ltd., Bangalore, India		RS 2,000,000
2	Aspect Development Corp., California, USA	Component library management system	US$ 350,000
	DCM Limited, New Delhi, India	(CLMS)	RS 2,000,000
3	Crosscheck Technology Inc., San Jose, USA	PCB testing system	US$ 400,000
	Ncore Technology Pvt. Ltd., Bangalore, India		
4	Custom Cut, Inc., Los Altos, USA	Computer-aided garment production system	US$ 500,000
	Anamak Technology Pvt. Ltd., Bangalore, India		
5	Cybermedia, California, USA	Network management	US$ 290,000
	SR Associates Pvt. Ltd., Chennai, India	package	RS 900,000
6	Data Parallel Systems Inc., Indiana, USA	Commercial decision support	US$ 350,000
	Persistent Systems Pvt. Ltd., Pune, India	Software package	RS 1,500,000
7	Duet Technologies Inc., Massachusetts, USA	Rapid prototyping system	US$ 200,000
	Duet Technologies Pvt. Ltd, New Delhi, India		RS 3,150,000
8	FrontierSoftware Development Inc., Massachusetts, USA	LAN management system	US$ 387,000
	FrontierSoftware Development India Pvt. Ltd., India		RS 510,000
9	Genus Software Inc., California, USA	Multimedia applications for health care sector	US$ 350,000
	Wipro Infotech Ltd., Bangalore, India		
10	Indchem Electronics Ltd., Chennai, India	VLSI-CRT controllers for Indian language terminals	RS 794,000
	Modular Semiconductors Inc., California, USA		US$ 28,000
11	Mediaway Inc., Sunnyvale, USA	Multimedia database management system	US$ 400,000
	SGC Comsoft Pvt. Ltd., Chennai, India		

No.	Partnering Companies	Collaborative Project	Assistance
12	Omniview Inc., Pennsylvania, USA Bharat Electronics Ltd., Bangalore, India	Design synthesis system	US$ 500,000
13	Powerplan Corporation, California, USA Duet Technologies Pvt. Ltd, New Delhi, India	Corporate financial planning software package	US$ 350,000 RS 500,000
14	Reach Software Corporation, California, USA HCL Limited, New Delhi, India	Mail management system-Mailman	US$ 500,000
15	Reach Software Corporation, California, USA HCL Limited, New Delhi, India	Workflow management system-Workman	US$ 250,000
16	Research Engineers Inc., Virginia, USA Research Engineers Pvt. Ltd., Calcutta, India	Computer-aided structural drawings	US$ 180,000 RS 1,800,000
17	SEEC Inc., Pittsburgh, USA Era Software Pvt. Ltd., Hyderabad, India	Tools for database re-engineering	US$ 255,000 RS 4,000,000
18	Taurus Technologies Inc., Virginia, USA Tata Electric Companies, Mumbai, India	Multiprocessor system for use as simulators	US$ 500,000
19	Veritas Software Inc., California, USA FrontierSoftware Development India Pvt. Ltd., India	Disk and file management system	US$ 230,000

B. Engineering/Chemical Process

No.	Partnering Companies	Collaborative Project	Assistance
1	Active Technologies Inc., New Mexico, USA Globe Active Technologies Ltd., Mumbai, India	Permanent magnet alternator	US$ 315,000 RS 2,630,000
2	Almex Inc., California, USA Godrej & Boyce Manufacturing Co., Ltd, Mumbai, India	Liquid aluminium refining system	US$ 500,000
3	Amcane Praj (India) Ltd., Pune, India Amcane International Inc., Minnesota, USA	1200 cane separation system	RS 6,500,000 US$ 190,000
4	Armour Polymers Ltd., Mumbai, India Xytel Corporation, Illinois, USA	Catalyst and fluidized bed reactor (FBR) system for pyridine/picoline manufacture	RS 12,400,000

No.	Partnering Companies	Collaborative Project	Assistance
5	Caliente Systems Inc., California, USA	High conductive polymer sheet heaters	US$ 200,000
	Dyhir Engineers Pvt. Ltd., Calcutta, India		RS 600,000
6	Cipla Limited, Mumbai, India Byron Chemical Inc., New York, USA	New process for anti-cancer agents	RS 6,500,000
7	Ecoair Corporation, Connecticut, USA	Environmentally safe air conditioning system	US$ 350,000
	Globe Scott Motors Pvt. Ltd., Mumbai, India		RS 2,250,000
8	Esvin Advanced Technology Ltd., Chennai, India	Thermo chemical conversion reactor (TCCR)	RS 8,200,000
	Manufacturing & Technology Conversion Inc., USA		US$ 50,000
9	Janak Intermediates Ltd., Indore, India D & O Chemicals Inc., Pittsburgh, USA	New process for manufacture of chloroquin phosphate/ sulphate	RS 8,300,000
10	Kistler-Morse Automation Pvt Ltd., Hyderabad, India	Semiconductor strain gauge-based sensors	RS 8,000,000
	Kistler-Morse Corporation, Washington, USA		US$ 150,000
11	Laxmi Boilers (South) Pvt. Ltd., Bangalore, India	Cogeneration system	RS 7,100,000
	Barber-Nicholas Eng. Co., Colorado, USA		US$ 20,000
12	Monitoring Technology Corporation, USA	Online vibration monitor for predictive maintenance	US$ 340,000
	Ramco Industries Ltd., Chennai, India		RS 2,000,000
13	Pennwalt India Limited, Mumbai, India Pennwalt Corporation, USA	Dewaxing of rice bran oil	RS 1,300,000
14	Pest Control India Pvt. Ltd., Mumbai, India	Pheromones and controlled release formulations for cotton	RS 1,000,000
	Fermone Chemical Inc., USA		US$ 32,000
15	Precision Automation & Robotics (I) Pvt. Ltd., Pune, India	High performance industrial robots	RS 1,550,000
	Comutec Robotics Inc., USA		US$ 75,000
16	Standard Synthetics Pvt. Ltd., Mumbai, India Florasynth Inc., New Jersey, USA	Super-N manufacturing system	RS 7,600,000
17	Sudarshan Chemical Industries Ltd., Pune, India Amvac Chemical Corporation, USA	New process for manufacture of isoproturon	RS 1,500,000

No.	Partnering Companies	Collaborative Project	Assistance
18	Thar Designs, Pittsburgh, USA SMS Natural Products Pvt. Ltd., Chennai, India	Supercritical fluid extraction process for natural products	US$ 275,000 RS 3,160,000
19	Thermax Limited, Pune, India Babcock & Wilcox Corporation, Ohio, USA	Internally circulating fluidized bed boiler	RS 2,000,000
C. Biotechnology/Health Care			
1	Akron Rubber Development Laboratory, Ohio, USA Shangrila Latex Industries Pvt. Ltd., Surat, India	Urinary catheter	US$ 38,000
2	Biocon India Pvt. Ltd., Bangalore, India Biocon U.S. Inc., Lexington, USA	Solid state fermentation for microbial rennin	RS 1,500,000 US$ 21,000
3	Camdat Corporation, Pennsylvania, USA Bangalore Advanced Technology Pvt. Ltd., India	Drug database and clinical information system	US$ 285,000 RS 1,100,000
4	Four Eyes Research Pvt. Ltd., Pune, India Alcoa Corporation, Pennsylvania, USA	Spent wash treatment by membrane technology	RS 1,400,000
5	Gujarat State Fertilizers Co. Ltd., India Ecogen Inc., Pennsylvania, USA	Bacillus Thuringiensis-based bio-pesticides	US$ 500,000
6	ITC Agro-Tech Ltd., Hyderabad, India Indacom Inc., Chicago, USA	High yielding cultivars of sunflower hybrids	RS 8,500,000 US$ 35,000
7	Ponds (India) Ltd., Chennai, India Giorgio Foods Inc., USA	High grade button mushrooms using unconventional materials	RS 6,950,000
8	Reddy Healthcare Inc. Georgia, USA Shangrila Latex Industries Pvt. Ltd., Surat, India	New type of male contraceptives	US$ 400,000 RS 1,700,000
9	Spic Science Foundation, Chennai, India DNA Plant Technology Corp., New Jersey, USA	Improved varieties of seeds of rose and coffee by tissue culture	RS 3,400,000 US$ 240,000
10	Zandu Pharmaceutical Works Ltd., Mumbai, India Zandu (U.S.) Inc., USA	Herbal drug for Parkinson's disease	RS 3,480,000 US$ 217,000

No.	Partnering Companies	Collaborative Project	Assistance
D. Others			
1	Ballarpur Industries Limited, Bangalore, India Halophyte Enterprises Inc., Arizona, USA	Cultivation for production of saline water-based crop-Salicornia	RS 14,000,000
2	Kalyani Agro Corporation Pvt. Ltd., Pune, India ESCA Genetics Corporation, San Carlos, USA	Hybrid seed tubers and true potato hybrids	RS 9,450,000

Source: Courtesy Industrial Credit and Investment Corporation of India (ICICI), Mumbai, India

B. PACT-ASSISTED PROJECTS LISTED UNDER NASDAQ

No.	Company	Project	PACT Assistance	PACT Repayment	Remarks
1	Aspect Development Corp., California, USA	Component Library Management System (CLMS)	US$ 350,000	US$ 350,000	Repaid the entire amount
	DCM Limited, New Delhi, India		RS 2,000,000		PACT grant
2	Cybermedia, California, USA	Network Management Package	US$ 290,000	US$ 807,688	Completed PACT
	SR Associates Pvt. Ltd., Chennai, India		RS 900,000		Repayment obligation
3	Frontier Software Development Inc., Massachusetts, USA	LAN Management System	US$ 387,000	US$ 967,500	Completed PACT
	Frontier Software Development India Pvt. Ltd., India		RS 510,000	RS 1,275,000	Repayment obligation
4	SEEC Inc., Pittsburgh, USA	Tools for Database Re-engineering	US$ 255,000	US$ 747,505	Completed PACT
	Era Software Pvt. Ltd., Hyderabad, India		RS 4,000,000	RS 418,092	Repayment obligation
5	Veritas Software Inc., California, USA	Disk and File Management System	US$ 230,000	US$ 575,000	Completed PACT
	Frontier Software Development India Pvt. Ltd., India				Repayment obligation

Source: Courtesy Industrial Credit and Investment Corporation of India (ICICI), Mumbai, India

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