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Role of Transnational Corporations in the Evolution of a High-Tech Industry: The Case of India's Software Industry

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Summary. — India's software industry presents the case of an internationally competitive high-tech industry from a developing economy. This paper takes the evolution of the industry in terms of human capital accumulation. The initial stock of human capital leads to entry of transnational corporations (TNC), which triggers a cumulative process of further human capital accumulation through a process of externalities (spillovers) governed by firm-level and market structure dynamics. Spillovers from TNC operations are more effective when TNCs operate at higher end of technology and build backward linkages with local firms and institutions in a developing economy. The empirical exercises, based on the analysis of qualitative information collected through field interviews and econometric analysis of firm-level panel data, provide evidence of the positive contribution of TNCs for the evolution of the industry.

Key words — Asia, India, human capital accumulation, transnational corporations, linkages, spillovers

1. INTRODUCTION

India's software industry presents the case of an internationally competitive high-tech industry from a developing economy. India's exports of software services, which accounted for US$128 million in 1990–91 increased to $8.3 billion in 2001 (see Nasscom Report, 2000). The industry's exports of services, which started at the low end of data feeding, and onsite projects in the early and mid-1980s have moved up on the quality ladder of offshore development, niche products, and software consultancy services by the beginning of the millenium (Nasscom Report, 2000). Almost all the major US and European information technology (IT) firms have set up software development and R&D centers in India, especially in Bangalore.

The competitiveness of the industry is generally attributed to the low cost of scientific and engineering manpower with English language skills (Hanna, 1994; Heeks, 1996). The industry has been able to achieve export competitiveness without a domestic market base and inefficient input industries and infrastructure of telecommunications (Ghemawat & Patibandla, 1999; Patibandla, Kapur, & Petersen, 2000). The main critical input has been the human capital. The competitive dynamics of high-tech industries, which are subject to rapid technological change, have to do with more than the endowment of large pool of low-cost skilled manpower (Lall, 1992). The interaction between the policy factors, openness to international trade, and foreign direct investment (FDI), and local technological and financial institutions and firm-level dynamics determine the evolution of high-tech industries. This

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paper focuses on the role of transnational corporations (TNCs) in the competitive evolution of India's software industry.

There is a large body of literature in development economics which shows how openness of an economy is a source of growth for developing economies through technological, and informational externalities (spillovers) (Grossman & Helpman, 1991; Lall, 1992; Romer, 1990). The benefits of externalities associated with openness are supposedly important for developing economies because a major part of technological change and generation of new ideas takes place in developed economies with huge investments in research and development. Openness facilitates technological diffusion owing to the public goods nature of new ideas and technologies. TNCs are observed to be important transmitters of new technologies because their operations have demonstration effects to local firms, and are a source of technological and informational externalities (Aitken & Harrison, 1999; Branstetter, 2000; Grossman & Helpman, 1991; Kokko, 1994).

The process and the magnitude of benefits depends however, on several conditions, such as the endowment of local skills, technology institutions, market institutional conditions, local market size, technological capabilities of local firms, and policy factors. The extent of the net benefits depends on the nature of TNCs' operations, which, in turn, is governed by the conditions just listed. The nature of operations refers to local versus export market focus and centralized versus decentralized operations in terms of backward and forward linkages with the local economy (Archibugi & Iammarino, 1999; Dunning, 1993; Kobrin, 1999; UNCTAD, 2001). To illustrate this, TNCs, which build backward and forward linkages in the host economy, are more beneficial than those that operate as highly integrated units. This issue is highly relevant to the case of India's software industry, as it has been mostly an export-oriented industry with relatively little local market focus.

The issue of spillovers is a part of the economic growth process, which implies intertemporal changes in the economic factors. For example, spillovers increase skills of workers and with competitive input and product market conditions, and this is likely to increase wages and incomes. This, in turn, emanates incentives for local manpower to acquire industry specific skills, thereby increasing the pool of local skilled manpower. Furthermore, spillovers cause growth of the local industry, which in turn may change for the better local market institutions. This process may provide further incentives for FDI inflow and change in the nature of operations of TNCs in the host economy. This paper focuses on the effect of TNC operations on human capital accumulation and the consequent evolution of the Indian software industry.

We argue that the initial endowment of human capital, and technological capabilities of local educational and research institutions and firms determine the entry and nature of operations of TNCs. This determines the dynamic process of further human capital accumulation and growth. At present, India's educational institutions annually generate between 75,000 and 80,000 software professionals of varying technical skills with proficiency in the English language. About 16,500 engineering graduates are produced by the formal institutions, and the rest by the private training institutes. This pool of skilled labor is supported by some of the world class research institutions such as the Indian Institute of Science in Bangalore, the public sector firm the Bharat Heavy Electronics, and a half dozen Indian Institutes of Technology. This has provided major incentive for TNCs to enter India to tap into low-cost high-skilled workforce (Arora & Athreye, 2001; Arora, Arunachalam, Jai, & Fernandes, 2001; D'Costa, 1998; Patibandla *et al*., 2000). In this paper, we analyze how the entry of TNCs has generated a dynamic process of evolution of the industry.

In Section 2, we present the theory. In Section 3, we present the empirical analysis. There are two components to our empirical analysis. In Section 3(a), we present econometric analysis based on firm -level panel data to test for the presence of spillovers from TNC operations. Section 3(b) presents the analysis of the qualitative information and data of our field study of firms to bring out the underlying mechanism of the spillovers. The interviews were conducted on the basis of extensive questionnaires. We covered 30 firms, located in Bangalore, Hyderabad and Delhi, out of which 14 are TNCs and the rest are local firms. Section 4 provides the concluding remarks.

2. THE THEORETICAL ISSUES

We define the evolution of the industry in terms of increase in workers productivity and

increase in the industry size. Increase in the industry size is defined as increase in employment and total revenues. Increase in total revenues is caused by increase in workers' productivity over time and the scale effect of the increase in number of skilled workers. Workers' productivity is a function of capital accumulation and technological change. [1] Following Lucas (1988) we separate capital into physical capital and human capital. In the present case we focus on human capital accumulation although physical capital plays an essential, but subsidiary role. This is quite germane, as the software industry is primarily human capital-intensive. The following theoretical framework draws from the insights of the literature on technological capacity—building literature (Cantwell, 1989; Dunning & Narula, 1996; Lall, 1992; Nelson & Winter, 1982), and the literature on technological spillovers (Aitken & Harrison, 1999; Bell & Albu, 1999; Branstetter, 2001; Coe & Helpman, 1995; Kokko, 1994; Rotenberg & Saloner, 2000; Teece, 1977).

As it is well known in the literature, most technological change in terms of new products, ideas and blueprints are generated mostly in developed economies. A major part of the economic growth in developing economies is a matter of importing and imitating new technologies from developed economies. Open policies toward international trade and multinational investment is a major source of technological and knowledge diffusion and externalities (spillovers) to developing economies (Grossman & Helpman, 1991; Lall, 1992). But, local firms and workers in developing economies need to have minimum capabilities to absorb new technologies and ideas in order to benefit from international trade and investment. Lall (1992) groups these capabilities under three broad headings: physical investment, human capital and technological effort. This would imply that in the context of rapid technological change, firms in developing economies should be able to replace older technological assets and train workers in a sustained manner. In the case of software industry, this dimension is somewhat different: the physical capital intensity is very low while human capital intensity is very high. The developments in IT and telecommunications make global diffusion of new technologies very rapid with little cost. Furthermore, in this industry, the production activity itself embodies technological learning, while in manufacturing this is not often the case. A software engineer thus learns and upgrades as s/he does her/his work, while in manufacturing companies there may be little learning simply from production. [2] Therefore, technological capacity building in this context are basic skills of workers acquired in the universities and the ability of firms to train and retrain workers on new technologies rather than replacing physical capital. We argue that initial stock of human capital determines the entry and the level of technology brought-in by TNCs. [3] Technology brought in by TNCs is similar to a scale effect in production. This in turn engenders a dynamic process of further human capital accumulation and growth. The higher-end technology—such as investing in research and development—causes higher degree of spillovers than low-end operations of TNCs, such as data feeding and coding operations.

The dynamic process of the evolution of the industry in response to entry of TNCs has to be seen as interplay of firm-level (Lall, 1992) and market structure dynamics (Patibandla, 2002a; Rotenberg & Saloner, 2000) in conjunction with overall market institutional conditions (Williamson, 1998). This involves issues such as firm-level technological efforts, competition, learning by doing, workers' mobility, export and domestic market orientation, linkages, and market transaction costs.

Following from the above observation, on the market structure side, larger the number of firms higher are the incentives for workers to acquire both general and specialized skills. A small market size restricts number of firms to a few. This, in turn, can give monopsony power to firms which makes them pay skilled workers wages at par with unskilled workers. This discourages skilled labor to acquire specialized skills (Rotenberg & Saloner, 2000). Export orientation increases the market size and facilitates a large number of firms to enter the industry. The larger the number of firms, the larger the spillover effect, because TNCs bring in differentiated inputs and technologies (of both the competitive and noncompetitive kind, Romer, 1990). This, in turn, leads to a higher degree of spillovers to local industry and workers. [4] Second, different TNCs train local workers on different technologies, which results in a diverse range of skills in the local industry.

Export-oriented firms forming into a cluster cause faster aggregate human capital accumulation. High-tech industry clusters engender agglomeration economies, which contribute to aggregate human capital accumulation. Agglomeration economies imply that for given

inputs, the larger the output of an individual firm, the larger the aggregate output of other firms producing the same good in the same region. Export orientation relaxes the market size constraint, and thus increases the number of TNCs and local firms in a cluster. An increase in the number of firms in a cluster enhances agglomeration economies. The cluster activity increases spillover effects of diffusion of technologies and new ideas with ease because of concentration of a large number of high-tech industry firms within a geographic region. This is especially important if knowledge is tacit and uncodified (Baptista, 2000), and therefore requires close interaction among skilled workers. Mobility of workers is easier in a cluster because the costs of a job search are lower, owing to presence of large number of firms with complementary skills. A cluster also facilitates firms to hire workers with experience and skills more suitable to the requirements in the context of rapid technological changes. Mobility of skilled and experienced workers facilitates the free flow of new ideas and knowledge, which, in turn, increases aggregate human capital formation (Porter, 1990; Saxenian, 1996).

Transaction costs of exchange tend to be high in developing economies owing to presence of inefficient market institutions (Williamson, 1998). Cluster activity may remedy a part of this by facilitating closer and repeated interactions among agents and thereby reducing costs of formulating and enforcing contracts. This, in turn, facilitates contracting out work to other firms depending on their complementary skills. The interfirm linkages and cooperation increase spillovers. This is especially dominant if firms in the cluster are not competing for the small local market, but are international trade oriented. This becomes even more significant if TNCs and local firms in the developing country have complementary skills, which increases joint collaborations and cooperation between local firms and TNCs.

Following from the above observation, larger forward and backward linkages of TNC with the local industry cause a higher level of spillovers than TNCs operating as islands in a developing economy. Backward linkages involve linkages with human capital generating institutions such as universities, research labs, and with firms that produce complementary inputs and services. Forward linkages for an export-oriented, high-tech industry in a developing economy involve linkage with the home and international market operations of TNCs. A TNC that builds effective backward linkages stimulates further investment and development (Kobrin, 1999; UNCTAD, 2001) and generates knowledge spillovers in technology and organizational practices.

Linkages of TNCs with local firms could be at the lower-end and higher-end of technologies and the latter cause higher benefits to local firms and industry. Linkages at the higher-end technologies require two main conditions: (i) local firms and workers need to have minimum technological capabilities and skills (Lall, 1992, calls them "linkage capabilities"), and (ii) prevailing market institutions have to facilitate formulation and enforcement of complex contracts with low transaction costs (Williamson, 1998) and there should be protection of intellectual property rights (Teece, 1977).

The larger the technology gap between local firms and industry, the lower is the realization of knowledge spillovers (Blomstrom & Sjoholm, 1999). [5] For private firms to utilize and absorb this knowledge, they have to make their own private efforts in research and development and employees training (Coe & Helpman, 1995; Cohen & Levinthal, 1989). In a developing country in which there are market failures in R&D investment by private agents, spillovers from TNC operations can be turned into effective public goods, if the government undertakes investment in public goods of higher education and research and development. In other words, government investment increases the absorbive capacity of the local industry.

TNC investments in the lower-end technology in a developing economy contribute negatively to human capital accumulation the low-wage cost of skilled labor induces TNCs to invest in lower-end services, which leads to misutilization of human capital stock in a developing economy. If the cost of skilled labor is much lower than what is prevailing in developed economies, TNCs set up operations for the lower-end operations in developing countries. Lower-end technologies have low-level learning economies on the job and also exhibit a lower level of knowledge spillovers. This would lead to a net loss to the economy, if the similar skilled labor can be used in other activities with higher learning economies, but similar or slightly lower current wage rates. In other words, TNCs, by paying a slightly higher current wage than other sectors with higher learning economies, can crowd out the other sectors, which have higher potential contribution to growth. [6]

3. THE EMPIRICAL ANALYSIS

The empirical analysis consists of two subsections. In Section 3(a) we present the econometric analysis to test for technological progress in the industry and the presence of spillovers from the TNCs. This is done to set the tone for the analysis of the qualitative data and information of our field study in Section 3(b). The analysis of qualitative information brings out the underlying mechanism of the spillovers and human capital accumulation. [7]

(a) *The econometric analysis*

The objective of the econometric analysis is to test whether the increasing presence of TNCs in India's software industry contributes positively to productivity of software firms in India. As mentioned in Section 2, the main sources of productivity growth in the IT industry are human capital accumulation and technological change. The analysis is done at two levels. In Eq. (1), we estimate the Cobb-Douglas production by introducing time variable explicitly to test for technological progress in the industry. In Eq. (2), following Aitken and Harrison (1999), we estimate an augmented production function in which degree of TNCs presence enters as one of the explanatory variables along with the other inputs. The augmented production function tests for the spillovers associated with the degree of the presence of TNCs explicitly.

The econometric exercises are based on firm-level panel data for 20 large Indian firms covering 1990–99. The data were collected from the publications of the Center for Monitoring Indian Economy (CMIE) which publishes annually comprehensive firm-level data for the Indian public limited companies. The panel data analysis captures the dynamics of change because of inclusion of both cross-sectional and time-series dimensions. It makes use of information on both intertemporal dynamics and individuality of entities being investigated which also controls for the effects of missing or unobserved variables. The panel data estimates allow controlling for unobservable (omitted variables) by using fixed effects (Cheng, 1986). Eq. (2) is estimated by using the fixed effects model.

(i) *The variables*

Y = value-added
K = rental value of capital
L = salaries and wages
TNC = degree of TNC presence in the industry (total sales of TNCs/total industry sales)

This measure is at total industry level but not at the sample of 20 firms that are used in the exercises. Firms are classified as TNCs when the share of foreign equity is higher than the locally owned equity. [8]

RDS = research and development expenditure/sales
EX = exports/sales
RT = royalties and technical fees paid by firms/sales. This variable captures the extent of technological joint ventures of local firms with TNCs
t = time

The values for output and inputs are normalized by the appropriate price indices of producer and consumer prices.

(ii) *The results*

$$\log Y = \underset{(5.5)^*}{0.23} + \underset{(0.1)}{0.1}(t) + \underset{(4.6)^*}{0.03}(t)^2 + \underset{(12.3)^*}{0.49}\log L + \underset{(6)^*}{0.16}\log K \quad (1)$$

adjusted $R^2 = 0.94$ $F = 155$ $N = 129$.

Figures in the brackets are t-values: $*$ significant at 0.01 level.

The above results are statistically significant. The statistically significant positive sign of the estimated coefficient of the convex time trend (t^2) imply significant technological progress in the industry. Second, the results show higher value of the estimated coefficient of labor input than that of capital input which implies human capital is more important source than physical capital for productivity growth in this industry, which supports our argument in the previous section.

$$\log Y = \underset{(1.2)}{0.12} + \underset{(11.5)^*}{0.52}\log L + \underset{(4.7)^*}{0.15}\log K + \underset{(4.1)^*}{1.9}\mathrm{MN} + \underset{(2.3)^*}{2}\mathrm{RDS} + \underset{(4.2)^*}{0.63}\mathrm{RT} + \underset{(0.5)}{0.04}\mathrm{EX} \quad (2)$$

$R^2 = 0.90$ $N = 129$

Figures in the brackets are t-values: $*$ significant at 0.01 level.

The above results show a high degree of statistical significance with the appropriate signs of the estimated coefficients, which provide sufficient evidence for the presence of spillovers. The variables TNC and RT capture the effect (spillovers) of TNCs on the productivity of Indian firms in a direct manner. The estimated coefficient of TNC variable is positive and statistically significant which implies increasing presence of TNCs in the Indian software industry contributes positively to the productivity of firms. This mechanism could be in several ways—through spillovers, backward linkages with local firms and educational institutions, which will be discussed in the following section. The variable RT captures one of the aspects of backward linkages of TNCs with local firms. Firms with technological collaborations with TNCs pay royalties and technical fees. The positive sign and statistical significance of the estimated coefficient of this variable implies that the firms with higher degree of technological collaborations realize higher level of productivity.

As discussed in Section 2, local firms have to make their own effective technological efforts in terms of investing in R&D and training of manpower for effective realization of the benefits of possible spillovers from the operations of TNCs in a developing economy. The positive sign and statistical significance of the estimated coefficient of the R&D variable provides support to this proposition. EX variable is introduced to capture externalities associated with trade. [9] Although the estimated coefficient of EX variable is positive but is not statistically significant. [10]

(iii) *The analysis of qualitative information of the field study*

Software products are information goods for which research and development and marketing costs are high, but marginal costs of reproduction are close to zero (Mowery, 1996; Shapiro & Varian, 1999). Therefore, in the case of software products, local production is not necessary for TNCs for serving the local market irrespective of large market size because the transportation (telecommunication) costs and marginal costs of reproduction of software products are negligible. If the motive of TNCs is primarily to serve the local market, they open sales and service offices for serving the local market. TNC investment in software development centers in a developing country would be primarily to take advantage of low-cost skilled labor for software development and support of home operations. [11] In the case of software services, consultancy, and telecom related software development, however local market size is an important determinant of TNC investment.

The pattern of TNCs' investment, targeted at utilizing low-cost skilled labor in India, can be broadly segregated into three broad groups: offshore software development (programming and coding); investment in research and development; and IT-enabled services, such as medical transcripts, back office operations, call centers, data processing. The pattern can also be observed in terms of the segments, such as integrated circuit (IC) design, systems software, application software, and communication software. In the case of IC, both semi-conductor and related software development take place. [12] These different segments require different levels of labor skills and sophistication. The IT-enabled services are the least skill-intensive part and programming and coding requires basic skills while the other segments require highly specialized skills. For example, in the case of telecom-related software development, the skill requirements are high because it is necessary to have software skills and also understanding of telecom technology which is subject to rapid changes. Many software products include sophisticated mathematical algorithms used in data compression for telecommunications.

The waterfall model of software development involves the following stages: conceptualization, requirement analysis, high-level design, low-level design, coding, testing, and support. In the case of coding and programming, the waterfall model shows that the requirement analysis and design will be done in the customer's domicile whereas coding is carried out in India to take advantage of the low-cost skilled labor (Arora *et al*., 2001; Ghemawat, Patibandla, & Coughlin, 1999). It is done either by TNC subsidiaries or by joint collaboration with local firms. In the case of research and development, TNCs operate both at the low-end and high-end R&D. At the lower-end of R&D, TNCs could get into collaboration with local firms by subcontracting the work. At the higher-end, most of the work is done in-house in the Indian subsidiaries with the R&D teams linked with home and other foreign operations. In telecom-related software, TNCs such as

Nortell got into joint ventures with large local firms for R&D to make use of the complementary skills of the local firms at low costs under carefully formulated contracts for protecting intellectual property rights (Basant, Chandra, & Mytelka, 1998). As mentioned before, in the case of telecom-related software development both comparative advantage in low-cost skilled labor and also the growing local market is the motives for multinational investment.

The following qualitative analysis is based on the information and data collected from our field interviews of executives of a sample of TNCs and Indian firms in Bangalore and Hyderabad and Delhi. To understand the contribution of TNCs to human capital accumulation qualitatively, we need to observe their nature of operations. In the following, we discuss a few case studies of TNC operations in India, drawn from our field interviews of managers of a sample of firms. To recapitulate, the field study covered 30 firms. It is based on two sets of extensive questionnaires: one for TNC subsidiaries and the other for Indian firms. The main focus of the questions for the TNCs is the understanding of the level of technology of their operations, backward and forward linkages with local firms, and educational institutions, human resource (HR) practices, and their plans for growth and technology upgradation in the Indian operations. The main focus of the questionnaire for local firms is on the issue of the benefits of their collaborations with TNCs, skilled employee mobility and attrition. The interviews were conducted through one or two meetings with senior managers of the TNCs. In the following we discuss a few case studies in order to highlight certain broad general pattern to the nature of their operations and its implications on human capital accumulation and the growth of the industry.

India's software industry started at a low-end level of data feeding and coding and has been moving up on the quality ladder. In the initial years of the early and mid-1980s, several companies from the West out-sourced and set up units to undertake low-end work of data-feeding and coding and programming owing to low cost of large pool of skilled labor. Over time however, the market structure dynamics changed owing to large number of entrants both TNCs and local firms into industry doing high-end RD. Entry of TI in 1985 started the process of the change.

(b) *Texas instruments*

The subsidiary of TI was set up in Bangalore in 1985. It was made possible by the initiative taken by the then Indian Prime Minister, Rajiv Ghandhi. Apart from this, one of the senior vice presidents of TI happened be an Indian expatriate (Mohan Rao), who made the establishment of the subsidiary possible. At that time, the government did not permit private firms to own and install their own satellite communication facilities. The TI's managers brought in the most modern communication equipment at that time (a 64 khps data link) and gave it to the government (the Department of Telecommunications). They, in turn, then got the link from the Department of Telecommunication for TI operations. [13] The communication facilities made it possible for the R&D teams in Bangalore to be in direct and instant contact with the parent operations in the US. The excess capacity on the satellite link in the beginning allowed local firms get the link and facilitate their movement from onsite projects to offshore development. The TI subsidiary has been mostly export oriented in terms of supporting the R&D work at the parent and their global R&D teams in countries such as Israel.

The TI subsidiary today recruits highly skilled labor through rigorous screening from the IITs and regional engineering colleges and the Indian Institute of Science. The HR practices of the TI subsidiary are characterized by a flat organizational structure, as well as by team and individual-based incentives for promotion. Employees are given stock options. Once recruited, employees are involved in project training. Due to its HR policies, the attrition rate is observed to be at 15% below the industry average of 30%. Since R&D is done at a very high level, learning on the job to employees is very high. [14] Second, because of its high-end R&D, which requires strong synergy between different departments of chip designing and chip-related software development, it concentrates its work in one unit in Bangalore.

The TI subsidiary has developed strong linkages with the universities and research labs in and around Bangalore, e.g., through funding establishment of research labs in about 20 universities and through collaboration with university professors in designing and upgrading the curriculum of engineering education. Since the curriculum is outdated at several universities the last-mentioned task is stated to

be a very important element of TI's linkage with educational institutions. Because the TI subsidiary carries out high-level R&D in chip designing and digital signal processing, it does not often out-source its work to local firms. They have outsourcing to four or five firms for short-term projects for which they do not want to hire people. The subsidiary, which started with about 23 engineers, employs approximately 500 highly trained engineers at present. According to the chief executive, they plan to increase operations to a highly skilled workforce of 1,500 in three years and offloading most of the R&D work to the unit in India. The main reason is the large pool of skilled manpower available in India and the presence of highly sophisticated technological institutions such as the Indian School of Science in Bangalore.

The two significant contributions of TI are the spillover effects to local firms and the sophisticated telecom links. The TI operations with most modern communication links helped some of the large local firms such as Tata Consultancy Services (TCS), Infosys and Wipro (all of which are located in Bangalore) to imitate TI's practices and its move toward offshore development. Second, TI's successful operation in India gave a demonstration effect to other US and European IT firms to regard at India in a positive light for setting up high-end research and development centers. This in turn caused further new entry, which had significant implications on the market structure dynamics and human capital accumulation.

(c) *Hewlett Packard*

Hewlett Packard (HP) started its operations in Bangalore in 1989 with about 10 people. [15] At present, it employs about 1,100 engineers, with major plans for expansion. HP has two types of independent operations: one of software development and core R&D, and one of selling HP computer hardware to the growing Indian market. HP has a duplicate R&D center in the city of Chennai (Madras) which was set up for active collaboration of research and development with the large Indian firm TCS. HP in India follows a very active and effective backward linkage policy with both local firms and research institutions. HP has developed strong ties with both large Indian firms (such as TCS) and also with approximately 25 small and medium-sized firms. As outlined by the executive, HP's unique outsourcing model consists of three types: (i) outside specialists (consultants etc.), who are brought in regularly in order to work on short duration special projects; (ii) out-tasked specialists, i.e., employees of an Indian firm would be given a site at HP and work on a project; and (iii) out-sourced specialists—in which the project moves out to an India firm. The three different outsourcing models are adopted depending on the project needs.

HP out-sources some projects to a group of small companies who are selected under rigorous screening and bidding and are made to sign nondisclosure contracts. The firms are provided with HP technology and some training to the employees. HP deliberately selects small firms because entrepreneurs of small firms are highly motivated due to their linkage with HP is a strong source for growth and for establishing their reputation for high-quality work. [16] Some of the problems HP faces in relation to outsourcing are delivery time, cost overruns, and attrition issue of employees on a given project. In order to mitigate these problems, HP sometimes employs more than one firm on a similar task. HP's operation in the Bangalore cluster facilitated its linkage with technologically strong small firms and also its growth through partnerships with the local firms. This, in turn, results in strong spillovers to local firms and human capital accumulation through active movement of skilled workers.

The HP subsidiary in Bangalore developed a strong linkage with the Indian Institute of Science in Bangalore for its R&D activities. Furthermore, it funds research in selected universities in and around Bangalore. HP helps the selected colleges and universities in developing course curriculum, and elective courses. HP has programs for training teachers [17] in these colleges and has plans to expand its direct involvement in education and training.

The primary motive for HP to invest in R&D center in India is to make use of the large pool of skilled personnel. Engineering graduates are recruited from the Regional Engineering Colleges. HP imparts them with six months of rigorous in-house training. HR practices, in terms of flat organizational structure, operational freedom, and strong employee incentives are provided for employee job satisfaction, which keep the attrition rate low. Employee incentives are very strong, not only in terms of profit sharing, but also because employees are allowed to patent their research. During the last

three years, the employees of HP in India have taken out approximately 60 patents. Between 15% and 20% of HP's employees travel regularly to the US and other countries (such as Israel) where HP has R&D centers (which is a strong source for reducing idea gap and increasing information externalities).

(d) *Oracle*

Oracle started its operations in Bangalore in 1994 to contribute to Oracle's global Internet strategy with design, development, and maintenance of its products. At present, it employs approximately 450 skilled personnel. Oracle has plans to expand to 2,000 R&D personnel within the next five years. The TNC has R&D centers in Bangalore and Hyderabad. The setup works on four groups: database, tools, education, and a platform technology division. The Bangalore center concentrates on data-based tools while the center in Hyderabad focuses on application and systems development. The multiple centers are set up to tap into local skill pools and make use of infrastructure and state government support. The primary motive for coming to India was the parent's experience with skilled Indian skilled workers in the US, but the demonstration effect of TI's and HP's operations in Bangalore also played a role. The primary motive for setting up the R&D center, according to the CEO, is not cost cutting, but to make use of a large pool and high-quality skilled labor in India.

Similar to HP, Oracle has two types of operations that are independent of each other: (i) sales and marketing to serve the growing local market, and (ii) software development and R&D. In the first case, it is quite aggressive in promoting its technology with users in the Indian market-local consumers and firms with active tie-ups. Along with Microsoft and a few other TNCs, Oracle was involved in the setting up of Indian Institute of Information Technology. The R&D work is to support the parent's R&D in the US. Second, the center in India provides electronic support to Oracle's customers in all English-speaking countries. According to the executive, the quality of R&D work done in India is comparable to the work in the US. Its development work does not undertake outsourcing with the local firms because of complexity of high level R&D work. Specialists from the other firms and also consultants are brought in-house on project basis. Projects are not in operation outside Oracle's premises. Similar to Microsoft, Oracle does not adopt open-code programming. Therefore, a certain degree of secrecy involved. But, the development center in Bangalore collaborates with the other TNCs in India such as AT&T and Nokia for developing telecom related software.

The skilled personnel are recruited with rigorous screening from selected universities and engineering colleges. Four to six months of intensive training is provided. Providing job satisfaction with challenging tasks is the primary objective of its HRM policies. The most highly skilled people are attracted to Oracle because of its international brand name. Some of the skilled personnel are regularly sent to the parent in the US for training and coordination of the R&D work. The skill deficiency in India is effective product management skills, which the Oracle subsidiary imparts to its employees in cooperation with the Indian Institute of Management in Bangalore. Oracle has research linkages with Anna University, IIIT Hyderabad and IIM Bangalore for sponsoring research and training of skilled labor.

(e) *Microsoft* [18]

Microsoft started its operations in 1987 mainly to sell its products and services in the Indian market. Although the market from consumers for Microsoft's operating systems was small, the growing Indian software industry for developing software programming for the international market has provided large potential market from the Indian firms. Second, the lock-in characteristics of its platforms provided an opportunity for Microsoft to lock-in Indian firms into its technology, thereby promoting its products globally. As such, Microsoft undertakes quite active and aggressive approach in getting collaborative arrangements with almost all the leading Indian firms. Microsoft's sales operations but not the R&D center in Hyderabad, which actively invest in education to spread Microsoft's technology. This is very unlike TIs, which does not have any local market focus. Microsoft provides certified technical courses at Microsoft Authorized Technical Education Centers and end-user training courses on Microsoft products via Authorized Training Centers. Furthermore, Microsoft organizes seminars and hands-on, lab based, and video courses which emphasize

skill transfer by providing the necessary technology, and help to build, implement, and support real-world business solutions that take full advantage of Microsoft Technology. Microsoft is also involved in the course development of the Indian Institute of Information Technology (IIIT) in Hyderabad. The operations of Microsoft's R&D center in Hyderabad are carried out without any out-sourcing or collaborations with the local firms. [19]

(f) *Motorola*

Motorola started operations in Bangalore in 1991 with 50 employees. At present, the subsidiary has about 1,300 employees, of which approximately 1,000 are in software development and chip designing—mostly telecom related. At present, it has operations in three cities in India, Bangalore, Hyderabad and Gurgaon (adjacent to Delhi). According to the executive interviewed, the Bangalore center has state-of-the-art technology concentrating on high-end R&D, whereas Motorola's center in Hyderabad has been set up in order to tap into local labor market for lower-end software programming and coding. Motorola in Bangalore has developed strong backward linkages both with local firms and educational institutions. Motorola operates three types of projects: (i) high-end R&D projects (that are kept in-house with substantial secrecy precautions); (ii) specific projects that bring in specialists from outside for a short period; and (iii) projects that are contracted out to Indian firms. There are about 15 Indian firms—both small and large—with which it has developed subcontractor relations. The firms are provided with training on Motorola's technology and project management. According to the executive interviewed, they see rapid growth in out-sourcing to local firms, especially to small firms that are carefully identified. Furthermore, Motorola invests significantly in universities and research institutions. After looking at 100 colleges in and around Bangalore, Motorola short-listed 15 of them. Motorola provides the institutions with technology and tools, and training to the faculty. Furthermore, faculty members are brought in for sabbatical in Motorola's center. Motorola has also invested in the courses of IIITs of Bangalore and Hyderabad. Fresh and highly qualified graduates are recruited from the colleges and universities and IITs and are provided with intense in-house training. After a few years of experience, they are given stock options.

(g) *Nortell*

Similar to Motorola, Nortel has operations in India for developing telecom-related software. Its sequence of entry into India however is different. Technologically well-advanced local firms facilitate entry of TNCs through joint ventures and collaborations. Nortell entered India in 1989 through a joint R&D collaboration with large Indian firms such as TCS, Infosys, Wipro, and Silicon Automation Systems to make use of mutual complementary assets in technology, human capital, and infrastructure. The collaboration was possible because these Indian firms had achieved high levels of technological capabilities.

Once again, its initial entry was inspired by the success of TI and facilitated by a few Indian expatriate senior managers in its parent unit in Canada. The partnership became possible because Nortel could formulate nondisclosure contracts by each of its partners. In each partner's location, Nortel created infrastructure, the state of art telecom hardware and large capacity for communications. It also invested heavily in training the employees of the Indian firms. [20] As the partnership became successful, Nortel transferred more complex technologies to the Indian firms. The partnership benefited Nortel in reducing costs of developing telecom-related software significantly and the Indian partners in terms of transfer of latest technology and Nortel's international management practices and markets. Owing to the transfer of technology, one of the Indian firms has been able to develop a new product and market it globally. As Nortell gained experience with the Indian market institutions through the partnerships, it set up its own subsidiary in Bangalore in 2000.

(h) *Cisco*

Similarly, Cisco entered India through partnership with two Indian firms (Wipro and HCL) in 1996 and then later in 1998 set up their own R&D center in Bangalore. At present, it employs about 300 skilled personnel and plans to expand to 800 by 2002 with US$150 million investment. Cisco developed backward linkages with the educational institutions and also local firms through outsourcing. Cisco continues its partnership with the leading local firms such as

Infosys, Wipro, and HCL for product development. Cisco plans to set up 34 regional networking academies in the country in partnership with the government of India and educational institutions. It also set up a center for networking excellence in Bangalore in partnership with the Ministry of Information Technology to promote advanced networking education. Apart from this, Cisco, which grew by acquiring companies, plans to provide venture capital to start up companies in India. [21]

(i) *The Indian firms*

The following are some of the general patterns of the benefits to local firms from the tie-ups with TNCs on the basis of our field interviews of leading Indian firms such as Infosys, Wipro, Satyam computers, and Visualsoft. In the initial stages, collaborations with TNCs give local firms a brand image internationally, which generates more customers. Collaboration with TNCs provides access to international markets. If a local firm teams up with a leading TNCs, such as Microsoft, to make compatible products of the TNC technology, then the TNC promotes the local firm internationally. For local firms there are hazards to being locked-in to the TNC's technology with concomitant high switching costs. In order to minimize these hazards, local firms get into tie-up with several TNCs gaining access to each of the platforms. Some of the large Indian firms have tie-ups with a large number of TNCs. Furthermore, the collaborations provide local firms insights into the R&D and management practices of the TNCs. In partnerships, employees (the project teams) receive training both in India and in the parent operation of the TNCs. The movement of skilled workers to the developed economies exposes them to the latest technologies, ideas, and practices. In recent years, several Indian firms started acquire firms in the US and Europe. The experience with the joint collaborations with TNCs helped them to gain experience in the efficient management practices of the TNCs, which helps them in acquiring and running firms abroad easier.

Smaller Indian firms at the lower-end of technology in India focus mostly on the domestic market in developing niche products and client services. In this case, leading TNCs such as Microsoft and Oracle, have an incentive to provide free training and technology because these Indian firms are instruments to spread their platforms in the Indian market.

(j) *The analysis of the broad patterns*

The above discussion of the case studies provides qualitative evidence to the theoretical issues of Section 2. In the following, we discuss the evidence with respect to the issue of the link between market structure, export orientation, and human capital accumulation as discussed in Section 2. As mentioned earlier, until the mid-1980s, a few US and European firms outsourced low-end software development to India such as data feeding, and coding, etc. The large pool of low-cost skilled labor and the small number of firms with monopsony power allowed firms to use highly skilled labor for mundane tasks. The entry of TIs in 1985 and its successful R&D operation in Bangalore provided a demonstration effect to other leading US IT firms to enter India for the set up of development center for supporting the parent companies operations. It gave a further boost to the entry of both US and European IT firms to set up development centers. At present, in the Bangalore cluster alone, there are about 140 TNC development centers. They not only set up development centers, but also expanded their Indian operations substantially. Simultaneously, several Indian firms came into the market and grew rapidly, mostly through exports to the US market. The market reforms of 1991, which devalued the overvalued exchange rate and liberalized imports of technology, gave a significant boost to the exports.

As discussed earlier, most development centers of TNCs and Indian large firms are 100% export oriented to make use of the skilled labor in India for the international markets. The firms' export orientation relaxes the market size constraint and thereby facilitates entry of large number of both large and small firms. All this has contributed to a rapid increase in demand for skilled labor with both general and specialized skills. Consequently, wage rates for skilled software professionals have been increasing at an annual rate of 30% since the mid-1990s. At present, there is intense competition among TNCs and large Indian firms for skilled people with a few years of experience in project development and management. This has provided strong incentives for people to acquire both the general and specialized skills. The increase in demand for education led private firms to enter the education market. According to our interview with NIIT, a leading Indian IT training firm, it has plans for expansion even to smaller towns all over India. Apart from this,

there has been increasing cooperation between the governments at the national and state levels, some of the leading TNCs, and Indian large firms to invest in higher education. This collaboration led to setting up institutions such as the IIITs and expanding training in government institutions such as IITs and regional engineering colleges.

Furthermore, as illustrated earlier, most of the TNCs upgraded their operations in India to the technological frontiers of product development. For example, as gathered from our field study, several leading TNCs such as TI, Motorola, Nortell, Oracle, and Adobe are working at the cutting edge of their technology in the Indian operations. [22] To illustrate an example, the Indian subsidiary Adobe India of US-based $1.2 billion Adobe System has developed Acrobat Reader for handheld devices from its concept to the final product at its R&D center in Noida. This software increases the efficiency of handheld devices and one-load large PDF files on the handheld devices. The technological high-end operations of the TNCs give higher learning economies in human capital accumulation. Several of the TNC executives told us that one of the reasons they had for attracting the brightest graduates is exposure to the technology at the frontier in the Indian operations. All this put together, there is a significant contribution of TNCs for human capital formation both in scale in terms increasing number of skilled graduates and also upgrading of skills.

Except in a few cases such as Adobe and TI's digital signal processing R&D, most TNCs' R&D operations are in support of parents' R&D. In this case, there is generally a frequent movement of skilled personnel to the parent's center and the operations in India, which is an effective channel for reduction in idea gap and information externalities in a developing economy context.

There are several TNCs such as GE capital, PriceWaterHouse, HSBC, and Citibank etc., which use cheap labor for mundane IT-enabled services. These operations employ young people with bachelors degrees in basic science and arts proficient in the English language, and make use of them by providing about three months training on the IT-enabled services and back-end operations. Most of these graduates otherwise would be unemployed. Therefore, these operations have to be seen as mainly employment rather than technology generating (externalities).

The negative side of the increasing presence of TNCs in the Indian software industry is that it inhibits the movement of small local firms into high-end operations. Most of the high-skill graduates prefer to work for the well-known TNCs because of their brand name and technology and large Indian firms and also migrate to the US. Therefore, the smaller and also several large Indian firms have to do with low-end skilled manpower. Our field interview of Indian firms shows that these firms hire from local engineering colleges and impart training to them for three to four months. Some of the local firms make employees sign a three-year job contract. With these skills, the Indian firms can undertake software development only at the lower end. Second, the smaller firms become training grounds for the TNCs and firms in the US because once the workers gain enough experience, they leave to work for TNCs and/or to the US. One more negative impact of the growth of the industry and increasing wages of skilled workers is that it signals a disincentive for professionals to take up doctoral education and teaching. As mentioned by some executives, there is a shortage of teachers at present because they are attracted away by companies offering high salaries. This, in the long run, could result in a shortage of scientists for fundamental research and development.

With regard to our arguments about cluster dynamics, software firms are concentrated in Bangalore, Chennai, and Hyderabad of the Southern India, Pune of Western India, and Gurgaon of the Northern India. Several TNCs and large Indian firms have multiple development centers in all these cities. Since fixed costs of physical capital in this industry are low, duplicating plants does not cause loss of economies of scale. As the critical input is human capital, the multiple centers are set up to tap into locally available skilled workers. The development at the higher end of R&D work is however, concentrated in Bangalore owing to the strong agglomeration economies of the cluster. Of all the centers, Bangalore has become the most dynamic high-tech cluster (Balasubramanyam & Balasubramnayam, 1999). Most of the TNCs and leading Indian firms' development centers are concentrated in Bangalore. In Bangalore alone there are approximately 140 TNC development centers. There are approximately 750 large and small domestic IT firms. About 40% of India's total exports of $8.3 billion in 2001 have come from Bangalore.

There are about 60,000 IT professionals employed in Bangalore.

There is some degree of mobility of skilled workers among TNCs and local firms. As gathered from our field interviews, a few young engineers who worked for some of the TNCs such as HP and Motorola became successful entrepreneurs and innovators and started new firms one their own. A few TNCs also functioned as venture capitalists in supporting the start-ups. The export orientation of the cluster also forces the skilled workers to move in and out to the developed economies, which causes the free flow of ideas and spillovers. In Bangalore, there are a few strong joint ventures and partnership agreements among TNCs and TNCs and local firms. This linkage facilitates effective realization of technology spillovers.

Regarding backward and forward linkages of TNCs, we bring out some broad patterns with regard to the nature of the operations of TNCs in order to shed some light for their implications on human capital accumulation. The backward linkages are in terms of linkages with the local universities and research institutions and local firms and forward linkages is with respect the linkage with the parent company and international markets. There are broadly three types of operations of TNCs: (i) sales and service, (ii) software development (programming and coding) and (iii) research and development. In the case of the first one, leading IT companies such as Microsoft, Oracle, and IBM have a strong incentive in promoting their technology and platforms, especially with lock-in characteristics, with local firms and consumers and IT graduates of universities. They aggressively collaborate with local firms and provide free training for their employees on their platforms. Furthermore, several of the companies invest directly in the universities and engineering colleges and private training institutions such NIIT and Aptech for developing curriculum and training teachers on the technologies to promote their platforms. As mentioned before, in collaboration with the government and large Indian firms, TNCs started IIITs in major cities in India. Several of TNCs such TI, Intel, and Oracle also invest in the universities and research institutions for the general-purpose skills. For example, recently, Intel announced they would train 100,000 teachers in Internet and IT tools in India. Cisco, as mentioned before, announced they would set up 34 regional networking academics in the country. TNCs such as Intel and Cisco also function as venture capital funding in providing capital and technology and training to entrepreneurs in India. This strategy is crucial for the leading international firms not because of local market size, but because the Indian industry has become a major software development center for the global market. Generation of basic skills in India is beneficial for the TNCs, given the shortage of engineers in the US and the European Union countries. This part of the linkage is the direct contribution to the human capital generation in India.

The other aspect is the spillover effect through the linkages. In the case of high-level research and development operations, a few TNCs got into joint ventures with local firms (such as Nortell and HP). In such cases, TNCs entered collaborations with Indian large firms, such as Infosys, Wipro, and TCS, who had achieved high levels of technological capabilities. Subsequently, TNCs provided technology and training to local firm's skilled personnel at the cutting edge of the technology. At the higher end of R&D operations, however, TNCs, in general, are reluctant to out-source projects to local firms in which case the spill-over effects are low. In the case of lower-end operations of software programming, coding and data work, as we gather from our field-work, there is higher incidence of out-sourcing to Indian firms. In these operations, however, the learning economies and externalities are low owing to the lowend of technology.

4. CONCLUSIONS

India's software industry presents the case of an internationally competitive high-tech industry from a developing economy. There are several factors that contributed for its birth and growth: the previous import substitution policies, which invested heavily in subsidized higher education, and a critical level of technological endowments; emergence of a few dynamic local technocrat-entrepreneurs; the policy support, and the entry of TNCs. The market reforms that were initiated in 1991 in India increased the openness of the economy, and gave a big boost to the industry.

This paper has focused on the issue of contribution of TNCs for the software industry's growth and competitiveness in terms of human capital accumulation. The theoretical issues draw insights from the literature on technological capabilities and spillovers. The

empirical analysis is based on both econometric exercises and analysis of qualitative information collected from the field study of a sample of firms located in Bangalore, Hyderabad, and New Delhi. The empirical analysis provides significant evidence for the positive contribution of TNCs for the competitive evolution of the industry.

The recent literature on economic growth shows that openness to trade and investment is an important source of economic growth to developing economies. This is because most new technologies and ideas are generated in developed economies with large investments in R&D and openness functions as a channel for the free flow of ideas and technology and associated externalities. In order to realize benefits from FDI, and trade, developing economies have to meet two conditions: first, they should have a critical level of initial human capital and technological capabilities, and second, local firms and governments have to make investments in technology-capacity building to increase absorptive capacity of new technologies and ideas.

The initial human capital stock of large pool of engineers generated by the past policies in India led to the entry of TNCs to utilize the low-cost skilled manpower. The entry of TNCs has caused a dynamic process of further accumulation of human capital and consequent growth. The process can be broadly seen in terms of firm-level and market structure dynamics for their implications on spillovers and their absorption. Most TNCs entered the Indian industry to utilize low-cost skilled labor for their global operations. Export orientation of the firms relaxed domestic market size constraint and allowed entry of a large number of TNCs since the mid-1980s. As they gathered experience and confidence in the quality of skilled workers in India, over the years several of them expanded their operations and upgraded their technology level significantly. This led to rapid increase in demand for skilled workers. Increasing wage rates have provided incentives for the acquisition of both general and specialized skills, which has caused further supply-side response of both the private schools and the government institutions expanding educational infrastructure.

For technological externalities to be significant, TNCs have to operate at high-end of technology and build linkages with local firms and technological institutions in developing economies. This requires two conditions: (a) local firms and workers need to possess certain critical level of technological capabilities and skills, and (b) there has to be market institutional conditions that facilitate formulation and enforcement of complex contracts with low transaction costs, and protection of intellectual property rights. Following from this, in order to derive benefit from foreign direct investment, the policy measures in developing economies have to be comprehensive rather than piecemeal. The policies should be aimed at not only generating human capital and technological capabilities, but also generation of critical market institutional conditions that give incentives for TNCs to build linkages with local firms and institutions.

NOTES

1. We do not deal with the issue of labor replacing technological change, we assume technological change can be neutral or skill worker augmenting.

2. The learning costs and periods involved are thus much more significant in complex manufacturing activities than in moving up the software technology ladder. We are thankful to one of the referees for pointing this out.

3. Endowment of low-cost skilled labor on its own would not result in FDI and its contribution to the development of the local economy. For TNCs to take full advantage of skilled manpower and contribute to its endowment, the endowment of skilled labor has to be supported by efficient market institutions, the government policies, and local technological institutions such as the universities and research institutions. In this paper, we focus the human capital dimension. For detailed discussion of determinants of FDI in India's software industry see Patibandla (2002b).

4. Lall (1992, p. 179) observes, "a strong foreign presence with advanced technologies can prevent local competitors from investing in deepening their own capabilities." This is more applicable if foreign firms and local firms compete for small domestic market in a

developing economy than when TNCs and local firms are highly export oriented.

5. There are two public goods in the system: the knowledge spillovers, and the government investment in higher education and research and development.

6. This result has to be seen in terms of market structure dynamics. If there are only a few firms and large supply of skilled labor, it is likely that the skilled workers would be utilized suboptimally. As more firms enter the market, demand for skilled labor increases, which puts upward pressure on wages. This, in turn, induces firms to utilize skilled workers more productively.

7. Econometric research aimed purely at testing hypotheses may miss out on the underlying mechanisms of an outcome, which analysis of qualitative information and data could rectify.

8. One of the drawbacks of the data is that several 100% foreign-owned firms are not listed in the Indian stock market and these firms do not enter the CMIE's database. In other words, TNCs' presence is underestimated.

9. Hejazi and Safarain (1999) observe firms in developing countries derive externalities both from FDI and international trade and incorporating only one of the elements may lead to overestimation of externalities.

10. A part of the reason could be multicollinearity between RDS and EX variables.

11. The interesting aspect of the industry is that there is a two-way flow of FDI. Large IT firms from the US and Europe invest in India for software programming, coding, and research and development. Large Indian IT firms invest in the Europe and the US for customer development and software consultancy services. The latter part could be through both stand-alone units and joint ventures of Indian firms with the major TNCs.

12. The following are the few examples of major TNCs in the different segments of the Indian industry. In IC: Texas Instruments (TI), Siemens, Philips, Synopsis, Analog Devises, National Semiconductors. In Systems Software: Oracle, Novell, Sun Micro Systems, Digital, Apple. In Communication Software: Lucent Technologies, Nortel, Siemens, Motorola, Cisco Systems, Ericsson, and Sony.

13. At this time the idea of Software Technology Parks was formulated to provide the satellite and other infrastructure facilities to software exporting firms.

14. The digital signal processor chip was developed independently by the TI's subsidiary in Bangalore and it has been globally marketed.

15. Its coming to India is also partly responsible to a senior vice-president who is an expatriate Indian in its US unit.

16. One of the small firms, HP supported in Bangalore has developed a product for Internet technology and has become very successful.

17. According to the executive, one of the problems of labor market is the shortage of good teachers of IT skills as most skilled teachers are absorbed by the industry offering higher salaries than the universities.

18. The observations regarding Microsoft's operations are based on secondary information because despite numerous attempts by us, the executives of the development center in Hyderabad refused to meet us on the grounds of secrecy of their operations.

19. Since we could not secure the interview with the executives, we are not in position to bring out the qualitative information about its operations.

20. Also see Basant *et al*. (1998).

21. Venture capital funding by TNCs can be a significant element of evolution of the industry as TNC are geographically insensitive whereas a typical venture fund in the US is very provincial (see Dossani, 1999).

22. In the beginning of 2001, US-based majors like Cisco, IBM, GE, and Ford announced investment plans worth over a billion US$ for the following two years which is expected to create 10,000 IT professional jobs. General Electric is investing $100 million in Bangalore to build its largest R&D lab in the world, employing 2,600 scientists, including more than 300 with Ph.D. degrees. The technological evolution of the industry is supported by the fact that more than half of the software development centers in the world with Carnegie Mellon University's CMM Level-5 rating are located in India (Kapur & Ramamurti, 2001).

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