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Inter-Firm Linkages and Development of Capabilities in the Indian Telecom Software Sector

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I. Introduction

Recent literature on technological change and economic development has focused a great deal on the determinants of building technological capabilities in developing economies. Earlier research focus on macro changes has been gradually replaced by studies, which try to relate macro changes to micro (firm level) developments. A few noteworthy strands in this literature include role of multinationals (MNC) in developing technological capabilities, host country policies to attract foreign firms, nature and role of inter-firm linkages, and the impact of information technology on developing global inter-firm network.

Studies have shown that MNC activities can have a significant and positive impact on technological capabilities of firms in developing countries provided these firms make technological investments and countries adopt pro-competition policies (Kokko, 1992; Evenson and Westphal, 1994). Another set of studies begin with the premise that MNC activity can enhance capabilities and explore how policies can help developing countries win "locational tournaments" to attract foreign investments (Mytelka, 1998).

With the decline of Fordism, many researchers have started looking at inter-firm linkages with renewed interest in recent years. 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. Basant and Chandra (1997) have discussed this issue in the context of telecom technologies. Within inter-firm linkages, issues relating to "hierarchies and markets" and "strategic networks" have received considerable attention (Williamson, 1995; Hamilton and Feenstra, 1995). The information revolution has further added new dimensions to strategic alliances and flexible networks. As a result, global networks are increasingly becoming relevant for developing country firms (Kobrin, 1998). Given the above developments, an understanding of how inter-firm networks evolve and function and how developing country firms can benefit from these alliances becomes crucial.

Inter-firm linkages for raising equity, marketing and distributing products, licensing of technology and brands, sub-contracting etc. have been a common feature for several years. Technology co-operation/development agreements among firms, however, have recent origins. The potential role of inter-firm linkages in developing technological capabilities of partner firms (especially in developing countries) is well recognised. (See, for a recent review, Bell and Pavitt, 1997). 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 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 exploration of these aspects is the focus of this paper. The paper is divided into five sections. We begin with a taxonomy of inter-firm linkages and discuss how the structure of such linkages has changed in recent years. Section III examines the structure of recent inter-firm linkages among telecom related firms in India. The case of Nortel R&D network in India is discussed in detail in Section IV to assess its role in developing technological capabilities among the Indian participants of the network. Section V contrasts the Nortel network in China with its network in India to

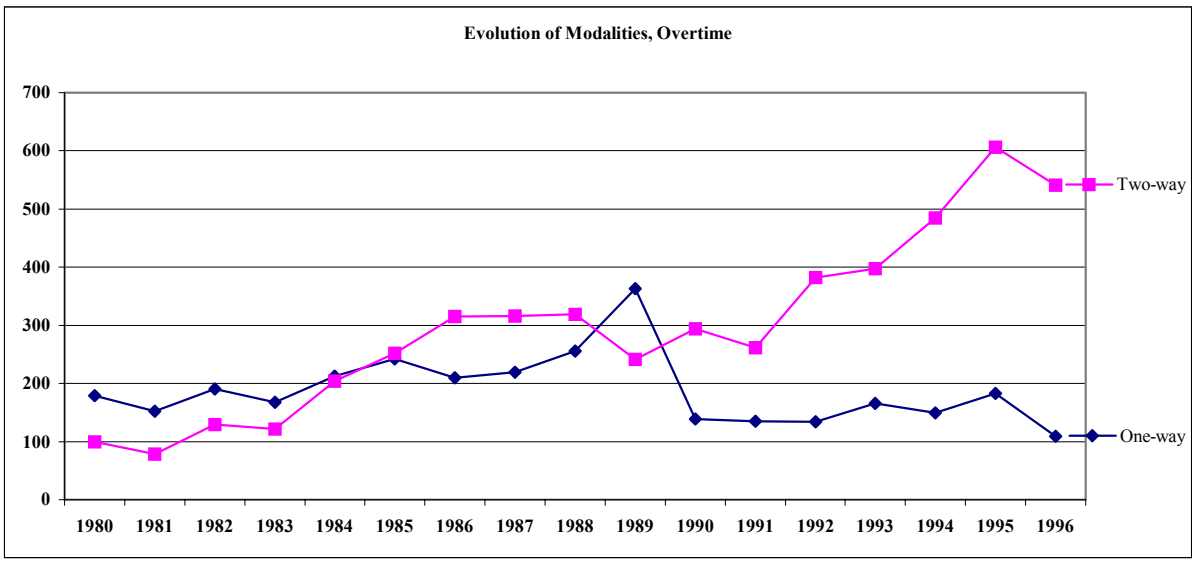
examine the relative advantages of the two vis-a-vis the learning potential for the domestic economies. The final section summarises the key findings to highlight aspects of inter-firm linkages, which may result in higher learning for firms in developing countries.

II. Recent Trends in Inter-firm Linkages

Firms are engaged in a various forms of collaborative activity (See Table 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. While the unidirectional linkages have existed for a long time, the two way relationships are more recent; the newer forms of partnering activity in R&D, production and marketing have also become more prominent over the years (Mytelka, 1999; WIR 1998). Recent data for the years 1980 to 1996 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 (Figure 1).

Figure 1

Evolution in the type of inter-firm technology agreement: 1980-1996



Source: WIR, 1998, 25.

Furthermore, the nature of some of the traditional relationships like joint ventures and sub-contracting have 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 as suppliers are drawn into joint research and collaboration in the design of new products for their clients and 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). 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. We will describe the evolution of one such relationship in a subsequent section.

Among the two-way inter-firm agreements, technology co-operation agreements have seen a significant rise in the 1990s. According to some estimates compiled by UNCTAD, the number of technology co-operation agreements per year was only 63 during 1975-79. This increased to 502 per year during 1988-91 and to 626 in 1992-95. In 1996 about 650 such agreements were signed. 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 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. 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. (WIR, 1998: 27-29) For developing country firms, the two-way linkages are an important mechanism for accessing knowledge bases abroad. However, some studies have shown that among the third world countries only firms from some newly industrialising economies, especially South Korea and Taiwan, have any significant participation in technology/R&D co-operation arrangements (Hagedoorn and Freeman, 1994).

III. Inter-firm Linkages in the Indian Telecom Sector

Telecom related technologies are undergoing significant changes. It has been suggested that development of telecom related software could prove to be a useful market opportunity for Indian software firms. But for exploiting such opportunities, access to

hardware knowledge will be crucial. Technology co-operation between telecom hardware and software firms can provide such an opportunity (Basant and Chandra, 1997).

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 maturity" or is trapped in a low-level equilibrium. Heeks (1996) has 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 market.[1] 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 customised 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. Irrespective of which of these trends are dominant, outsourcing for product development is likely to create significant opportunities for learning for participating firms in India.

The Indian telecom sector firms are engaged in a wide variety of inter-firm linkages. Table 2 presents some estimates of the nature of alliances entered into by these firms in the late 1990s.[2] As can be seen, linkages for financial participation, joint production, supply of equipment and for accessing complementary assets (infrastructure, distribution and sales and marketing support) are most frequent. Joint R&D and other types of technology linkages are relatively less common. Joint service provision seems to be becoming somewhat more popular in this sector.

One interesting feature of these alliances is that except in a few types of relationships, bundling of activities does not take place. For example, linkages for the supply of equipment, provision of infrastructure or for accessing distribution and marketing channels are almost exclusively for these activities; financial participation and activities like technology transfer, servicing etc. are not part of these linkages (Table 2 and 3). Similarly, joint R&D and technology collaboration are also not part of "package" alliances, linkages are usually established to exclusively undertake such activities. Bundling, however, does take place with financial collaboration, which is usually combined with joint production and licensing of technology.

It is difficult to assess, on the basis of published information, whether the majority of these linkages are "two-way" or correspond to the "one-way" traditional relationships. However, joint production, service provision, bidding and R&D are obviously "two-way linkages". The linkages between software and hardware firms are

[1] This market seems to have grown quite rapidly in the late 1990s, especially the last two years.

[2] The data on alliances used in this section has been compiled at the Indian Institute of Management, Ahmedabad mainly from financial dailies and weeklies and publications of the Centre for Monitoring Indian Economy, Mumbai.

significant in number but do not dominate the inter-firm linkages among firms engaged in telecom related activities. Of the 176 linkages on which we have information, 35 (20 per cent) were between software and hardware firms, 85 (48 per cent) between hardware firms, 39 (22 per cent) among software firms and the remaining 17 (10 per cent) among other firms, mainly between new service providers and software and hardware firms.

About 58 per cent of these linkages were between MNCs and domestic firms and the remaining involved only domestic firms. But the nature of linkages among these two groups of firms was different: while the linkages among domestic firms mainly involved provision of equipment and infrastructure and distribution arrangements, the links between MNCs and domestic firms were more varied and involved financial collaboration, joint production and accessing of marketing and distribution channels. (Table 4) Most of the technology related (joint R&D, collaboration, licensing etc.) linkages were between MNCs and domestic firms. This is expected, as the MNCs are the main sources of technology and they also need complementary assets to enter the Indian market; domestic firms prefer to collaborate more with MNCs for technology development and access and their need for complementary assets is relatively less. However, given the diverse and fast changing nature of the telecom technology and the rapidly changing market structure, both sets of firms need complementary assets of various kinds.

It must also be recognized that technology in this sector is changing very rapidly. Even the MNCs recognize the roles of specialised skills and technologies in keeping up with this change and linkages with firms in different sectors having such capabilities. This need is even stronger for firms in developing countries. Most MNC firms in India entered into an alliance with local partners for accessing their marketing and distribution assets (and in a few cases, manufacturing facilities) and because of regulatory requirements. The domestic partners, in return, acquired technology from their partners. As policies liberalize and MNCs gain more experience in the domestic market, their need for local partners may diminish and they may opt out these alliances. Domestic firms that hope to survive in this sector will have to pro-actively use these linkages to absorb and learn quickly not only about the technologies under transfer but also the process of technological innovation. As marketing and distribution assets become more generic from the MNCs perspective, technology related competencies can provide flexibility and growth potential for the domestic firms. Technologically capable domestic firms can either compete on their own or remain valuable partners in any alliance.

IV. Nortel's Network in India

In this section we present a case study of an international technology development network in telecom software. The R&D network of Nortel with four Indian software firms brings together hardware and software firms to develop telecom related software. This research is based on survey questionnaire and in-depth interviews of firms participating in the network.

Context

India is emerging as a major software development centre in the world with the current estimated exports of US $ 1.1bn worth of software and related services. Bangalore, Mumbai, New Delhi, Chennai and now Hyderabad have emerged as important centres of software related activity in the country. About 30 per cent of Indian software firms are located in Bangalore. They contribute about 25 per cent to the country's export revenues. The Bangalore cluster has slowly evolved from one that provided on-site turnkey services at client's location to one that is starting to develop branded products. Within this broad spectrum, global software outsourcing (GSO) has emerged as an important and rapidly growing activity. GSO arrangements have significant strategic implications as they not only have a potential of increasing the volume of business significantly but also require capabilities of higher order, improving thereby the opportunities of learning for the participating firms. Not much work has been done on GSO activities in India. A study by Barrett et al (1997) is an exception, which focuses on one such relationship in India to highlight changes in managerial practices in domestic firms.

One such experiment is Northern Telecom's (Nortel) partnership with four Indian software companies, three of which are located in Bangalore. The alliance is unique in various ways. It was envisaged as a long-term stable relationship among "peers" and not between "master and slaves". The Indian partners were asked to contribute to the mainstream of Nortel's work and the implicit division of labour that keeps "architects" in the North and "coders" in India was sought to be broken. Nortel, therefore, does not view its Indian partners merely as a cheap source of software production; financial gain by squeezing the partners is not the long-term goal. Instead, they are willing to help them evolve into genuine two-way partners. Finally, the network in India is being developed in the image of the mother lab of Nortel in Ottawa, which does research in all areas covering a broad spectrum of telecom products. Some evidence to support this characterisation of the network is discussed below. The relevance of such networks is obvious. Such alliances, unlike many other `one-way' alliances, have significantly higher learning potential for participating firms in developing countries. The conditions under which such knowledge generation is facilitated needs to be explored.

Participating Firms

Nortel is a leading telecommunication firm from Canada which specializes in developing technology for digital networks. Its revenue in 1997 was US$ 15.5bn, 37 per cent of which emanated from outside North America. Nortel has 38 R&D collaboration sites in different parts of the world including India. Recently, it has developed strong relationships with some leading software firms in India to develop products that will utilize the telecom knowledge of Nortel and the software expertise of Indian firms. Over the past ten years, Nortel and its Indian partners have been developing software and software testing tools for Nortel products like DMS, Meridian, Norstar, S/DMS Transport Node and products for the personal communications services market.

In 1989, the International R&D Group of Nortel entered into GSO arrangements with two Indian software development companies - Silicon Automation Systems (SAS) located in Bangalore, and Tata Consultancy Services (TCS) which has headquarters in

Mumbai. Two more companies were added to this arrangement in 1992. These were Infosys Technologies (Infosys) and Wipro Systems (Wipro), both of which are located in Bangalore. These firms compete with each other in the domestic and international markets. Infosys was founded in 1981. It is a premier software development company with an annual turnover of about US $ 37.8 mn in 1996-97. It spent around 5 per cent of its turnover on R&D. Infosys focuses on software services in the areas of distribution, finance, retail, telecom, insurance, internet and engineering services. In addition, they have products in the area of bank automation. Established in 1989, SAS develops tools & services that enable the design of semiconductors, telecommunications, computing & networking equipment. The company's stated core competence is signal processing which has resulted in solutions for digital communications, with specific emphasis in multi-media technologies. Currently it employs 300 people of which 250 are engineers. Its annual turnover in 1996-97 was US $ 4.6 mn. Setup over 30 years ago, TCS is Asia's largest consulting group with activities that range from management consulting to IT solutions, offshore development & branded software products. About 9,800 people work for TCS whose sales turnover in 1996-97 was US $ 201 mn. TCS invested about 8 per cent of its revenue on R&D. Wipro Systems is a division of Wipro Infotech that was started in 1984 (while Wipro Infotech was formed in 1981). Wipro Systems has over 2500 employees with an annual turnover of US $ 14.3 mn. in 1993-94. Within Wipro Infotech, Wipro Systems has been setup as a unit focusing on global software outsourcing. Each of these companies have offices in different parts of the world.

Genesis and Formation of the Network

The International R&D group at Nortel started to think about forming linkages with firms in India in the late 1980s. Two senior employees of this group, both of Indian origin, spearheaded this effort. These two were involved in conceptualizing and implementing various aspects of these relationships. While the major impetus for forming this alliance came from Nortel, some of the Indian partners were also actively looking for such linkages. As a part of their preparation Nortel checked with Texas Instruments and Hewlett Packard about their experiences of working in India. With the help of individuals in these and in other companies known to Nortel initiators, a long list of potential partners was developed. With further queries, a short list of 30 companies was prepared. Each of these 30 potential partners were visited by the Nortel employees. Selection of the four Indian firms was done by Nortel on the basis of very specific skills and capabilities that these firms had developed over the years. There appear to be three broad reasons for this partnership to emerge - active interest of the two Indians at Nortel to develop long term links with India, emergence of India as a strong, low cost software development centre and the desire of Nortel to externalize its R&D work to reduce its costs. The Indian firms were looking to earn foreign exchange, keep their best people within the country, enter into domains like telecom and for opportunities to learn the latest technology & management practices and climb up the product complexity ladder.

Organisation of the Network

The partnership is not an equity-based joint venture. It is an ongoing contractual relationship between Nortel and its partners; each relationship is individually defined. Bulk of the physical investments were made by Nortel. In each partners location, Nortel has

created an infrastructure, which is comparable to what exists in Canada. Apart from the state-of-the art telecom hardware (switches etc.), Nortel has installed large capacity (2 gigabits) dedicated lines for communication between Nortel and its partners. Nortel also invested a great deal in training activity.

Linkages between Indian firms and Nortel are not organized in a manner, which requires interaction among the Indian partners; collaboration is extremely limited and informal. This interaction, typically focuses on sharing of some standards and practices but mainly on communication infrastructure related issues. Besides, training of partner firms employees is common. They, however, do not collaborate with each other on any project. Each Indian partner has an independent project relationship with Nortel. Allocation of projects to each partner by Nortel is governed by its overall strategy to map disciplines across partners and avoid overlap. Each partner in India has specialisations and "collectively" the four Indian partners are growing in the image of Nortel's mother lab in Ottawa, which works on a broad spectrum of telecom products. As the firms do not work together, Nortel remains the "Director" of the network.

The alliance does not preclude entry of new partners in the future. However, from Nortel's point of view, addition of new partners would imply investment by Nortel in developing infrastructure (including hardware) at partner's premises. This can be quite expensive. Moreover, catching up for the new entrant may be difficult. Nortel, however, is not averse to additional partners if they can bring in specialised know-how to expand the technology domain of the network.

Clearly, the parameters of these linkages are driven by Nortel's International R&D group. The relationship is somewhat hierarchical with Indian firms feeding into Nortel's research and product development activities. However, an attempt is made to minimise hierarchy, particularly at each centre, where young professionals are encouraged to interact with seniors and "participate" in a variety of ways in the operation of the group.

The Nortel projects, which started with low skill assignments such as program testing have gradually evolved into full fledged off-shore development centres for Nortel to develop, modify and support software products or software components of Nortel products. The initial projects were arms-length technical contracts with very limited interaction between development teams of Nortel and the Indian firms. This relationship evolved with the successful completion of many of these projects. Gradually, Nortel commissioned larger and more complex development projects requiring more sophisticated hardware & communication infrastructure along with enhanced interaction between Nortel and Indian teams. Current projects include DMS-100 feature development for Asia/Pacific markets, such as Japan; interface approval for a cellular switch in India; DMS-10 and Meridian feature development for global markets. At the offshore development centres, Nortel has installed advanced telecom hardware for testing these software. It is hoped that with the synergistic interaction between increased access to telecom hardware & software, communication infrastructure and the improving project skills, these alliances will graduate to product design & development centres. Most of the current work focuses on the further

development of existing Nortel products; only a small proportion can be categorised as research.

It must be re-emphasized, however, that at this point in time, each Indian partner works on independent projects; integration of these projects, if at all, is done by Nortel. There are reasonably well-defined rules for protecting the intellectual property of Nortel. Trust plays a key role in avoiding leakages of proprietary knowledge. While the relationship does not prohibit collaboration of Indian companies with Nortel's competitors, movement of persons working on Nortel projects to substantially similar projects of competitors is not permitted. An agreement on non-disclosure at the corporate level is signed and each person working on Nortel projects individually signs such an agreement. Anything the partners develop with Nortel belongs to Nortel unless they agree to negotiate and to share. Interestingly, within the Indian firms' premises, Nortel projects are located in physically separate areas with restricted access. Each of the Indian partners have different types of relationships with many international firms. For instance, one of these Indian firms also has a Nortel like offshore software development centre for NCR. Besides, the Indian firms have a large number of Fortune 500 firms as customers around the world like Microsoft, IBM, Oracle, Fujitsu, Philips, Hitachi, Sharp, Toshiba, National Semiconductors, Texas Instruments etc. The Indian companies compete fairly aggressively in the international market for projects.

Strategic Intent of Nortel

Software is increasingly substituting for a variety of tasks, which were earlier performed by telecom hardware. Software development in North America has become extremely expensive due to the shortage of skilled manpower. It seems that the strategic intent of Nortel was to outsource software development for telecom devices from relatively inexpensive off-shore locations. Indian firms provided a rich pool of software development capabilities as well as ability to gear up fast to develop new application software. However, their telecom related knowledge base was limited. This provided excellent opportunities of collaboration between firms with complementary capabilities. Nortel made specific efforts to develop/update the telecom hardware/software related knowledge of its Indian partners. While the expectation of cost savings was important and it fructified with Nortel saving of about $ 50 million per year due to the network, the long term perspective was probably more important. Only that can justify the kind of investments Nortel has made.

Nortel has been seeking opportunities to adapt its telecom technology for Asia-Pacific market. Besides, it has so far been unsuccessful in entering the Indian telecom market; its international competitors like Siemens, Allocate, AT&T and Ericsson are already present in India. This alliance, therefore, not only provides Nortel an access to the inexpensive software development resource in India, but also allows them to enter the Indian market with products specially designed for India. Moreover, an R&D arrangement of this kind brings product development activity closer to the markets in the Asia-Pacific region. The concept of a more open "two-way" partnership was partly necessary to attract good Indian firms and provide stability to the relationship. There was always a possibility of another international competitor to build such a network if Nortel had not taken the initiative.

At the moment, however, the Indian market is not growing as rapidly as expected and on that count, Nortel's investment only makes long term strategic sense.

Benefits to Indian Firms

Benefits of this alliance to Indian companies have been numerous. The firms together make about $ 50 million per year for the country. The major gain has been in developing telecommunications related knowledge and acquiring expertise to produce to world standards and satisfy global markets in this sector. Since there was reciprocity and Nortel was not averse to connecting Indian firms to the world market, the partners learned the whole package, got exposed to how Nortel functions, how it deals with the customers and so on.

Strategically, the entry of Indian firms into telecommunications software market has been a significant outcome of this alliance. This market is likely to grow rapidly in the near future. The alliance not only facilitated entry into this market segment but is also creating learning opportunities which may eventually help Indian partners to become important players in this emerging segment.[3]

The Indian partners also received training on telecom technology and Nortel's products. Such learning opportunities arose during visits of Nortel experts to Indian sites as well as visits of Indian engineers to Nortel's facilities overseas. Specific learning occurred through the use of new telecom related software (especially in switching), entry into new markets segments relating to various telecom product lines, development of new products (mainly in the form of new features on existing products), acquisition of knowledge relating to international programming standards as well as protocols/standards in telecom process (process & quality standards for developing highly complex products) etc.

The Indian firms feel that association with Nortel has accelerated the development of their technological capabilities in this business. However, since they have other linkages with large number of international firms, such capability building could have occurred, *albeit at a much slower pace*, in the absence of this alliance. All these firms also view this relationship in a long term perspective. They would like to graduate to become equal partners of Nortel in their product development process and marketing. As indicated earlier, Nortel too views this relationship in a similar perspective given its huge investment of time and resources in building these relationships.

There have been two other spillover benefits. The alliance has enhanced the credibility of and has provided better visibility to Indian partners. This, in turn, has helped them attract other customers. The Nortel development centres have had strong demonstration effects within each company. Similar spillover effects of the partnership on the telecom software sector is, however, difficult to ascertain.

[3] It has already started to happen. See discussion below.

The Indian software industry is very competitive with very high employee turnover. There are several other firms in the industry, which are as good as the Indian firms in the Nortel partnership. A large and fairly well distributed pool of software related knowledge exists in the country. This creates a potential for competing firms to learn from the Nortel partnership. The organisational form chosen for the alliance tries to minimise knowledge spillovers from one participating firm to the other and within the participating firms through certain norms and protocols. But knowledge spillovers through employee turnover continue to take place.

Looking Ahead

The long term sustainability of this alliance would depend on the nature of learning by the Indian partners and the extent of locked-in investment by the participating firms. Though Nortel has invested significantly in this partnership, it is not clear what role this alliance plays in its global network of alliances. Nonetheless, Nortel views this network as one of their most advanced ones. Likewise, Indian firms have developed similar linkages with other MNCs, probably not as intensive. There is no doubt that Nortel has shared with the partners a lot of its proprietary technology. As the technological capabilities of the Indian partners improve, Nortel will have to share more of such technologies to sustain the alliance. A significant part of the knowledge embodied in this technology is tacit and its mis-appropriation difficult to monitor and detect. However, the credibility of the Indian partners and, therefore, their ability to attract partners in future is highly dependent on their protecting Nortel's intellectual property. It is this "shared vulnerability" which is most likely to keep the alliance alive and help it grow. Some of the Indian partners may be asked to do the sunset phase of some telecom products, including dealing with Nortel's customers. Working with Nortel on its new products can also not be ruled out, although this might prove to be riskier for Nortel. In any event, it is important to note that if this relationship continues to grow as vigorously as it has in the past, at some stage the issue of the ownership of intellectual property will also have to be addressed[4].

The organisational arrangement was probably optimal for Nortel. It is clear that intensive interaction among the Indian partners would have helped them learn more from the alliance. However, Indian partners may not have preferred such an arrangement given the fact that they compete with each other vigorously. In fact, Nortel claims that collaboration among Indian firms was part of its vision and they did make some rudimentary efforts at inducing more collaboration among the Indian partners. However, the Indian partners did not seem very enthusiastic. Being competitors and collaborators at the same time is probably not very easy. Nortel also appreciates many of the concerns raised above, including those relating to IPRs and is open to sharing proprietary benefits, as they have done in the case of one of the partners (see foot note 1). Their expectation, however, is that such sharing of IPRs would require Indian partners to bring more to the table; be more entrepreneurial and take risks to develop new products and markets. Two of the Indian partners prefer the "command-

[4] Recent developments have made IPR related issues more relevant. One of the partners in India has come up with three innovations, patent applications for which have been filed by Nortel in North America. The Indian firm and Nortel are co-patentees and will share the royalties based on a geographical division. The Indian firm certainly has rights over the Indian market but it is not clear if it has any other rights.

execute" mode and are reluctant to take risks, while the other two are more entrepreneurial. As a result, the relationship between Nortel and the two entrepreneurial partners has matured more than its linkages with the other two firms. Nortel has some sort of a "World Product Mandate or Charter" with one of these entrepreneurial Indian firms to develop Meridian PBXs (small switches) for which there is demand in Europe. This project is being done on a risk-sharing basis. Significantly, the same Indian firm is one of the six groups in the world to develop a new ADSL – high band width over copper wire – technology on their own. This technology was offered to Nortel but Nortel has its own one megabyte modem, which is a competitor technology, and therefore they declined this offer. However, the Indian company now has two potential clients in the U.S. and thus has been recognised as a world source of technology. While Nortel claims that its alliance with this growing Indian partner was instrumental in instilling confidence in them, the MNC will have to deal with the issue that this Indian firm and other partners may come up with competing technologies in future as well.

V. Nortel China and BUPT

In this section we describe Nortel's technology developments in China. In contrast to India, Nortel has established eight joint venture facilities and one R&D centre in China. The R&D lab was setup in 1994 as a cooperative arrangement between Nortel and the Beijing University of Post and Telecom in order to transfer telecom technology to Chinese Government. As part of the setup, a few key personnel were deputed both by the University and Nortel. Nortel provided the initial capital (e.g., switches, office setup, computers, software etc.) while the University provided space and researchers. The mandate of the project at the beginning was to make Chinese adaptations to software in Nortel's technology. Now it has moved to doing various projects within China for a variety of agencies including MPT in addition to specialized subcontracting work for Nortel. There are two distinct areas at this research centre: one devoted to only Nortel's product development and the other for both Nortel and MPT projects.

The BUPT-Nortel R&D Centre is situated on the campus of BUPT. The lab is headed by two director generals: one each from Nortel and BUPT. It employs 85 employees of which 60 are software designers. At inception, it employed 40 people. Most employees were from BUPT though few have been hired from Quinghua, Beijing and other universities. The lab hires those graduates and employees of the University who are telecom/wireless/radio engineers and have a computer background. Several professors of the university are also involved with the activities of the lab. The lab faces a high turnover of engineers. As their work at the lab is research oriented, many go abroad (chiefly to US and Canada) for graduate studies. Nortel sends over some people from other facilities worldwide to this lab.

The lab is developing software for mobile networks, wireless in local loop, MTX switches, broad band networks, FWA products as well as helping MPT develop telecom standards. Nortel has four WLL sites in China. Some are GSM while others follow the CDMA standard. However, most of the GSM research at the lab is being done for China Telecom while the CDMA work is being done for Nortel. Some other projects that the

lab has done over the years are: software for handset interface (this was bought over by Nokia), messaging for wireline, wireless and internet, enhancements to existing software for MPT and field installation at national & provincial levels, customization of some features for various municipalities on their telecom equipment, base station work for Nortel Maitra – contract work for GSM development in France etc. This lab has created a niche for its products in China. There are very few firms that are developing telecom software especially in the area of switching (MTX switches) or base station software, which is the focus of the lab, as they requires special capabilities. Its main competitor is Lucent China, which is working in the area of wireless telephony. There are a few Chinese software firms that are developing software for some low to medium quality technology for switching that is still being used by China Telecom.

The first project of the lab was to develop a GSM provision centre (i.e., storage of customer profiles) which was a local Chinese requirement from it wireless equipment vendors. Now the lab is developing messaging models for various platforms – fixed to wireless, intra-mobile, and internet. This project is an example of how the complexity of tasks that are performed at the lab has gone up. And with this product, the lab is starting to compete globally. BUP-Nortel facility is becoming more integrated with Nortel. They follow Nortel standards and practices. While the Nortel hardware has not changed much, software has changed rapidly. It has also increased the spectrum of languages that are being at the lab – ranging from Protel (Nortel's Proprietary Software Language), C++, Opex to Rose Modeling where the document gets updated automatically. Marketing at the head office helps find Nortel projects for the lab.

In comparison to Nortel's network in India, its alliance with BUPT has the following differentiating characteristics:

- BUPT & Nortel are involved in joint development of software with the presence of Nortel personnel as opposed to subcontracting in India. This was operationalized by setting up a research centre at a telecom university in China with joint management; while in India separate linkages were formed with four Indian companies working independently of each other.

- The alliance with the telecom university has the potential of upgrading technology, teaching material and skills of both faculty and students. Besides, the location also provides an academic & research focus. In essence Nortel was participating in developing manpower for the industry as well as future researchers. In the Indian case, only the four firms benefited.

- The alliance in China had a strong domestic focus assisting in the development of local telecom sector. The Indian firms were developing products for Nortel's markets abroad. It appears that Nortel's objective in India was to tap the superior software capabilities while the focus in China was to support the large local market.

- The Chinese professionals participating in the alliance combined software skills with strong telecom knowledge. In the Indian case, Nortel provided the telecom knowledge while the domestic firms brought in their software skills.

- In both the alliances, projects have moved up the complexity ladder. It is believed that the Indian projects were more complex than the ones in China though it needs to be confirmed.

- The number of professionals involved in the Chinese alliance was much smaller as compared to those in India (around 600).

- While the Chinese alliance may be developing less complex projects, they were more focused in terms of developing complete products. The Indian teams were developing parts of a product, which was being integrated by Nortel.

Some of these differences can be explained by the fact that China has a large telecom market (about US$ 1bn per year) which has not suffered from the Asian financial crisis. Besides, Nortel has a large presence in the Chinese telecom market and they are present in a larger segment of the telecom supply chain in China (e.g., from manufacturing semiconductor to transmission devices and telecom services). Their eight joint venture facilities are spread out in eastern China (in Beijing, Shenyang, Nanjing, Shanghai, Xian, Guangzhou, Shekou and Shunde). Hence the strong need to service the domestic developments. Nortel is barely present in India.

VI. Factors Governing Capability Building Through Inter-firm Linkages and Policy Implications

It is apparent from the last section that MNCs may follow different strategies vis-à-vis inter-firm technology related linkages in different host countries; they might follow a "domestic market supported" R&D model in countries where the market is large and growing and where the MNCs have significant presence, while following "domestic market independent" R&D strategies where market is relatively small and MNC presence is insignificant but where specialized skills are available. The latter strategy not only permits the use of specialized and often low cost skills of the host country, it may also facilitate market entry for the MNC at a later stage. These two strategies will have obvious implications for the host country firms participating in the alliance as both the technologies they can learn from and the participation of the MNCs in the learning process will differ in the two cases. The foreign firms may wish to share more technology, especially the tacit variety, where they have more control over the use of that technology. The links of Nortel manufacturing facilities with Nortel-BUPT provided such control in the case of China, while Nortel retained the role of managing the network and integrating technologies developed by different partners in India to try and retain this control.

The fact that MNC strategies have implications for the learning of host country firms can be seen in another context. Any restructuring at the international level by the MNCs can impinge on the desirability and/or the nature of inter-firm linkages. Significantly, Nortel's merger with Bay Networks has created such a situation for the Nortel network in India.[5] The key issue is that host country firms participating in Nortel like alliances will have to be prepared for such changes. Restructuring of this type may result in a shift in the focus of the MNC leading to a change in strategy with respect to how the MNC deals with the firms in such networks.[6]

From the perspective of host country firms, some key elements that facilitate capability building through linkages are apparent:

- Rapid changes and convergence in telecom technologies and continuous unbundling of telecom service provision provides ample scope for firms to specialize and benefit from linkages with firms having complementary capabilities. As mentioned, linkages are critical even for the large MNCs to keep pace with the fast changing technology frontier.

- Firms with good skills along with risk-taking ability are likely to gain more from such alliance, as they will prove to be more valuable to the foreign partner. However, the issue of IPRs will still need to be resolved.

- Presence of telecom related skills may 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.

- 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.

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[5] . Since the merger with Bay Networks [with major installations in Wellfleet, Massachusetts and San Francisco], Nortel Networks, as it is now called, is undergoing a major restructuring. This will affect its central R&D laboratory and its functions. Nortel henceforth will be structured into its five business lines with the former Bell Northern Research [BNR], i.e. the central R&D functions being decentralized to each of the five business lines. The head of each of these lines will now take on greater importance and the central laboratory will virtually disappear. As mentioned, the Indian network was fashioned as a multidimensional laboratory modeled on the old BNR falls between the cracks.

[6] For example, in the case of Nortel, the restructuring has also meant some personnel changes and a small number of layoffs. One of the major changes in the current context is that the Vice President to whom the champions of the Nortel network in India reported has now been let go. The project champions are still there and now will need to save the Indian network and restructure it into the new interests of the company. The CEO, John Roth believes that Nortel needs "to move like Cisco (in data communications) and have the respect of Lucent (in telecommunications)". A leitmotif is the notion of a "webtone", that is to make the web as easy to access as the dialtone. Bay networks has been integrated into the Nortel business line "Enterprise Data Networks" and will give this new approach a major boost. The key issue then is whether and how the Indian market and firms with capabilities like the four Indian partners fit into the new scheme of things.

- Learning from alliances will need to be a strategic intent of the host country firms and they will need to make conscious efforts to learn from different projects and consolidate learning across projects. Mechanisms will need to be devised to disseminate the learning within the organisation. Movement of key personnel from one project to the other may facilitate diffusion of knowledge within the organisation. Of course, turnover of employees will automatically result in spillovers of knowledge gained though inter-firm linkages to other firms in the industry.

- 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. 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.

Frequent changes in technological trajectories and standards by the government prevents 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. 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. Apart from ensuring competition in the telecom market, the government can zero-in on a few technologies and announce that these will constitute the standard in the medium term. This choice of technology can be reviewed periodically as international competition throws up new technologies. This will reduce technological (if not market) uncertainties and facilitate flows of foreign direct investment and inter-firm linkages in the telecom sector.

The linkages of Nortel with BUPT, China and four Indian companies throw up several other questions on the potential of developing, nurturing and sustaining such hi-technology networks in developing countries. Given India's reasonable capabilities in telecom technology (for example, switches developed by Centre for Development of Telematics, C-Dot) and high knowledge base in software, and given the tremendous potential of synergies between these two knowledge systems, one would have expected "Nortel like" arrangements to emerge within the country among Indian software and telecom hardware firms. Why did this not happen? One possible answer can be that the telecom activity was largely in the domain of the public sector and the State did not recognise the value of innovation related interactions between manufacturers of telecom equipment (e.g., Indian Telephone Industries, ITI) and the technology developers (e.g., C-Dot and software firms). The other explanation can be sought in the fact that Indian telecom firms were not competing on the basis of innovations in domestic or export markets. They mostly focused

on adaptation activity for the local market and on cost reductions. Consequently, the need for such partnership was not felt.

Nortel, on the other hand, was both a manufacturer and developer of technology, competing with other international firms on the basis of state of the art technology. Unlike many other multi-nationals, Nortel was unable to enter the liberalising Indian telecom sector with its existing products. It foresaw, on the one hand, the large and significant emerging role of software in telecom technology and recognised on the other, the potential of Indian software firms in contributing to the development of these technologies. It also needs to be noted that the technology gap between the Indian software firms and their counterparts abroad was relatively narrow. It can be argued that in technologies where the gap in capabilities among the participating firms/countries is high, such linkages may not come about or may not result in significant learning for a developing country partner.

These networks add to the growing evidence that technology alliances of developing country firms with MNCs having excellent manufacturing and 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. While the participating Indian companies have gained a lot through this arrangement, it needs to be ascertained whether such linkages can result in significant spillover benefits for the rest of the sector/economy. If yes, under what conditions? Does the spillover potential depend on the nature of the organisation of such arrangements or the technology gap between the participating firms and their competitors within the domestic economy? The Chinese strategy of locating such alliances in a specialised university has obvious advantages vis-à-vis training and other spillover benefits. Do we also need to pro-actively build/develop telecom universities or departments in existing educational institutions or hope that the market forces will automatically create such facilities?

For an MNC like Nortel, in addition to cost advantages, such alliances can provide an opportunity to enter emerging markets like India through the "technology development" route and this collaboration may prove to be extremely useful for Nortel's entry into India in the near future. How can one encourage such "entry" by MNCs? Technology gap may prove to be crucial in this regard. For example, Bangalore was the right choice for Nortel - with three of the four partners located there, the cost of installing additional infrastructure (in addition to what the city already provides) was relatively low, and the ease of installation was high. Moreover, the pool of competent people, with software as well as telecom related skills, was very high. It is noteworthy that, both ITI and C-Dot, which had the potential of forging such networks on their own are located in Bangalore. Interestingly, most of the alliance partners in India depended to a significant extent on telecom engineers from these two public sector firms to set up their respective Nortel facilities.

Under what conditions would the Indian partners collaborate on product and technology development, since that seems to be an optimal strategy to maximise learning? Can the much maligned Indian public sector still take the lead in this direction and facilitate co-operative R&D among competitors? Will the lack of significant public or private investments in telecom training not act as a barrier to the growth of such alliances in future?

Answers to these questions may partly define the future of collaborative product development and research in this sector.

Table 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 development	• Joint production • Use of common components • Modularisation • Joint ventures • New forms of sub-contracting • Subsidiaries • GSO arrangements	• Joint marketing • Shared Distribution/ Service • Joint service provision • System products • Standardisation of interfaces

Source: Adapted from Mytelaka (1999)

Table2: Distribution of Alliances in the Indian Telecom Sector by Broad Categories, 1995-98		
Nature of Alliance	**Frequency**	**Percentage**
Financial Collaboration	38	21.6
Joint Research and Development	7	4.0
Technical Collaboration/Assistance	9	5.1
Bidding Consortium	3	1.7
Licensing/Licensing of Production	6	3.4
Licensing of Brand	3	1.7
Joint Production Contract	30	17.0
Joint Service Provision	13	7.4
Supply Arrangement (Provision of Equipment/ Infrastructure)	49	27.8
Distribution and Sales Arrangement	32	18.2
Marketing Arrangement	25	14.2
Customer Service Support	3	1.7
Subsidiary	8	4.5
Total	176	100.0

Source: IIMA Data Base.

Note 1: No cases of subcontracting, minority holding or cross holding were found in the database.

2: In addition there were 12 cases of acquisitions and mergers.

Table 3: Distribution of Alliances in the Indian Telecom Sector by Detailed Categories, 1995-98		
Nature of Alliance	**Frequency**	**Percentage**
Financial Collaboration + Joint R&D	1	0.6
Financial Collaboration + Bidding Consortium	2	1.1
Financial Collaboration + Joint Production	26	14.8
Financial Collaboration + Joint Service Provision	5	2.8
Financial Collaboration + Marketing	2	1.1
Financial Collaboration + Joint Production + Marketing	1	0.6
Others	1	0.6
Financial Collaboration (Total)	**38**	**21.6**
Only Technical Collaboration/Assistance	8	4.5
Only Bidding Consortium	1	0.6
Only Joint R&D	6	3.4
Only Joint Production	2	1.1
Only Joint Service Provision	8	4.5
Supply Arrangement (Provision of Equipment/ Infrastructure)	49	27.8
Only Distribution &Sales	27	15.3
Only Marketing Arrangement	17	9.7
Only Customer Service Support	1	0.6
Technical Collaboration/Assistance + Marketing	1	0.6
Joint R&D + Marketing	1	0.6
Marketing + Distribution & Sales	1	0.6
Distribution & Sale + Customer Service Support + Joint Production	1	0.6
Joint Production + Distribution & Sales + Licensing of Brand	1	0.6
Licensing of Production + Licensing of Brand	2	1.1
Licensing of Production + Marketing	2	1.1
Licensing of Production + Distribution & Sales + Customer Service Support	1	0.6
Licensing of Production + Distribution & Sales	1	0.6
Subsidiary	8	4.5
Total	176	100.0

Source: IIMA Data Base

Table 4: Distribution of Domestic and International Alliances by Broad Categories in Indian Telecom Sector, 1995-98

	Alliances among Domestic Firms		Alliances among Domestic and Foreign Firms	
Nature of Alliance	Frequency	Percentage	Frequency	Percentage
Financial Collaboration	10	13.5	28	27.5
Joint Research and Development	1	1.4	6	5.9
Technical Collaboration/Assistance	1	1.4	8	7.8
Bidding Consortium	0	0.0	3	2.9
Licensing/Licensing of Production	0	0.0	6	5.9
Licensing of Brand	0	0.0	3	2.9
Joint Production Contract	8	10.8	22	21.6
Joint Service Provision	6	8.1	7	6.9
Supply Arrangement (Provision of Equipment/Infrastructure)	38	51.4	11	10.8
Distribution and Sales Arrangement	14	18.9	18	17.6
Marketing Arrangement	3	4.1	22	21.6
Customer Service Support	0	0.0	3	2.9
Subsidiary	2	2.7	6	5.9
Total	74	100.0	102	100.0

Source:IIMA Data Base.

Note 1:No cases of sub-contracting, minority holding or cross holding were found in the database.

2: In addition there were 12 cases of acquisitions and mergers.

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