US-India Technology Co-operation and Capability Building: The Role of Inter-firm Alliances in Knowledge Based Industries

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Abstract

The paper reviews some Indo-US technology cooperation initiatives and analyses data on inter-firm alliances in knowledge based industries, especially Information Technology (IT). It shows that the market driven increase in the alliances between Indian and US enterprises has significantly enhanced the variety of linkages between Indian and US 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-US co-operation at different levels need to be analyzed together in order to appreciate the complementarities across linkages of various types. For example, linkages between the public sector entities of the two nations may enhance the potential private sector networking initiatives. The paper also argues that while building of public institutions and policies relating to trade, technology and investment remain important for Indo-US technology co-operation, a shift in policy focus to "market induced" inter-firm alliances may be desirable.

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1. Introduction

Indo-US technology co-operation has a long history and a variety of initiatives at the level of the two governments have been tried out. At the same time, market driven co-operation efforts between firms of the two countries have also been in existence and, as we shall see below, are on the rise. The key question is whether the nature of co-operation between governments and firms should change in this new context of globalization and liberalization. India has access to good software and biotechnology-based skills and therefore significant opportunities to further build capabilities in these sectors through alliances exist. The paper reviews some Indo-US technology cooperation initiatives, especially in the Information Technology (IT) sector to explore the following questions:

- What is the nature of Indo-US technology cooperation especially in the form of inter-firm 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 public policies can contribute to linkages based capability-building process?

The paper shows that the market driven increase in the alliances between Indian and US enterprises has significantly enhanced the variety of linkages between Indian and US 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-US co-operation at different levels need to be analyzed together in order to appreciate the complementarities across linkages of various types. For example, linkages between the public sector entities of the two nations may enhance the potential private sector networking initiatives. The paper also argues that while building of public institutions and policies relating to trade, technology and investment remain important for Indo-US

technology co-operation, a shift in policy focus to "market induced" inter-firm alliances may be desirable.

The rest of the paper is divided into six sections. Since the focus of the paper is inter-firm alliances, the next section briefly reviews the changing role of such alliances. Section 3 discusses a variety of technology collaboration linkages between Indian and US entities. The idea is to identify some key elements that distinguish various types of linkages and their roles. The section also attempts to place inter-firm linkages in a broader context, as inter-firm linkages need to be seen as complementary to other Indo-US relationships in the knowledge intensive sectors. Sections 4 and 5 focus on issues relating to inter-firm linkages. While the former uses survey and interview data to analyze how international linkages contribute to capability building among Indian IT firms, the latter discusses the implications of R&D alliances between Indian and US firms under a specific international co-operation programme. Section 6 discusses an interesting alliance between Indian and US firms and an Indian educational institution. The last section explores policy options that can foster Indo-US technology co-operation especially through inter-firm alliances in the knowledge intensive sectors.

2. The Emerging Role of Inter-firm Linkages

Economic policies the world over, and especially in the developing world, are being liberalized. While there is no consensus on appropriate policy instruments for developing nations to benefit from such liberalization, North-South technology flows, especially through linkages between private businesses, are expected to contribute to capability building endeavors.[1] Given these flows, the complexity of the relationship between sources of technology acquisition (making, buying and copying) makes the policy choices even more difficult.[2] The research on the determinants of inter-firm linkages/alliances and their impact on developing technological capabilities and on competitiveness is in its infancy. This is particularly true for developing countries and even the Newly Industrializing Economies (NIEs).

[1] The links between policy choices, technology efforts and technological capabilities are quite complex. See, Evenson and Westphal, 1994 for a useful review.
[2] See, Basant (1999) and Kumar and Siddharthan (1997) a discussion of these issues.

Firms are engaged in various forms of collaborative activity (See Exhibit 1). Two types of inter-firm 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 relationship involving joint R&D or research programmes to create common standards etc. While the unidirectional linkages have existed for a long time, the two-way relationships are more recent and have become more prominent over the years (Mytelka, 1999; WIR 1998). Furthermore, the nature of some of the traditional relationships like joint ventures and sub-contracting has changed considerably in recent years. For example, in many JVs 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 some sub-contractors 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 (See, for recent examples, Mytelka, 1999 and WIR 1998). Recent literature on global production networks also 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 like sub-contracting linkages have undergone significant changes in recent years, the nature of global software outsourcing (GSO), a kind of sub-contracting, has also changed with the outsourcing firms' participating more actively in such relationships.

Recent data for 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 inter-firm agreements, technology co-operation agreements have seen a significant rise in the 1990s. Moreover, technology co-operation agreements in knowledge intensive sectors like information

technology and life sciences industry have risen most rapidly in recent years and now constitute about 55 per cent of all agreements; information industry alone constitutes about 37 per cent of such agreements (Mytelka, 1999; WIR 1998). Participation of developing countries in inter-firm technology agreements is limited but has improved a bit in recent years. The share of developing countries (especially East Asian), in technology agreements has increased from 4.9 per cent in the 1980s to about 6.2 per cent in the 1990s. Even among those agreements, which involve developing countries, information technology related technology agreements dominate, their share being as high as 27 percent.[3] Besides, the share of two-way relationships among the agreements involving developing countries is also on the rise, which suggests that firms in developing 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. Given the experiences in East Asia, with globalization and liberalization, opportunities for similar alliances are likely to emerge in the Asia-Pacific region. Exploitation of such opportunities may 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 inter-firm alliances, has led many researchers to look at such linkages with renewed interest in recent years (Basant and Chandra, 1997, 2001, 2002). The growth in product sophistication and variety has induced inter-firm linkages as no single firm can develop capabilities in all aspects of product and process technology. The potential role of inter-firm 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 also brought out by a case study of technology partnering in the telecom software sector (Basant, Chandra and Mytelka, 1998). In the hierarchy of linkages, technology development related agreements typically require more technological competence among participating firms than in production and distribution related linkages. The

[3] Using alternative estimates, Vonortas and Dodder (2000) show that the number of international inter-firm alliances in the IT sectors have increased significantly in the 1990s. Developing countries led by the East and South-East Asian newly industrializing countries (NICs) have increased their share in such alliances from about 6 per cent in 1988 to almost 13 per cent in the mid 1990s. The technology content of alliances in which developing countries are involved has also increased.

learning opportunities are also higher in the former. The key issue is whether firms participating in these linkages are able to reap potential learning benefits of such alliances and if so, under what circumstances? An understanding of these circumstances is important both for the policy makers as well as firms participating in such alliances.

3. Changing Modes of Co-operation between Indian and US Entities

The linkages between the Indian and US entities have taken various forms. Both private and public entities have participated in these linkages. However, the nature of these links has changed in recent years. In the pre-1991 period, The Indo-US technology co-operation at the government level has taken various forms[4]:

(a*) Institution building* (e.g., Indian Institute of Technology, Kanpur, Punjab Agricultural University, Ludhiana);
(b) *Collaborative research* by US entities and Indian public sector R&D institutions in specific areas;
(c) *Exchange of germplasm* (e.g., the collaboration between Cornell University and the Indian Council of Agricultural Research);
(d) *Participation of US agencies in technology based public programmes* (e.g., vaccination programmes); and
(e) Organization of workshops and exchange of science and technology personnel.

The linkages between Indian and US private enterprises during this period were very limited. Till the onset of the liberalization measures in early 1990s, usually technology flows from the US took the form of trade in machinery & inputs, arms-length technology licensing and limited foreign direct investment (FDI). Very few Indian firms were part of the global production networks. In general, most of these links were of the "one-way" variety. 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 linkages seems to have changed drastically. Liberalization of trade, technology licensing and FDI policies has enhanced knowledge flows through these means. At the same time, Indian firms are

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

gradually getting integrated into global production networks, a large variety of inter-firm alliances are becoming popular. Many of these alliances or linkages are aimed at developing, modifying or absorbing technologies. This reflects the emergence of India as an important entity in the development of certain technologies, especially in the areas of information technology, pharmaceuticals and biotechnology. But Indian firms still have a long way to go before they can actively participate in the global knowledge networks. A significant effort is required to upgrade technological capabilities in a variety of areas so that the nation is not bypassed by the knowledge revolution.

The Indian private sector is now involved in a variety of linkages with US entities. Exhibit 2 summarizes the variety of technology-based linkages between Indian and US entities. It is noteworthy that the linkages are now dominated by private entities. The linkages between Indian and US private enterprises have not only increased significantly after 1991, many of these are 'two-way' linkages.[5] A variety of entities are involved in these linkages including educational institutions, enterprises and research labs, both in the public and private sectors (see Exhibit 2). Interestingly, new varieties of linkages between public entities have also emerged. Apart from inter-firm alliances, a few initiatives in the Indo-US technology co-operation in recent years have been particularly interesting. In this section, we briefly discuss some alliances in which public sector entities were involved and try to identify a few insights in terms of the changing nature of these linkages.

3.1 The CMM Certification Revolution

In 1998, Department of Electronics, Government of India 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 (CISE) of CMU works with the Indian software community to introduce software process improvement technologies in India. This subsequently developed into a Capability Maturity Model (CMM) certification process wherein CMU collaborated with the private sector (through the Appraiser programme) to upgrade process quality among Indian software firms. Thus, a public-public initiative became a public-private initiative

[5] Some evidence to this effect will be discussed in a later section.

very quickly and has contributed significantly to the quality up gradation process of the Indian software industry. According to an estimate, in early 2002, of the 58 CMM Level 5 firms in the world, 32 were based in India (www.ida.gov.sg/Website/IDAContent.nsf).[6] CMM Level 5 is the highest level of certification. The Indian software firms have caught the quality bug and are in the process of getting certified under several quality related programmes, including the CMM and the ISO. Of the top 300 software firms in India, 216 already had some kind of a quality certification by December 2001. Many more firms are in the process of being certified. Besides, many firms have multiple certifications (NASSCOM, 2002). Interestingly, there have been cases when a US multinational has gone in for CMM quality certification in their Indian subsidiary first and later import those high quality practices back to its U.S. development centers.[7] Thus, the quality related Indo-US collaboration has not only contributed to the 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 US.

3.2 The Sankhya Vahini Project

In 1998, an MOU was signed for a collaborative venture between the Department of Telecommunications (DOT), the Department of Electronics, the Ministry of Information Technology, some premier Indian educational institutions and the Carnegie Mellon University (CMU) of the U.S. to launch a high-speed data transmission backbone over a 10,000 km of optical fiber network. In the first phase of the project, it was proposed to provide a speed of 2.5 gigabits per sec (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 (SVIL), in which the equity shares of the CMU and of the Indian government were not to exceed 49 per cent. 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 Rs 1,000 crores and the initial paid-up capital was pegged at Rs 300 crores. The 45 per cent equity share to be held by DOT was to be in the form of providing a pair of optical fibers from the existing optical fiber cables of the Department, infrastructure and cash. IUNet's equity of 49 per

[6] According to NASSCOM (2002), the number of Indian software firms with CMM Level 5 certification was 36 in December 2001 (p 108).

cent was to be essentially in the form of equipment, systems, technology and some cash.[8] This project ran into some problems and was shelved in November 2001.

An interesting element of the Sankhya Vahini project was that the Government of India recognized the need for a significant improvement in the communications infrastructure in India and decided to have a joint venture with a foreign firm created by the CMU instead of having the conventional transfer of technology agreement. Moreover, the participation of the Indian educational institutions in the project indicated the recognition of the fact that such participation facilitates the learning and technology diffusion processes. While the project did not take off for political reasons, these elements of the project need to be noted. Another dimension that needs to be noted is that if Indian educational institutions wish to participate in an alliance as was done by CMU, they cannot do so because Indian laws do not permit them to promote firms and own equity. This should change, although, as we shall see in a subsequent section, an educational institution in India has found creative ways to participate in Indo-US commercial ventures even though the laws did not permit financial participation.

3.3 Media Lab, Asia

The Government of India (GOI) and the Massachusetts Institute of Technology (MIT) have established a one-year exploratory project to create the Media Laboratory Asia (MLA), which is conceived as an independent, non-profit organization. The GOI has committed US $ 12 million seed funding for the one-year programme, $ 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 $ 800 million would be raised chiefly from the Indian and foreign corporate sponsors. The broad objective of MLA would be to facilitate the invention, adaptation and deployment of innovations to benefit all sectors of the Indian society, especially the poorer sections. The idea is to take technology to the masses by making products that would enhance the quality of life in the country. A large variety of initiatives in entrepreneurship, health, disaster control, education, low cost computation technologies

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

[8] Most of the details of the project are taken from Ramachandran (2001).

multilingual and multi-literate systems, and accessible telecommunications are being discussed.[9]

MLA is also an effort that is initiated through collaboration between the GOI and MIT but is expected to expand into a collaboration that will involve public and private entities in both India and the US (see Exhibit 2). The transition from a "public-public" collaboration to one that involves both the public and private sectors would be critical for the success of the programme. We shall revert to this issue in the last section.

To conclude this section, and before we move on to the discussion of inter-firm linkages, one needs to emphasize that linkages within each cell in Exhibit-2 can be quite different. Activities in which the public sector and the Universities were involved are more prone to market failures than the activities in which only private sector entities were involved. Thus, public sector/state participation helped to overcome the market failures. The other issue that needs to be noted is that if one views Indo-US collaboration in a wider perspective and looks at the linkages outlined in Exhibit -2 in their totality, one can immediately recognize the complementarities between linkages in different cells. For example, 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 automatically create more opportunities for alliances. Finally, the policy needs for linkages in different cells may be different. We shall revert to some of these issues in the final section where we discuss various policy choices to enhance alliances between Indian and foreign firms.

4. Alliances between Indian and US Firms: Nature and Contributions

This section focuses on issues relating to inter-firm alliances. The first part of the section discusses a specific R&D collaboration programme between Indian and US firms in high-tech areas that was funded by USAID. Results of a survey of Indian IT firms with a focus on inter-firm alliances are analyzed in the second part of the section. To the extent

[9] The project description is based on the material available on the MIT web site and an Joseph (2001)

possible, an effort is made to highlight the nature of these alliances and their firm and economy specific contributions.

4.1 Inter-firm R&D Co-operation: The PACT Programme[10]

In August 1985, an agreement was signed between USAID and the Government of India (GOI) to initiate a Programme of Advancement of Commercial Technology (PACT, USAID Program No. 386-0496). US $ 20 million were earmarked for this ten-year programme. ICICI was appointed as the implementing agency of the programme. The objective was to assist private sector companies in India and U.S. for joint research and development projects. These projects were expected to lead to commercialization either in India or U.S. Conditional grants to both Indian and U.S. companies with a maximum of up to 50 per cent of the project cost or US$ 500,000 (whichever is lower) were given. The terms of repayment were easy and 2.5 times of 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 5 years. If the product was not sold, the repayments were not expected. By 1995, PACT had assisted 50 projects and disbursed US $ 18.72 million. The areas in which the projects assisted included Information Technology, 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 the royalty to PACT; and 10 are facing problems in commercialization. Total re-flows received, as on March 01, 2002 were US$ 4.2 million and Rs. 34.7 million. Five of the US firms assisted through PACT got listed at Nasdaq (Appendix I). Apparently, the joint project went a long way in facilitating this transition.

PACT was a technology development programme wherein the USAID and the Indian government facilitated coming together of Indian and US firms for joint research. Broadly, PACT promoted two ideas: joint technology development by Indian and US companies and external funding of R&D by venture capitalists or others. The Project financed a total of 50 joint R&D projects. Of these 35 led to a commercial use of new technologies, mainly in the US market. Through these joint R&D efforts, PACT also

supported expansion of a number of high technology firms. Some of them turned out to be great successes. For example, a new mushroom growing technology generated substantial exports that have risen from zero to US$6 million per year (USAID, 1999).

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 importantly, the prohibition on the use of USAID funds to acquire equity prevented PACT from benefiting from success. One firm, ERA Software, had had offered stock for its PACT grant that would have yielded a US$ 20 million profit had PACT been able to accept it.[11]

However, the spillover benefits of the PACT programme may have been significant. It is argued that the Programme's main contribution lay in creating an impetus for policy changes with respect to venture capital. In 1988, the Government of India 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.[12] The other significant spillover benefit has been that the success of PACT showed that linkages to international technology through links to US firms were useful and not harmful, to national R&D capability development (USAID, 1994). Both firms and policy makers were able to see these advantages (USAID, 1993).

Taken these two developments together, the PACT project was able to demonstrate the feasibility of joint R&D and the creation of an active private market for R&D financing. In fact, PACT firms placed a much higher value on joint R&D after participating in the PACT-supported activity than non-PACT firms. The assisted firms also performed better in export growth than unassisted firms (USAID, 1994). According to the estimates

[10] The author is thankful to officers at the ICICI, Mumbai office and the Delhi and Washington DC offices of USAID for discussions and information on this project.
[11] This view is articulated in USAID (1999). Officers at ICICI raised similar issues.
[12] 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 start up operations. Admittedly, PACT's impact on the venture capital sector was indirect. Very few people in new VCs 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 strongly suggest that

provided in USAID (1993), for about 82 per cent of the PACT firms in India, the project was their first joint R&D effort. About two thirds considered foreign participation in joint R&D crucial. Paired firms (similar firms not receiving PACT assistance) were much less convinced, with only about 20 per cent considering foreign participation crucial. Thus, experiencing joint R&D with foreign entity is important for discovering its importance.

Another interesting spillover benefit has been the learning at ICICI, the organization that implemented the PACT project. ICICI has gradually learnt 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 rationale of the PACT project can also be based on "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" is not 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 create an active private market for R&D financing.[13] The role of inter-firm alliances in correcting market failures relating to financial markets is a very important spillover benefit and we shall revert to this issue in the final section.

4.2 Inter-firm Linkages in the Indian IT Sector[14]

Capability levels in the Indian software industry are considered to be quite high. However, there are divergent views on whether the industry is "moving towards

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PACT demonstrated a demand for VC financing. Thus PACT stimulated TDICI which became a model for most other VC institutions (USAID, 1994).

[13] Interestingly, the responses of the PACT firms suggest that in about half of the cases, the R&D investments would have taken place without PACT support. It is not clear if joint R&D would have occurred in the firms that do not consider PACT support to be critical for R&D. We know, however, that PACT identified partners for the Indian firms in very few cases: the matchmaking was done by the participating firms (USAID, 1993).

[14] This section draws heavily from Basant and Chandra (2003).

maturity" or is trapped in a low-level equilibrium. Some earlier work (Heeks, 1996) had suggested that Indian software firms predominantly participate at the low end of the global outsourcing arrangements and the movement to more complex jobs is constrained by the domestic IT market. Besides, while global software skills shortage is likely to continue, the shortage may be more of analysts (or analysts cum programmers) than of programmers. Consequently, countries like India may face problems if they rely mainly on supplying programming staff. 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 domestic market is facilitating such growth. It is noteworthy that the domestic IT has grown quite rapidly in the late 1990s and in 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.[15]

Irrespective of which of these trends are dominant, inter-firm alliances, including outsourcing for product development is likely to create significant opportunities for learning for participating firms in India. Tentative estimates from a database being compiled from secondary sources shows that alliances in the IT sector are on the rise and the bulk of foreign alliances of Indian firms are with U.S. firms.[16] While analysis of secondary data is still underway, in this section we assess the role of inter-firm alliances using data from a survey of one hundred Indian IT firms conducted by us in the year 2000. The survey sought to cover software as well as hardware firms.[17] Preliminary investigation showed that often enterprises have more than one alliance and within each alliance they work on multiple projects with their partners. Therefore, data on inter-firm linkages has been analyzed at two levels: alliances and projects.

[15] The size of the Indian domestic IT market was about US $ 5.65 billion in 2000-01, showing a growth of 40 per cent over its size in 1999-00. The contribution of software and services was about 36 per cent in 2000-01. (NASSCOM, 2002: 44-45)

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 sub-contracting contract. To facilitate analysis the alliance activities were divided into five broad categories: technology related; production related; finance related, marketing & distribution related and those involving a management agreement. Table 1 reports the distribution of alliances across these activities and sub-activities within them.[18] The alliances covered a variety of activities: while technology, production and marketing & distribution related alliances) were equally important (52-54 per cent alliances involved these), finance and management agreement related linkages were found to be less popular, as less than 25 per cent alliances involved such linkages. Broadly, the inter-firm alliances among the sample IT firms focus on technology, production, marketing & distribution activities. Unlike, many alliances in recent years, linkages among IT firms do not seem to focus mainly on raising financial resources.

A more detailed analysis of technology related linkages showed that collaborations for establishing standards were dominant. Significantly, more than 26 per cent of the alliances involved joint research and development agreements. Besides, many of the technology related alliances involved joint R&D as well as collaborations for establishing standards.[19] 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 bulk of these are "two-way" alliances.

Table 1 also shows that inter-firm alliances in the Indian IT sector have significant involvement of foreign firms. Overall, foreign alliances constituted more than 81 per cent

[16] This statement is based on a preliminary analysis of data done by a graduate student, Vivek Gupta at the Indian Institute of Management, Ahmedabad, India.
[17] Basant and Chandra (2003) provide details of the survey and a more detailed analysis of the data.
[18] If an alliance had multiple dimensions, (e.g. involved technology-transfer as well as joint production), it was counted in both categories, i.e., technology and production related.
[19] See, Basant and Chandra (2003) for detailed estimates. These are not reported here to save space.

of the total alliances. In fact, for all categories of alliances, incidence of alliances between domestic and foreign firms is significantly more than the incidence of alliances among domestic firms. The survey data shows that a large majority of these foreign partners are U.S. firms.[20]

Objectives of Alliances

The fact that accessing financial resources is not the prime motive for alliances in the IT sector is also evident from the Table 2 which reports the distribution of alliances by objectives (multiple objectives were permitted). Here again the focus on technology is clearly evident. Technology based objectives were clearly dominant in these alliances and took various forms. These forms included exploitation of technological complementarities among partners, monitoring technological opportunities, accessing partners' technology, acquisition of world class practices, reduction in innovation time span, conducting basic research and so on. A large proportion of sample firms reported most of these objectives.

Market expansion and monitoring was the other important objective of reported alliances. Besides, a large majority of firms (79 per cent) entered into alliances to increase profitability. A significant proportion of firms (40 per cent) also established inter-firm linkages to reduce costs and risks. Overall, market and technology access seem to be the dominant reasons for alliances. Table 2 read with Table 3 would also suggest that accessing complementary assets like 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 objectives was more than for other objectives. In general, the estimates reported in Table 2 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

[20] Interestingly, the distribution of "domestic" alliances by categories is not significantly different from the distribution of "foreign" alliances. Technology, production, marketing & distribution related alliances

realization rate was significantly more for objectives like exploiting technological opportunities, accessing and monitoring technologies, increasing market share, acquiring world-class practices and increasing profitability. The alliances therefore seem to have a positive impact on sample firms' technological capabilities, market share and profitability.

Learning from Inter-firm Alliances: Some More Insights

That the alliances were by and large mutually beneficial is also brought out by the information summarized in Table 3. In almost all the alliances the size of the projects and the number of employees devoted to the alliance increased over time. The proportion of alliances in which the partner helped set up factory or other facilities was rather low (22 per cent). This can probably be due to the fact that not many alliances may have involved manufacturing linkages. However, in about 44 per cent of the cases the partners helped improve managerial practices. Besides, in about 53 per cent of the cases, alliances facilitated improvements in shop floor or programming practices. While these relatively low percentages may be partly reflective of the nature of alliances, one would have preferred a more positive impact of alliances on firm level practices. Perhaps, firms are not consciously trying to exploit this benefit.

On the positive side, a large proportion of alliances (about 45 per cent) facilitated development of new products. This would certainly have enhanced sample firms' product development capabilities. In about 41 per cent of the cases, the sample firms also had (either jointly with the partner or alone) the intellectual property rights (IPRs) over the technology generated through the alliance. In about 26 per cent of the cases, the partner firm owned the intellectual property 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 can be protected. Interestingly, only about 65 per cent firms considered IPRs to be important in an alliance. This could essentially be due to the dominance of "service" orientation of alliances where proprietary technologies and products were less important. As alliances focus on more complex projects, IPRs are expected to become critical.

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dominate for both domestic and foreign alliances, with finance related linkages not as important.

Apart from the direct benefits in the form of product or/and process (e.g. factory, facilities) capabilities, the sample firms seem to be benefiting from spillover effects as well. About 67 per cent of the sample firms reported that the investments in hardware/software made through the alliance are useable in other projects. Besides, in almost 70 per cent of the cases, the alliance helped in training employees other than those involved in the alliance projects. Significantly, for about 78 per cent 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 mentioned earlier, more than one project may be undertaken within an alliance. Our survey collected some information at the project level. Table 4 summarizes the key findings. On average, the sample firm made 73 per cent of the total financial investment in the project. This is consistent with our earlier finding that alliances captured in the survey were not primarily geared towards raising financial resources.

Provision of design, software and hardware can be seen as important aspects of inter-firm alliances. The estimates reported in Table 4 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 the sample firms (either alone or jointly with partners) provided these inputs was higher than the percentage of cases where the partner alone provided them. The cases where both the firm and the partner provided these inputs can certainly be seen as "two-way" linkages. Besides, in most cases where the sample firm is providing the design, software and hardware linkages are likely to be of the "two-way" variety. Consequently, few projects can be characterized as "one-way" partnerships. The fact that in more than 81 per cent of the projects the sample firm played an important role in planning strengthens this impression. And in 83 per cent of the cases, the firms had access to the final product of the alliance.

Another important feature of the projects has been that in a large proportion of cases (58 per cent) employees with skills not hitherto available with the firm were hired for the

projects. The projects, therefore, created opportunities of firms to enhance their knowledge base through recruitment of better-trained people. This advantage is over and above the benefit of training existing employees through such projects.

Overall, the survey findings discussed in this section seem to suggest that inter-firm alliances in the IT sector have been used to access technology and complementary assets (e.g. marketing & distribution, manufacturing) and expanding markets. Accessing financial resources does not seem to be a key objective. Of course, firms try to reduce risks & costs and improve profitability through such alliances. The survey results show that in a significant proportion of cases these objectives are met. The survey results also show that apart from other benefits, these alliances have facilitated building of technological capabilities among sample firms. As is the case in most situations, some firms have gained more than others. The survey data is inadequate to identify the characteristics of those firms, which have benefited more than others. Our firm level case studies of alliances show that only 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. Learning from alliances is not an automatic process and requires significant effort on the part of the participating firms.[21]

Another issue that has not been referred to so far relates to the fact that external market needs are generally the focus of alliances, although there is some evidence to show that more and more international alliances are catering to the domestic Indian market.[22] As mentioned earlier, many argue that the small size of the domestic market will constrain the growth of the Indian IT sector and delay its maturity. While the sector can continue to grow on the basis of external markets that are large and growing, there is no doubt that the benefits of this growth would flow to the domestic economy if the IT market in the country grows rapidly. In the same vein, international alliances would also contribute more to the economy when the IT sector has significant linkages with the rest of the economy through the growth demand for IT products and services. Thus, policies that enhance the growth of the domestic market may be critical for international

[21] See, Basant, Chandra and Mytelka, (1999) and Basant and Chandra, (2001; 2002) for some case studies.
[22] This is based on the data from the survey firms as well as on the preliminary analysis of a larger data base being compiled by Vivek Gupta at IIM, Ahmedabad (IIMA).

alliances in the IT sector to contribute to growth of other sectors in the economy. We shall revert to this issue when we discuss various policy imperatives.

Scope for Learning & 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. To conclude the discussion, I summarize the key insights from my interviews with some senior IT professionals in India. Exhibit 3 shows that different IT tasks are associated with different levels of complexity, risk, profitability, investment and infrastructure requirements. Inter-firm alliances seem to have facilitated Indian firms to move from less to more complex, risky, investment intensive and profitable services. In the absence of the alliances, the Indian IT firms may not have been able to undertake such transitions. Table 5 provides examples of the variety of alliances between Indian and US firms in the IT sector.[23]

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 & implementation capabilities in early stages of the product/package life cycle;
- Specialization in service provision through acquisition of domain knowledge and entry into specific verticals like telecom, banking etc; and
- Transition from a "service" firm to a "product" firm.

The first three processes have been more 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 (see Exhibit 3) are also different? We shall come back to this issue in the concluding section.

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[23] Preliminary analysis of the alliance patterns of a few top Indian IT firms' (e.g., HCL Technologies, Infosys, Satyam, Tata Consultancy Services and Wipro) suggest that these firms have a variety of alliances with different levels of complexity, risk, investment etc.

5. Collaborations with Indian Educational Institutions: The Case of Indian Institute of Technology, Chennai [24]

In the early 1990s, the Telecommunications and Computers Network (TeNeT) group was formed by nine faculty members from the Electrical Engineering and Computer Science departments of IIT Chennai with an objective of creating indigenous technological solution for reducing the access network costs in India. Over the years, the group has developed a variety of systems.[25] Many entrepreneurial ventures, which become part of the expanding TeNeT group, have been set-up to commercialize these technologies. In the formation of two of these enterprises, links with US 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 DECT technology while the company was fully owned by the promoters. Such an organizational set up was necessary as the IIT was not able to hold equity in the firm. The Indian laws do not allow such financial participation by educational institutions. These institutions can, however, earn royalties and therefore, ownership of the initial product was feasible.

The TeNet group persuaded nine of their former graduates (who had worked with the group) to start a company called MIDAS Communications Technologies that would commercialize the CorDECT technology. These students provided equity for the company. The TeNeT group provided technical support. IIT and MIDAS jointly owned the product, CorDECT. In the initial days, the firm 'operated' out of IIT laboratories where all worked together on the CorDECT project that was spawned by IIT and MIDAS. Research funding came to MIDAS and IIT raised the project. Research assistants were hired and the project went off ground. Early on in the project, the group realized the

[24] This section draws on Basant and Chandra (2003).

[25] These systems include CorDECT (a wireless in local loop,WLL, solution for access networks); 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).

critical role of high quality specially designed ICs in the development of their product and also appreciated that such ICs (especially in small volumes) could not be developed in India. The group contacted Ray Stater, Chairman, Analog Devices, a premier IC manufacturer in the U.S. He evaluated their technology and agreed to develop the ICs designed by IIT. Analog Devices agreed to market their ICs outside India and pay them royalty. They also agreed to help the group license the ICs 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 with about 250 people working across all departments. Of these about 200 are R&D engineers who work in the Design and Development area – both in Wireless (e.g. CorDECT) and Fibre applications (e.g., OPTIMA). Others belong to the Technical Assistance cell that performed 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 the 3G standards to enhance its range. The group is also working to modify their products so that they can be used for new airwave ranges. Analog Devices has been an active partner in all these endeavours. Apart from IIT, Chennai, MIDAS considers the U.S. firm to be its major partner that has contributed to its growth.

Banyan Networks

While MIDAS was trying to address the last mile problem of telephone access by 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. It once again helped start a company, with its former students that would work on the 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. Ray Stator of Analog Devices provided angel funding.

As the firm grew, other entities also showed interest in investing in it. Apart from Ray Stater, who is a major investor in his personal capacity, two other U.S. firms invested in the firm. 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 VC firm has strong links in the telecommunications and computer networking industries in the U.S. and the Far East. In addition to the US investors, two Indian firms have also invested in Banyan Networks: a VC (IL&FS Venture Corporation) and a telecom service provider (Himachal Futuristic Communications Limited, HFCL).

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 US. 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 US and other international markets. Over the years Banyan has come with many products.[26]

Formation of partnerships discussed above were based on derivation of mutual benefits though 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 the one with Analog Devices, USA. Analog Devices was interested in the activities of the group, as they were chipmakers that were looking for chip designers. Since they were not equipment producers, they did not foresee any competition from

[26] A product, DSP (Digital Switch Processing) was ahead of its time – it was licensed to Fujistar. Then came DIAS (Digital Internet Access System) – 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 their manufacturers and service providers (HFCL, Shyam Telecom and ARM, Hyderabad) in the country. The seed money provided by these licensees as well as US 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 ISDN technologies, as Voice–over–IP has now become legal in India.

MIDAS. Moreover each time MIDAS used their DPS chip (general purpose chip) for building its designs, it increased the sales of Analog Devices. MIDAS also helped this Company find several good chip designers in India (including some in the IIT team). In return, the IIT team benefited by securing help of this company in producing specialized ICs for them in smaller volumes, finding in the company a marketer of their IC designs, and a funder of their projects.[27] In the initial stages of Banyan, a number of engineers from Analog Devices helped Banyan with resolving technical problems. They also helped Banyan procure components from US.

Similarly, Intel's participation as the lead investor in Banyan Networks was motivated by its interest to sell 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. It also allows them to attend various product portfolio conferences of Intel globally (and especially in Asia Pacific) and thereby track developments in chip designing and new applications.

From the perspective of Indo-US 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; and
- For telecom software firms in India, partnering with foreign hardware (including IC) may be critical for growth and diversification.

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

[27] Analog Devices advanced money to the group against future royalty for their designs.

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 the groups like TeNeT, when coupled with the low cost of performing R&D in India provided a formidable combination for forming partnerships with international and domestic firms that possess other complementary assets.

The discussion above identified the variety of linkages that were formed. However, the inability of the institutions to own equity restricts the growth of such linkages. It may be useful to recall that Carnegie Mellon University was able 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 the educational institutions. Such research will flow to the classroom and the faculty would be able to train students to become better technologists. Masters 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 would also learn how to take an idea from the laboratory to market.

One must admit that all these benefits accrued to IIT, Chennai. However, incentives for similar efforts elsewhere will get enhanced if institutions are allowed to own equity. It will also enhance the flexibility of these institutions and make them more autonomous and financially independent.[28] In the absence of laws that facilitate equity participation by educational institutions, direct linkages with foreign firms can only take the form of research projects funded by foreign entities. These are useful but in a liberalized environment equity participation is perhaps desirable. Policies that facilitate this transition in the operation of educational institutions and that facilitate linkages of Indian software firms with foreign hardware firms may therefore be useful.

6. Some Policy Issues

Indian firms in the IT-telecom sector have entered into a variety of inter-firm alliances in recent years. Many of these alliances have been with foreign firms. This paper analyzed

inter-organizational (especially inter-firm) alliances and their role in capability building at different levels. Insights from published data were combined with results of a primary survey and case studies to identify the key processes at work. The survey data as well as the case studies suggest that such linkages have helped Indian entities build technological capabilities. Besides, these alliances have also resulted in a variety of spillover benefits. In what follows we try to highlight some key insights and explore their policy implications.

The emergence of India as an active player in the knowledge economy and the market driven increase in the linkages between Indian and US enterprises has resulted in a variety of linkages between Indian and US entities. This paper has highlighted a number of issues that are relevant for Indo-US technology co-operation at different levels. While building of public institutions and trade, investment and technology policies are still important areas for Indo-US technology co-operation; a shift in focus in the changed circumstances may be desirable. A focus on "essentially market induced" inter-firm linkages or alliances may be a very useful starting point for Indo-US co-operation. These can be complemented by alliances in other segments. We have seen that inter-firm alliances IT sector have been extremely beneficial to both the countries. The PACT experience also suggests that R&D alliances in other sectors can be very useful. Juma and Konde (2001) suggest that the importance of international partnerships in the evolution of biotechnology industry in developing countries is growing.[29] They also argue that such alliances (especially among private entities) serve a larger function of creating markets for technology and new products. Imperfections in these markets often constrain the adoption of new technologies. Besides, apart from reducing risks and facilitating information exchange, partnering activities tend to correct capital market imperfections. The IIT, Chennai case showed that such arrangements help provide new sources of financing which may include licensing and up front fees for R&D, milestone payments and royalties etc. Thus, partnering can be critical where venture capital is difficult to access. Even when venture capital is available such alliances can reduce risks. Under specific circumstances, as was the case with PACT, such partnerships can even support the evolution of the venture capital market. Given these

[28] Some members have the TeNeT group have now established a non-profit company which will hold equity in a firm floated by the group, nlogue.com.

[29] The authors provide a very interesting account of how the evolution of a biotechnology firm in India (Biocon) was influenced by a variety of international alliances.

advantages, it is critical to understand what policies will facilitate strengthening and growth of these linkages. It is to the discussion of this issue that we now turn.

At the outset, it needs to be recognized that success of the Indian IT industry and the alliances were in no small measure due to the 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). Policies relating to education may still be quite relevant and we will discuss those and other policy initiatives in this section

Polices Relating to Foreign Direct Investment (FDI)

As mentioned, the significant rise in the number of inter-firm alliances has been due to liberalization of FDI related policies. The 1990s witnessed consistent liberalization of investment policies and also of policies relating to technology collaborations. Most types of collaborations are now automatically approved. In most industries, MNCs can now own more than 50 per cent equity.

It is well known that entry of transnational corporations through technology transfer, investment or alliances is significantly affected by host country policies. Typically MNCs strategically seek those host countries that have large market size, specialized skills, good infrastructure or very liberal and FDI friendly policies. Therefore, all policies that impinge on these elements will automatically impact on the nature and quantum of international inter-firm alliances. Most people interviewed by us felt that liberal FDI policies are critical for the growth of the Indian IT sector and for the maturity of inter-firm alliances. The liberalization of FDI policies so far has been generally welcomed. However, some more liberalization may be required in the policies relating to mergers and acquisitions (M&As). Industry persons argue that such deals are very cumbersome with a lot of paper work and high court permission requirement, which leads to delays. In the case of cross-border acquisitions, currently only all cash deals are allowed. As a stock swap[30] deal is not permitted, Indian firms are not able to leverage their high

[30] 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 case of acquisitions but permit them for mergers.

valuation (Kumar, 2002). These policies are important, especially for the equity based alliances due to several interesting developments in recent years:

- A typical trajectory of international inter-firm IT alliances has been that they start with small offshore projects, which subsequently become large and more complex. With time and building of trust, these projects take the shape of dedicated development centers and then of equity JVs. 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 US firms built linkages with Tier-1 Indian firms. Many of these large Indian firms like Tata Consultancy Services (TCS), Infosys and Wipro have now started to compete with global IT firms like IBM, Electronic Data Systems (EDS) and Computer Sciences Corporation (CSC). In this phase when Indian collaborators of yester years are beginning to compete with the large US multinationals, it is imminent that Tier-1 firms of each country build linkages or acquire Tier-2 in the other nation. Global Tier-1 IT firms would acquire (or ally with) Tier-2 Indian IT services firms to compete with Tier-1 Indian IT services firms. In response, Tier-1 Indian IT service firms would need to acquire (or ally with) Tier-2/3 (typically front-end marketing or consulting) firms in the US or Europe.[31] More liberal M&A policies in India would be required for this transition.
- The transition from on-shore to the offshore model was not easy but high capabilities and performance of the Indian firms facilitated the same. The offshore model has now become quite stable and the Indian firms have already tapped the "easy" customers in the Western economies. Typically these "easy" customers were large US corporations who were not that concerned about owning equity in the firm to control their alliance with the Indian firms. The Tier-2 IT firms in the US and Europe are now facing competition and in order to be cost competitive, need to build linkages with Indian IT firms. However, they do not feel very comfortable if equity participation and the possibility of acquisition are difficult.[32] Liberal FDI and cross-border M&A policies may

[31] 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 U.S. According to unconfirmed reports, one of the firms they are talking to is the accounting firm Deloitte Touche Tohmatsu to buy their consulting arm.
[32] I am thankful to Vinod Nair of McKenzie Consulting to point out this trend to me.

facilitate the deepening of the linkages between the Indian and US firms that are based on the offshore model.

- It has been pointed out that inter-firm alliances have facilitated movement from less to more risky, complex and investment intensive IT activities. Ability to own or acquire equity is very critical for risky, investment intensive and complex tasks. A more liberal policy in this regard would create potential for more learning by Indian firms through more complex alliances.

It may 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 up gradation and Training

As mentioned, policies relating to higher education provided the basis for the IT boom in India. Good IT skills and quality orientation also facilitated building of alliances. It is recognized now that higher education in IT may have limited market failures and therefore limited state participation in this segment of education is desirable. Private entrepreneurship can now deliver what the market needs (Arora and Athreye, 2002). However, state intervention in other areas may still be required. Computer education and a sharper focus on the English language in primary and secondary education in mid-sized towns may 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 labour market in India as Indian firms could now utilize the segmentation in the labour market to their advantage. For onshore tasks, they could only hire engineers and that too from good institutions because the nature of these tasks was very diverse with complex elements. The offshore model permits Indian firms to hire/use non-engineers and engineers from less renowned universities to undertake less complex tasks, leaving the higher-level tasks for senior and better-trained employees. This put a downward pressure on labour costs that were rising to 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 labour market so that for different levels of IT tasks, people with different levels of training and background can be used. Besides, IT enabled services have seen significant growth in recent years and is 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 facilitate cost competitiveness of Indian firms in the IT enabled services for many years. This is not to suggest that the focus on English language is necessary for the entire country; in large parts a focus on basic numeracy and literacy would suffice.

The other role the State can play is to facilitate curricula up gradation. Large number of educational institutions is still run by the State. If the nature of courses has to be changed the government may need to take an active part this activity. Several industry people suggested that a sharper focus on microelectronics related course would facilitate India's participation in embedded software and will also create a potential of alliances in this area of IT activity. In the same vein, presence of telecom related skills might facilitate movement along the learning curve as well as provide impetus for incremental and eventually significant innovations. If telecom is seen as a major area of growth then public intervention may be required to solve 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.

Broadly, a policy focus on education along with firm level incentives for quality upgradation and training would not only enhance the potential of alliances but also improve the absorption capacity to benefit from alliances.

From External to Internal Focus of Alliances: Policies for Domestic Market Creation

It was noted that although many alliances now have domestic market orientation, generally the international inter-firm linkages focus on the external markets. While the external markets are large and growing and provide significant opportunities for learning, absence of domestic focus results in limited spillovers of these alliances on the domestic economy. If

the domestic market also becomes larger and grows at a decent pace, potential for international alliances to create products and services for the domestic market also grows up. In a recent analysis it was found that the alliances of a North American MNC in India were for external markets while in China it collaborated to serve the local market (see, Basant, and Chandra , 2001). One way of creating local demand is to enhance utility of IT in primary, tertiary and secondary sectors. Currently this use is very limited. Besides, 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 the domestic software (hardware) firms may need to proactively forge linkages with hardware (software) firms to reap the synergies between software and hardware skills in telecom and other sectors. Besides, there seem to be several other advantages to such alliances. 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 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 as China is seen as an emerging competitor in the software sector. At the same time, the large 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 partnership 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 US, which for the past decade has accounted for 70-90 per cent of the Indian software exports (Financial Times, May 21, 2002).[33] It is not entirely clear if the Indo-China cooperation would be beneficial for the US firms in the long run.

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

Apart from the role of manufacturing linkages in creating the market, 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 changes in technological trajectories and standards by the government prevent MNCs from investing in R&D in developing countries like India. Firms are unable to predict patterns of usage of equipment & services and hence are unsure of making investments and build linkages. Given the possibility of government failures and 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 which can potentially lock-in the economy in specific technologies. However, all efforts need to be made to reduce such technological uncertainties.

The software-hardware linkages may be particularly critical for telecom industry in times to come and Indian IT firms should participate in these alliances actively. Unlike China, India has failed to become a large base for telecom equipment manufacturing. There is still a 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 $ 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. The current trends do not suggest any major improvement on the manufacturing front. Even if India is able to attract manufacturing related FDI in telecom or become part of the global production networks of telecom equipment manufacturing, it does not seem desirable that all firms should get tied to specific telecom standards. Given the technological uncertainties and other concerns, discussed above, it may be useful for India to strategically keep its options open vis-à-vis telecom equipment manufacturing. A technologically diversified manufacturing base may be more useful for both hardware and software industries as Indian firms can be part of alliances to make software (embedded and others) for telecom equipment following different standards. A policy of neutral telecom standards makes sense at this stage from the perspective of broad-

based learning through alliances. A large and growing telecom market in India can support such a strategy without compromising economies of scale.[34]

Learning of standards and getting observed in the international market are important advantages of inter-firm alliances. The developing country firms 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 "lock-in" into one firm's standards or technology. If one goes by the linkages patterns of large Indian firms (data not reported here), one would notice that they have entered into a wide variety of alliances to reduce the potential lock-in. However, "open-access" strategy of host country firms creates a potential of technology spillovers across networks and the MNC partners may be reluctant to facilitate learning of 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

Till very recently, intellectual property (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 will become increasingly important. For example, if inter-firm linkages involve application service provision, sharing of data would 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 argued that given the legal system in India, most of IP related issues could be sorted out through a proper contract and trust. For MNCs, however, a more stringent IP policy would reduce contracting costs and the cost of legal remedies. Moreover, for the Tier-2 US 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 to the lack of experience with Indian

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

firms and their relatively small size; Tier-1 US firms have the muscle to arm twist Indian firms in case a problem arises.

IP related issues might not only be relevant for inter-firm alliances. These may be equally important when public sector entities are involved on both sides. For example, the project Media Lab Asia (MLA), initiated by the Government of India and 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 upon who will own the IP produced through the project. As mentioned, among other things, MLA is expected to develop affordable products for the poor in rural areas. One option being considered now is that IP will be shared equally between 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, as the market may be flooded with similar products.[35] Therefore, the time for which the rights will be defined and if one firm would be allowed to buy out the rights of the others would be critical for the success of the project. And 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. Besides, if such partnerships are to facilitate the maturing of the venture capital related institutions, existence of an IPR regime that provides comfort to investors and inventors seems desirable.

Infrastructure Related Policies

By all accounts, up-gradation of infrastructure is critical for building alliances between Indian and foreign firms. This would be particularly important for IT tasks that are infrastructure intensive like IT enabled services and application service provision. It may be recalled that the market for these activities is expected to grow in the near future. A review of Exhibit-3 would suggest that infrastructure requirements are important for most IT tasks. Moreover, if policy makers on both sides want participation of Tier-2 firms

[35] See Joseph (2001) for an interesting piece on this issue.

in global alliances, an up gradation of infrastructure would be very critical. Tier-2 firms in India and the US may not have the resources to spend very heavily into infrastructure on their own and therefore any project that can achieve Sankhya Vahini like objectives would 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 US 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 the large US firms and enhance the strategic options of US firms, as they would now be able to build alliances more easily with the Tier-2 Indian firms. At the same time, Tier-2 US firms would also have more options. There is no doubt that infrastructure creation would enhance both competition and collaboration among Indian US 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 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 mentioned 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.

Broadly, the survey findings and the case studies suggest that technology alliances of developing country firms with other entities (multinational or domestic) having excellent manufacturing and/or technology development capabilities in areas where the technology gap is relatively narrow can potentially play a crucial role in upgrading capabilities of developing country firms. Thus, the key policy focus should be to reduce the technological gap through a variety of instruments. Policies on human capital and infrastructure development, and those that facilitate active participation of educational institutions in international alliances should be seen from this perspective. Given the complementarities among various types of alliances, policy makers should view alliances in different cells in

Exhibit-2 in a comprehensive manner. In a period, where 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, e.g., augmented support for formal education, private sector R&D and for linkages between formal research and business sectors would be useful as well.

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Exhibit 1: A Matrix of Inter-firm Linkages				
Nature of Linkage	**Technology Generation and Transfer**	**Pre-Production**	**Production**	**Post-Production**
One Way	• Licensing • Cross-Licensing		• Arms-length buy-sell contract • Sub-contracting • OEM • 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 • Inter-firm technology collaboration agreements • University industry partnerships	• Joint bidding • Joint project devt.	• Joint production • Use of common components • Modularization • Joint ventures • New forms of sub-contracting • Subsidiaries • GSO arrangements	• Joint marketing • Shared Distribution/ Service • Joint service provision • System products • Standardization of interfaces

Source: Adapted from Mytelka (1999)

Exhibit 2:Types of Collaborations in Terms of Organizations Involved			
Type of Entities	*U.S. Entities*		
Indian Entities	Public/ University	Private	Both
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*	US firms alliances with Indian educational institutions	Sankhya Vahini (Carnegie Mellon University,CMU, IUNet, Dept of Telecom, Bharat Sanchar Nigam Limited, IIT, Mumbai and Institute of Science, Bangalore, Indian Institute of Information Technology, Hyderabad)
Private	TCS links with CMU, University of California, Riverside/San Diego & University of Wisconsin	Variety of inter-firm linkages	CMM Certification (CMU, private entities)
Both	TCS, Indian Institute of Science and UC, San Diego? (Multimedia)	Midas, IIT (Chennai) & Analog Devices	PACT Programme Media Lab?

Exhibit 3: Hierarchy of Software Services and Products						
IT Tasks	*Investment*	*Net Profit*	*Market Valuation*	*Complexity*	*Risk*	*Infrastructure Requirement*
All Services	Medium	High	Medium	Medium	Medium	Medium
Staff Augmentation	Low	Medium	Low	V. Low	Low	V. 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 (ASP)	High	Medium	Low	High	High	V. High
IT Enabled Services	High	Medium	Medium-	Low	Medium	V. High
Products	High	Medium	High	High	V. High	High

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

Table 1: Extent of Participation of Foreign & Domestic Firms in Different Categories of Alliances (Percentages)						
Category	Distribution of Alliances by Categories		Share of Domestic & 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 & 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 96. 2. Total number of reported alliances was 258.
3. Figures in parentheses are the number of alliances/alliances reporting each type of linkage.

Table 2: Distribution of Alliances by Objectives		
Objective	*Intentions (%)*	*Realised (%)*
To reduce cost & risks	40.3	68.3
To seek financial support	17.1	61.4
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 to 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 out sourcing)	3.9	50.0
(Total no of Valid Alliances)	258	

Table 3: 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 involved in projects	69.6
IPRs are held by (or plan to hold):	
Partner	25.5
Firm	19.1
Both	21.7
None	33.8
Alliances in which e - mail was used as a communication channel	77.6

Note: The number of responses varied for each question and therefore, the percentages were computed for valid responses only.

Table 4: Profile of the Projects and the Associated Learning Potential	
Characteristics of Projects	*Per cent*
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 with New Skills	58.2
Total number of projects	156

Table 5: 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 - Persistant Systems
Remote Maintenance	TIS-Silverline Technologies
ASP	Satyam-Computer Associates (JV)
IT Enabled Services	Wipro-Spectramind (Equity)
Non-service industries	
Computer Hardware	IBM-Wipro
Bio Technology	Satyam-CCMB
Verticals	
Engineering Services	Van Dorn Demag – Infosys
Telecom & Internetworking	Nortel Networks – Infosys
Retail	
Finance	Nordstorm – Infosys
Aviation	Swiss Air –TCS
Embedded Systems & chip design	DCM Datasystems – Intel
Manufacturing	Oncourse-Geometric Software
Systems Integration	Wipro-HP
CRM	Siebel-Infosys
Technology Consulting	Answerthink-HCL
Alliance Categories	
Marketing Alliance Market Access New Area	JASDIC-Infosys (JAPAN)
Marketing Alliance New Domain	Wipro – Spectramind
Technology Alliance Implementation	SAP-Infosys
Technology Alliance Product Development	Microsoft-Infosys (Hailstorm technology development
Technology Alliance IP	Synopsis -HCL Technologies
Joint Product Development Alliance	Tata Infotech Ltd-WFS
Product Marketing Alliance	Vision Compass - Oasis
Product Technology Compatibility Alliance	Servion -Infosys
Standards	TCS (Internet Security Alliance)

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 Corpn. Pittsburgh, USA	Network Management System	US$ 245,000
	Indian Organic Chemicals Ltd. Bangalore		RS 2,000,000
2	Aspect Development Corpn,CA,USA	Component Library Management	US$ 350,000
	DCM Limited,New Delhi	System (CLMS)	RS 2,000,000
3	Crosscheck Technology Inc. San Jose,USA	PCB testing System	US$ 400,000
	Ncore Technology Pvt. Ltd , Bangalore		
4	Custom Cut,Inc. Los Altos,USA	Computer aided garment production	US$ 500,000
	Anamak Technology Pvt.Ltd.<Bangalore	System	
5	Cybermedia,California,USA	Network management package	US$ 290,000
	SR Associates Pvt.Ltd. Chennai		RS 900,000
6	Data Parallel Systems Inc.,Indiana,USA	Commercial Decision Support	US$ 350,000
	Persistent Systems Pvt.Ltd. Pune	Software Package	RS 1,500,000
7	Duet Technologies Inc.Massachusetts,USA	Rapid Prototyping System	US$ 200,000
	Duet Technologies Pvt.Ltd, New Delhi		RS 3,150,000
8	FrontierSoftware Development Inc. MA, USA	LAN Management System	US$ 387,000
	FrontierSoftware Development India Pvt. Ltd.		RS 510,000
9	Genus Software Inc. California, USA	Multimedia applications for	US$ 350,000
	Wipro Infotech Ltd.,Bangalore	health care sector	
10	Indchem Electronics Ltd., Chennai	VLSI-CRT Controllers for Indian	RS 794,000
	Modular Semiconductors Inc.,CA,USA	language terminals	US$ 28,000
11	Mediaway Inc. Sunnyvale, USA	Multimedia database management	US$ 400,000
	SGC Comsoft Pvt. Ltd., Chennai	system	
12	Omniview Inc.Pennsylvania, USA	Design Synthesis System	US$ 500,000
	Bharat Electronics Ltd. Bangalore		
13	Powerplan Corporation,California,USA	Corporate financial planning	US$ 350,000
	Duet Technologies Pvt.Ltd, New Delhi	software package	RS 500,000
14	Reach Software Corporation, CA, USA	Mail Management System-Mailman	US$ 500,000
	HCL Limited, New Delhi		
15	Reach Software Corporation, CA, USA	Workflow Management System--	US$ 250,000
	HCL Limited, New Delhi	Workman	
16	Research Engineers Inc. Virginia, USA	computer aided structural drawings	US$ 180,000
	Research Engineers Pvt.Ltd., Calcutta		RS 1,800,000

17	SEEC Inc.Pittsburgh,USA	Tools for database reengineering	US$	255,000
	Era Software Pvt. Ltd. Hyderabad		RS	4,000,000
18	Taurus Technologies Inc. Virginia, USA	Multiprocessor system for use as	US$	500,000
	Tata Electric Companies, Mumbai	simulators		
19	Veritas Software Inc., California, USA	disk and file management system	US$	230,000
	FrontierSoftware Development India Pvt. Ltd.			
B	*Engineering / Chemical process*			
1	Active Technologies Inc., New Mexico, USA	Permanent Magnet Alternator	US$	315,000
	Globe Active Technologies Ltd., Mumbai		RS	2,630,000
2	Almex Inc.California,USA	liquid aluminium refining system	US$	500,000
	Godrej & Boyce Manufacturing Co..Ltd,Mumbai			
3	Amcane Praj (India) Ltd. Pune	1200 TPD cane separation system	RS	6,500,000
	Amcane International Inc.Minnesota,USA		US$	190,000
4	Armour Polymers Ltd., Mumbai	Catalyst and FBR system for	Rs	12,400,000
	Xytel Corporation, Illinois,USA	Pyridine/Picoline manufacture		
5	Caliente Systems Inc., California,USA	High conductive polymer sheet	US$	200,000
	Dyhir Engineers Pvt. Ltd., Calcutta	heaters	RS	600,000
6	Cipla Limited, Mumbai	New process for anti-cancer agents	RS	6,500,000
	Byron Chemical Inc., New York, USA			
7	Ecoair Corporation, Connecticut, USA	Environmentally safe airconditioning	US$	350,000
	Globe Scott Motors Pvt. Ltd., Mumbai	system	RS	2,250,000
8	Esvin Advanced Technology Ltd., Chennai	Thermo Chemical Conversion	RS	8,200,000
	Manufacturing & Technology Conversion Inc,USA	Reactor (TCCR)	US$	50,000
9	Janak Intermediates Ltd., Indore	New process for manufacture of	RS	8,300,000
	D & O Chemicals Inc. Pittsburgh, USA	chloroquin phosphate/sulphate		
10	Kistler-Morse Automation Pvt. Ltd., Hyderabad	Semiconductor strain gauge based	RS	8.000,000
	Kistler-Morse Corporation,Washington,USA	sensors	US$	150,000
11	Laxmi Boilers (South) Pvt.Ltd. Bangalore	Cogeneration system	RS	7,100,000
	Barber-Nicholas Engg. Co. Colarado, USA		US$	20,000
12	Monitoring Technology Corporation, USA	on-line vibration monitor for	US$	340,000
	Ramco Industrries Ltd., Chennai	predictive maintenance	RS	2,000,000
13	Pennwalt India Limited, Mumbai	Dewaxing of rice bran oil	RS	1,300,000
	Pennwalt Corporation, USAi			
14	Pest ControlIndia Pvt. Ltd., Mumbai	Pheromones and controlled release	RS	1,000,000
	Fermone Chemical Inc., USA	formulations for cotton	US$	32,000
15	Precision Automation & Robotics (I) Pvt. Ltd.,Pune	High performance industrial robots	RS	1,550,000
	Comutec Robotics Inc. USA		US$	75,000
16	Standard Synthetics Pvt. Ltd. Mumbai	Super-N manufacturing system	RS	7,600,000

	Florasynth Inc., New Jersey, USA			
17	Sudarshan Chemical Industries Ltd. Pune	New process for manufacture of	RS	1,500,000
	Amvac Chemical Corporation, USA	Isoproturon		
18	Thar Designs, Pittsburgh, USA	Supercritical fluid extraction	US$	275,000
	SMS Natural Products Pvt. Ltd. Chennai	process for natural products.	RS	3,160,000
19	Thermax Limited, Pune	Internally circulating fluidised bed	RS	2,000,000
	Babcock & Wilcox Corporation, Ohio,USA	boiler		
C	*Biotechnology/ Healthcare*			
1	Akron Rubber Development Laboratory,Ohio,USA	urinary catheter	US$	38,000
	Shangrila Latex Industries Pvt. Ltd., Surat			
2	Biocon India Pvt.Ltd., Bangalore	solid state fermentation for	RS	1,500,000
	Biocon U.S. Inc. Lexington, USA	microbial rennin	US$	21,000
3	Camdat Corporation, Pennsylvania, USA	Drug data base and clinical	US$	285,000
	Bangalore Advanced Technology Pvt. Ltd.	information system	RS	1,100,000
4	Four Eyes Research Pvt. Ltd. Pune	Spent wash treatment by membrane technology	RS	1,400,000
	Alcoa Corporation, Pennsylvania, USA			
5	Gujarat State Fertilizers Co. Ltd.,	Bacillus Thuringiensis based		
	Ecogen Inc., Pennsylvania, USA	bio-pesticides	US$	500,000
6	ITC Agro-Tech Ltd., Hyderabad	high yielding cultivars of	RS	8,500,000
	Indacom Inc., Chicago, USA	sunflower hybrids	US$	35,000
7	Ponds (India) Ltd., Chennai	High grade button mushrooms using	RS	6,950,000
	Giorgio Foods Inc., USA	unconventional materials		
8	Reddy Healthcare Inc. Georgio, USA	New type of male contraceptives	US$	400,000
	Shangrila Latex Industries Pvt. Ltd., Surat		RS	1,700,000
9	Spic Science Foundation, Chennai	Improved varieties of seeds of rose	RS	3,400,000
	DNA Plant Technology Corpn., New Jersey, USA	and coffee by tissue culture	US$	240,000
10	Zandu Pharmaceutical Works Ltd., Mumbai	Herbal drug for Parkinson's	RS	3,480,000
	Zandu (U.S.) Inc., USA	Disease	US$	217,000
D	*Others*			
1	Ballarpur Industries Limited, Bangalore	Cultivation for production of saline	RS	14,000,000
	Halophyte Enterprises Inc., Arizona, USA	water based crop-Salicornia		
2	Kalyani Agro Corporation Pvt. Ltd., Pune	hybrid seed tubers and true potato	RS	9.450.000
	ESCA Genetics Corp[oration, San Carlos, USA	Hybrids		

B. PACT Assisted Projects Listed Under Nasdaq

No	Company	Project	PACT Assistance	PACT Repayment	Remarks
1	Aspect Development Corpn ,CA,USA	Component Library Management System (CLMS)	US$ 350,000	US$ 350,000	Repaid the entire amount
	DCM Limited, New Delhi		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		RS 900,000		Repayment obligation
3	Frontier Software Development Inc. MA, USA	LAN Management System	US$ 387,000	US$ 967,500	Completed PACT
	Frontier Software Development India Pvt. Ltd.		RS 510,000	RS1,275,000	Repayment obligation
4	SEEC Inc. Pittsburgh, USA	Tools for database reengineering	US$ 255,000	US$ 747,505	Completed PACT
	Era Software Pvt. Ltd. Hyderabad		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.				Repayment obligation