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Software in India: Development Implications of Globalization and the International Division of Labor

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1. INTRODUCTION

The traditional view of economic growth is that it is driven by savings, investment and capital intensity. The growth of East Asian countries has been attributed to these factors. A counter-view, argues that the micro foundations of growth, and thus the proximate cause of differences between national economic performances, lies in capabilities of firms for technological advances. Accumulation of technical knowledge is crucial in economic development; cumulative increases in firm level capabilities attract investment and drives growth.

If capital markets work well, capital will flow toward capable firms, and toward the countries that have more capable firms. In each region, firms would compete to enter into gainful activities. If there were wage differentials, and if labor were not free to move, firms would shift their activities to low wage regions. High capability firms would be distributed uniformly across regions. In practice, however, there are stable dif-

ferences across countries; real wage differentials persist, more capable firms do not move readily to low wage regions, and firms in poorer regions do not readily acquire higher capability.

Will the race for capability enhancement lead to convergence between national economies? What conditions will lead to economic polarization of the world? The convergence/non-convergence issue has gained increasing attention in both developed and developing countries, particularly in the context of internationalization of economic activity and international division of labor. What are the implications of globalization for developing countries? At the same time, what are the implications for the north of the increasing competition from the south for high quality employment and value addition, one reflection of which is de-industrialization.

The explosive growth of the economic role of IT technologies worldwide has highlighted these questions. IT has facilitated globalization, in the forms of international outsourcing, FDI and co-production. Do the diffusion of the general-purpose technology implicit in IT, and the growth of software industry mean fierce competition to developed countries from developing countries such as India and China? In the case of the US, it has been determined that firms have been able to derive substantial benefits from outsourcing software development and services, particularly essential maintenance and development services and system integration services to subcontractors, leaving their own IT staff to focus on higher value added work. Indian firms competed fiercely among themselves for contracts, leaving most of the gains from trade to US firms (Arora *et al.* [2000]).

At a more fundamental level, from the point of view of technological knowledge advance and capability building, there are now more transnational joint research and strategic technology alliances (OECD [1997]). The multidisciplinary nature of new technologies and high costs/risks has encouraged international partnerships and alliances (Hicks, Isard and Martin [1996]), facilitated by new communication technologies. Recent trends in R&D activity indicate increasing interaction between producers, suppliers, centers of learning (universities, etc.) and R&D organizations, often through communication networks (Howells [1995]). But developing countries have poor prospects of participating in these networks.

While the traditional literature on FDI and on export led growth provides some explanation for limited foreign economic presence in low

Venables [1999]) highlight the powerful reasons for the prevalence of geographic industry clusters. There may however be specific ways in which the IT industry is different from other traditional (commodity-type) industries. OECD [1997] reports that the trend toward globalization in the IT industry has been matched by, and to a large extent driven by, a shift in MNC activity in the industry (particularly, US-based MNCs) to Asia, and this shift has been prompted by labor cost differentials (OECD [1997]).[1] Any positive impact of such globalization is not likely to be sustainable, since internationalization should increase competition and lead to an equalization of wages across countries (Forge [1995]). But, are there more permanent effects of such globalization? Does co-production (even when the initial relationship is severely unequal) of skill-intensive services involving firms in low-wage economies and in advanced economies offer a route for developing country firms to step permanently up the value chain?

India is a good 'case' to explore these issues in detail as it is there, if anywhere, that software appears to have shown promise in beneficial international division of labor (Fernandes, Arora and Asundi [2000]; Lakha [1994]; Lateef [1997]). There is substantial foreign presence in the software industry in India, and many foreign firms have set up software development centers. Over a period of time, several of the domestic companies have also set up subsidiaries abroad, engaged in production of software and services, well beyond marketing. It would appear that longer lasting advantages are beginning to emerge from the ongoing process of globalization in the Indian software and services industry than what one would expect of a typically transitory relationship sustained only by low wage levels.[2]

This paper builds on Kattuman and Iyer [2001] and Kattuman and Bhattacharjee [2001], to explore differences and similarities between foreign firms and domestic firms (with and without foreign subsidiaries) in terms of their inputs and strategies (in terms of markets, specialization and application areas), and their resultant output variables. We attempt to identify aspects of performance in which (India-domiciled) foreign firms lead, and where Indian firms lead; this helps to draw out the impact of internationalization on firm performance.

2. GLOBALIZATION: INTERNATIONAL COMPETITION AND FIRM LEVEL RESPONSES[3]

A key implication of trade liberalization is increased competition. Efficient firms should be expected to respond to increases in competition by investing in building up capability, broadly defined, encompassing both productivity and quality levels. In low technology markets in developing countries firms oriented purely domestically may not find it worthwhile to invest in raising their capability.[4] It may not be worth sinking fixed costs in product development and process improvement, if the demand for older generation products is sustained. But in high technology markets[5] firms in both developing and developed countries have little choice; to survive, a firm will need to position itself in a narrow window in the range of capabilities; all firms cannot succeed. The key argument is that in these markets, the growing but more competitive global market does not draw increasing numbers of active firms, but spurs the efforts and fixed outlays of a smaller number of survivors. The optimal strategy for weaker firms may be to quit the race, and the long-term consequences of globalization may be consolidation by some and exit by the others.

In the race for increasing capability, firms can be expected to explore all avenues, and advanced firms in high wage countries may find it feasible and economical to locate some of their activities in lower wage developing countries. If it works well, developed country firms can reduce costs; from the perspective of developing countries, firms have at least the potential to begin enhancing capabilities from such subcontracted or out-sourced work. If that potential materializes and if the learning is cumulative, at least some of these firms may in turn, find it worthwhile to migrate part of their operations to locations in advanced countries, not only for marketing, but to take advantage of 'socialization' and 'local collective learning' (Maskell and Malmberg [1999]; and Cohendet *et al.* [1999]). The 'tacit knowledge' accumulated by these firms should increase their productivity in their home locations, and this process, if pronounced enough, could mitigate the strong arguments in favor of non-convergence.

These conjectured benefits would depend very much on the nature of the industry in question. One set of reasons why this does not happen, and why high capability firms cluster spatially and interact among themselves is given by the geography and trade literature (Fujita, Krugman

and Venables [1999]). Supply-side input-output linkages among firms in any region can sustain spatial clusters of high capability firms. Capable firms enjoy the positive externalities from there being other capable firms in their neighborhood, reducing costs of transport, coordination, monitoring and contracting (see also Maskell and Malmberg [1999]; and Cohendet *et al.* [1999]). If the backward and forward linkages are strong, in stable polarized equilibrium, some countries will be always high wage, and some, low wage: a capable firm will not find it profitable to migrate to a lower wage region because of the cost of the loss of high quality local supply. The coordination failure in migration in search of high quality workers with lower wages will forever consign poor regions to have low wages and less capable firms. Such an argument has been used to explain the existence of high tech clusters, like Silicon Valley, Route 128, and Silicon Fen in Cambridge, UK.

Sutton [2001] highlights another mechanism that contributes to such polarization. A firm's capability is embodied in large part in the 'tacit knowledge' possessed jointly by the firm's workforce. Poor mobility of even some individual workers may imply that, relocation of the firm's activities would involve costs that outweigh gains from lower wages. Moving the firm with the loss of a significant fraction of 'immobile' individuals would imply costly loss of collective tacit knowledge. Once capabilities are embodied in domestic employees, a firm is no longer perfectly mobile in the face of real wage differentials. Empirical evidence on multinational firms demonstrates their propensity to shift only some kinds of activities to low wage countries, while retaining core competencies in their 'home' location.

However, there may be a distinction to be made between 'commodity-type' industries and the IT industry, which can operate effectively with teams who may distributed across different geographical areas, and which is less reliant on inputs other than well-trained and learning capable software professionals.

A distinctive aspect of digital products is the nature of separability of the many activities that are necessary for their production and delivery. In the popular model of software development, the waterfall model (Royce [1970]) development of software is set out in terms of a hierarchy of sequential steps. The first stages (conceptualization, requirement analysis and high level design) are the high value added stages, while the later stages (low level analysis, coding etc.) are low value added segments. These different activities are separable in production across

space, so long as there are mechanisms for continuous coordination through information exchange. One consequence of the separability of activities in production is the potential for product differentiation that is common in software to a greater degree than all physical products.

The delivery and transmission mechanisms of the industry complement the seperability. Digital networks that make up the transmission infrastructure allow reliable and real-time transfer of digitial files that comprise both work in progress as well as final products. This makes it possible to work in geographically separated locations in co-production.

The above features reinforce a third aspect (which it shares with other high technology industries): continuous technological change. Consequently, production activities are not stable, they change rapidly, and firms themselves must undergo continuous restructuring. If production is geographically dispersed, suppliers and partners in developing countries also participate to varying extents in the process of change. There is inherent potential in the industry for learning by doing, and this could serve as the basis of enhancing the capability of vendors.

Producers and users of software may outsource projects to developing countries for a variety of reasons: primarily to access software engineering skills in sufficient quality and scale at lower operating cost, as well as to insure against the risk of cost escalation, through fixed price contracts and staged payments. While relationships typically start through well-defined projects that require low level of coding, there are demonstrated growth routes up the value chain. As projects get completed, vendors gain trust of clients, and aided by their certification, could move on to projects that call for somewhat more responsibility and accountability. By paying attention to quality, instituting industry standard quality practices, at least some firms can move from back-office work to focus more on strategic business projects, higher level (and higher paying) strategic business products and services.

The key issue in the move up the value chain is that while developing country vendors may have the aptitude to master advanced business models and practices they are not going to learn it operating purely in the domestic domain. To develop international business experience, they need to locate internationally. In the case of the Indian vendors, a significant number of firms have moved on to set up production subsidiaries abroad. If these firms acquire business capabilities as quickly and as aggressively as they did their high-level quality certification status, then it is not unreasonable to conjecture that they might grow in productivity

and market share, particularly in the business services segment.

3. THE INDIAN SOFTWARE INDUSTRY

The origins of the Indian software and services industry go back three decades to the founding of Tata Consultancy Services (TCS), a spin-off within the premier private sector TATA business group. The initial market was domestic, mainly software development for a few public sector firms and fewer large private sector firms. The early entrants into the industry were cross entrants. A few large firms in other sectors, including computer hardware firms, diversified into software: notably, TATA, Hindustan Computers Limited (HCL) and Wipro. Many of these cross entrants spun off in-house computing service divisions into independent business units, to serve the limited domestic market in a regime of import substitution.

From the beginning of the 1980s, the industry demonstrated export potential, and encouraged by this the government put together an export policy that allowed liberal imports of hardware and software, allowing entry of wholly owned foreign firms, and setting up of software technology parks as export processing zones (Heeks [1996]). The liberalized policy toward foreign direct investment (FDI) was seized upon by NRIs as well as multinational corporations (MNCs). Citicorp Overseas Ltd., a wholly owned subsidiary of Citibank, set up shop at Mumbai in 1985. A group of non-resident Indian executives in Texas Instruments (TI) promoted the setting up of a subsidiary in 1986 in Bangalore. Other MNCs followed, notably ICT majors like HP, Novell and Oracle. By the Nineties many foreign firms had set up offices and subsidiaries in India, often with domestic partners. While their initial objective was to sell their own software and hardware products in the Indian market, as advantages of locating software development in India became evident, these firms moved to establish significant software development centers in India; some well known firms in this class are Oracle, Texas Instruments, Motorola, Siemens, and Microsoft. Some of these software development centers do fairly sophisticated work.[6]

A number of firms followed this lead and have established significant operations to take advantage of the pool of relatively cheap skilled workforce to sell software services in the international market. With the advent of high quality communications, one advantage of India that has come to the fore is the time zone, making the location a prime site for

24-hour continuity in the development process. The same advantage is enjoyed, as far as the US market is concerned, by Indian firms who develop in India and test software among clients in the US.

As is typical of young industries with technology embodied in human rather than physical capital, and comprising of many market niches, established firms served as incubators for entrepreneurs. In the late Eighties de-novo entrants began to spring up in large numbers in the industry; one of the best known of which is Infosys. Many of these firms were started by breakaway groups of managers from established software firms. For example, Infosys was started by a group of managers who left another early entrant, Patni Computer Systems, sustained initially by a maintenance contract from a client of the parent firm. In this self reinforcing process, the growing population of firms served as the growing set of incubators of future firms. A small but potentially significant variant within this class are the firms set up by NRIs, some (not all) relocating in India having gained some experience after either long periods or shorter secondments abroad. On the other hand, some of the domestic firms, particularly among the market leaders, have established subsidiaries abroad that are engaged in software production and services.

Starting with 38 members in 1988, the industry association NASSCOM grew to have nearly 1,000 members by the year 2001. As of 2000, the industry was estimated to employ close to 300,000 employees. The growth rate of the industry, over the five years 1995-96 to 2000-01 has been in excess of 50 percent.

3.1. Typology of Firms

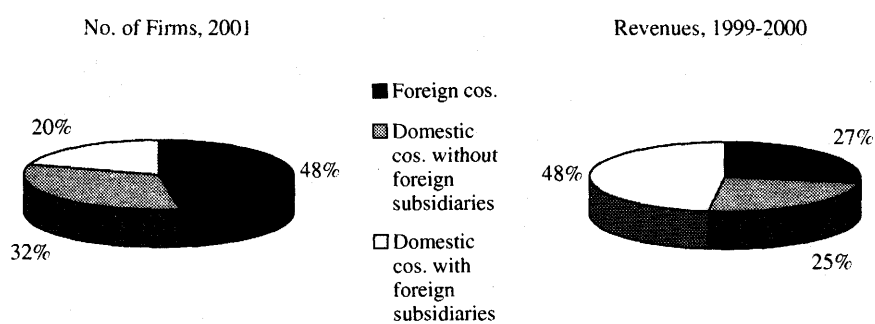
Traditionally, higher coordination and communication costs, and the importance of geographical and cultural proximity (Cohendet *et al.* [1999]) in the development of core competencies have deterred MNCs from subcontracting their critical core software development jobs to geographically distant locations. Indian companies, for the most part, have had to stay content with low-level routine and repetitive tasks with limited learning potential, and low opportunity for leapfrogging.[7] However some US companies have been outsourcing significant shares of high-end software development to their own subsidiaries in India (Arora *et al.* [2000]). At the same time, some Indian software companies have opened subsidiaries/development centers abroad. Notwithstanding the higher labor costs at these overseas centers, they provide the opportunity for

accumulating the essential tacit knowledge that comes out of engaging in the design and production of high value complex services and products.

Of the thousand and more Indian software producers registered with the NASSCOM, we collected data on ownership patterns of 293 Indian software firms, as on end-March 2001,[8] and the empirical analysis in this paper is based on this data. These 293 companies accounted for 73.7 percent of the market share in 1999-2000, as compared with 74.1 percent market share registered by the 482 companies listed on the NASSCOM directory (NASSCOM [2000]).

Of these 293 companies, 155 were of domestic ownership, while the remaining 138 were either subsidiaries/offices/software development centers of foreign firms, or had at least 30 percent foreign equity ownership. Of the 155 domestic companies, 59 have established foreign subsidiaries that are engaged in actual software services activities overseas, as opposed to purely marketing activities. These 59 domestic companies with foreign subsidiaries (about 20 percent of the 293 companies in number) accounted for as much as 48 percent of the total software revenues earned by the companies in 1999-2000 (Figure 12.1). By contrast, the foreign firms, nearly half the 293, cornered only 27 percent of the revenues. At first sight it would appear that, domestic companies with foreign subsidiaries are by far the size leaders in the Indian software market.

Figure 12.1: Distribution of Indian Software Firms, Number and Revenues



In this section, we analyze the cross-sectional distributions of several important characteristics of these three segments of firms, encompassing strategy, inputs and observable performance criteria, in an attempt to understand what the essential differences between the three categories are.

As alluded to earlier, considerable attention has been focused in the literature, on the nature of relationship between MNCs and Indian software companies, in terms of the contractual agreements (Arora *et al.* 2000; Banerjee and Duflo [2001]) and export orientation of Indian domestic software producers (Heeks [1996]; Arora et. al. [2000]), as well as the activities of MNCs in the ICT industry and their subsidiaries in India (D'Costa [2000]). As an aid to our understanding of the performance and operations of foreign and domestic software companies in India, we shall first examine, some of the broad characteristics of these foreign companies.

The geographical area-wise ownership pattern of the 138 foreign companies is quite concentrated (Table 12.1). A majority of these companies (97) are owned by corporate entities in North America; 27 are European, and the remaining 14 Asian. Country-wise, the US owned the maximum number of these companies (95), followed by the UK (10), Germany (6) and Japan (5). Either expatriate Indians, or foreign nationals of Indian origin promoted 17 of these 138 foreign companies (MNCs); 15 of these companies were from the US. 16 of the 138 foreign companies began operations under domestic ownership, and were later on taken over.

Table 12.1: Ownership of Foreign Software Firms in India

Continent / Country	No. of firms	Revenues, 1999-2000* (Rs.mn.)	Paid-up capital* (Rs.mn.)
North America	97 (70)	48,811 (75)	8,196 (78)
US	95	48,599	8,175
Others	2	212	21
Europe	27 (20)	14,531 (22)	1,436 (14)
UK	10	9,944	892
Germany	6	792	70
Netherlands	4	2,404	140
Denmark	3	172	138
Others	4	1,219	196
Asia	14 (10)	1,750 (3)	855 (8)
Japan	5	742	495
Singapore	4	386	160
Others	5	622	200
Total	138 (100)	65,092 (100)	10,487 (100)

Figures in parentheses are percentage of total.

Note * For some firms for which requisite data were not available, estimated figures are used.

Activity wise, the 138 foreign companies cover a wide range of types: some (like the subsidiaries of financial services companies such as Citibank, Deutsche Bank, Churchill Insurance, Phoenix Life Mutual, etc.) are almost entirely engaged in catering to software services for their parent companies, some (at least partially) work as software development centers of software MNCs, and some (e.g. IBM with Tata Group, British Aerospace with Hindustan Aeronautics, Bell South with Telecommunication Corporation of India, British Telecom with Mahindra Group) are joint ventures between MNCs and local enterprises. Some preliminary classifications of firms among these (not necessarily mutually exclusive) typologies reveal that, about one-third of the companies were joint ventures between MNCs and domestic enterprises. Also, approximately 70 percent of these foreign companies actually engage in (high-level) software development work in India, as opposed to low-level coding. The predominance of the above typologies would suggest a strong symbiotic relationship (also noted by Arora *et al.* [2000]) between MNCs (particularly based in the US) and their Indian counterparts. Probably, this would also partially vindicate the notion that geographical proximity (Cohendet *et al.* [1999]), which is noted to be very important in other hi-tech industries, and higher coordination costs would discourage delegation of high-end software development work to Indian firms.

On the other hand, most of the prominent domestic Indian companies have established overseas subsidiaries/offices engaged in production activities. In fact, these Indian companies, which are 39 percent of the 153 companies in numbers, accounted for as much as 66 percent of their aggregate software revenues in 1999-2000. This indicates the eagerness of these companies to circumvent the limited scope for 'local collective learning' (Maskell and Malmberg [1999]) in the domestic market and set up shop abroad, notwithstanding higher labor and coordination costs.

Thus, even though they largely operate in the same market geographically, it appears possible that the three classes of firms, namely, foreign firms located in India (138 firms), purely domestic firms (155), and of which, those having 'production' subsidiaries abroad (59), have markedly different business strategies. How different are the dimensions of these strategies, and how far have such strategies succeeded in enabling these firms to achieve consistently higher output performance, is an issue that the analysis in this paper would shed some light on. In terms of methodology, we shall profile the differences between these three classes of firms, in terms of their inputs, activities/strategies and outputs, and inte-

grate these quantifiable characteristics by building appropriate linkages.

Factor inputs in software production are human capital, physical and financial capital, probably in that order. *Ex ante* size, and age of the firms may also matter in productivity. The most significant input the main source of the competitiveness of the Indian software industry has been the inexpensive skilled manpower generated by Indian higher education and technology institutions (Fernandes, Arora and Asundi [2000]; and Kattuman and Iyer [2001]). As a measure of factor endowments of the three classes of software firms in India with respect to human capital, we have considered the number of software employees in March 2000. As regards physical and financial capital, it is well recognized that the software service industry does not require substantial upfront investment. However, software development requires substantial investment in both physical and financial capital, and most Indian software developers face severe supply-constraints in this regard. Most of these firms rely either heavily on equity financing from their parent companies or other companies in their business group, or have adopted a strategy of using services to finance product development (Arora *et al.* [2001]). In this paper, we have used equity capital as an indicator of input endowments in this respect. Beside these two major inputs, and access to infrastructure,[9] size and age profile are the other major inputs in the software production process. We have considered annual software revenues and exports (1997-98 to 2000-01) as measures of size. In the face of stiff competition in the Indian software industry, reputation is important in software market. Both age (Banerjee and Duflo [2000]) and exports (Shy [2000]) are acknowledged as important indicators for reputation, and so is the adoption of quality standards (Arora and Asundi [1999]).

Closely related to the factor inputs, and important contributors to production are the activities/strategies adopted by software companies. Indian software firms are widely diversified in their choice of activities/strategies, be that in the form of adoption of quality standards, or choice of activities (in terms of areas of specialization and application industries), export markets, and businesses (products, projects and services[10]) (Kattuman and Iyer [2001]). Adoption of quality standards has been an important strategy adopted by Indian software companies (Arora and Asundi [1999]). Arora and Asundi [1999] also find that adoption of quality standards is an important determinant of growth and productivity in the Indian software industry. Initially, ISO was the preferred quality certification in India, but the SEI CMM certification is popular now.

Similarly, these firms have shown substantial variation in the distribution of their areas of specialization and industries of application (D'Costa [2000]; Kattuman and Iyer [2001]). Kattuman and Iyer [2001] find that, while larger firms serve more industries as well as engage in larger technical portfolios (areas of specialization), a significant proportion of the smaller firms, though serving a lesser number of industries, have chosen to diversify their technical portfolios. Substantial variation is also evident in the orientation to markets, in terms of the export markets that the firms choose to serve, and in the choice of business (products, projects and services). In an earlier paper (Kattuman and Bhattacharjee [2001]) we have explored the effect of choice of activities/strategies in determining growth and market share in the Indian software industry. Here, we shall explore how far the distribution of these various strategies and activities has varied across the three classes of firms, and how such choices have impacted upon their output.

Probably, the output variable of the Indian software industry that has received most attention in the literature is productivity. The productivity of the industry (in US$ terms) is markedly lower compared to the ICT industries in other comparable export competitive economies (Arora *et al.* [2000]).[11] On the other hand, being an export competitive industry in an emerging market economy with low inter-industry linkages has enabled the Indian software industry to attain higher productivity, as compared with other domestic industries. The industry is also characterized by the incentives provided to employees to encourage higher productivity and possible innovations (Patibandla and Chandra [1998]). Unlike productivity, the Indian software industry has been comparable to its competitors (particularly, Israel and Ireland) in terms of growth and profitability. However, as Patibandla, Kapur and Petersen [2000] stress, the industry needs to increase its productivity through product innovations, in order to maintain high growth and profitability against a rising wage rate. Besides, while growth has so far largely been fueled by exports, maintenance of high growth in the industry is also contingent on being able to make domestic markets/demand grow (Patibandla, Kapur and Petersen [2000]). Again, while the revenues and exports of the industry are comparable by international standards, these have been driven by a higher share of low-skill export-oriented work (Heeks [1996]; D'Costa [2000]). Is the industry on the path toward higher productivity through product innovations? Who are the potential drivers in this direction? Are the domestic companies with foreign subsidiaries more likely

to carry the industry to a higher growth path, or are the foreign companies with software development centers in India more likely to take this role? How have growth and productivity translated into market shares for the different classes of firms? These are but some of the questions that our profile of differences between foreign software firms on the one hand and domestic firms (also, domestic firms with foreign subsidiaries) on the other will seek to address.

Tables 12.2A, 12.2B and 12.2C profile the cross-sectional distributions of usage of factor inputs, activities/strategies, and output measures respectively, for foreign firms, domestic firms and domestic firms with foreign subsidiaries, in the Indian software industry. The results indicate the input endowments of the three categories of firms, their positions of choice on the activity/strategy matrix, and the resultant distributions of their output parameters. The three categories display substantial differences in several features of their input usage, activities/strategies and output.

Table 12.2A: Cross-Sectional Variation in Firm Characteristics* — Factor Inputs

Parameters	Foreign firms	Domestic firms	Dom. firms having foreign subsidiaries
No. of companies	138	153	59
No. of employees, 2000 [Q1, Median, Q3]	298 (423) [42, 110, 396]	538 (1425) [55, 141, 340]	812 (1,436) [90, 262, 842]
Paid-up capital, 2000 [Q1, Median, Q3]	78 (129) [7, 35, 82]	131.2 (230) [22, 57, 132]	181.8 (206) [50, 100, 181]
Age (in years), 2001 [Q1, Median, Q3]	9 (5.4) [5, 7, 10]	12.3 (8.8) [6, 10, 15]	12.4 (6.4) [7, 12, 16]
Revenues, 97-98 (Rs.mn.)	199 (285)	446 (1251)	650(1,144)
Exports, 97-98 (Rs.mn.)	200 (261)	424 (1180)	518 (1,009)

Figures reported are sample averages (standard deviations in first brackets).
Quartiles and median are reported in square brackets.

Note * The data for Tables 2A, 2B and 2C are largely drawn from the NASSCOM Directory (NASSCOM [2000]), and supplemented with additional information from the India Infoline and Myiris investor information services, articles and special issues in several news dailies and magazines, as well as firm Websites. The distribution of activities/ strategies (Table 2B) pertain to March, 1998.

In terms of human and financial capital used, on the average, the domestic firms are substantially larger than their foreign counterparts;

domestic firms with foreign subsidiaries are the largest of the three groups. The medians, and first and third quartiles of the use of human and financial capital were also substantially higher for domestic companies. Similar observation holds also for the size (revenue and exports) and age (in years till 2001) of foreign and domestic firms. In terms of human and financial capital, thus, the foreign companies are worst endowed, while domestic firms with foreign subsidiaries are the best endowed. As far as the reputation implication of age goes (Banerjee and Duflo [2000]), the older domestic firms may be better off; on the other hand, reputation may not really be an issue for the subsidiaries of established foreign companies. It is not surprising then, that the Indian companies with foreign subsidiaries corner the highest share of the revenues and exports of Indian software firms. But, whether their production technologies compare favorably with the foreign companies, and whether they are higher on the learning curve and poised to make profitable investments in the high-end of the business will depend, to a large extent, on their position on the activity/strategy matrix.

Table 12.2B reflects several secular patterns and differences between the three categories of firms in their choice of position on the activity/strategy matrix. The preferences of foreign firms, domestic firms and domestic firms with foreign subsidiaries are almost the same, as regards application areas and areas of specialization (except that, domestic companies with foreign subsidiaries have a high degree of involvement in 'maintenance' as an area of specialization).

However, the portfolios of the domestic companies are considerably more diversified as compared to the foreign firms, in terms of the number of areas each firm specializes in, and the number of industries served by them. In this respect, the portfolios of the domestic companies with foreign subsidiaries are even more diversified. It would, thus, appear that the essential difference between the choices of foreign and domestic firms is in the degree of specialization versus diversification; domestic firms prefer a considerably more diverse portfolio. As compared with the foreign firms, a substantially higher percentage of domestic firms with foreign subsidiaries get quality certified; this may reflect, to some extent the necessity for these companies to acquire reputation. The choices of the domestic companies with foreign subsidiaries with respect to export markets and business areas are also considerably more diversified, as compared with the foreign firms. Even though, like the foreign firms, a majority of them operate in the US market, unlike the foreign firms,

almost an equal proportion of these domestic companies prefer to operate also in European markets.

Table 12.2B: Cross-Sectional Variation in Firm Characteristics — Activities/ Strategies

Parameters	Foreign firms	Domestic firms	Dom. Firms having foreign subsidiaries
No. of companies	138	153	59
Quality certified (No.), 1998			
ISO (percent of total)	50 (36)	64 (42)	30 (51)
CMM (ISO or CMM, percent of total)	21 (41)	23 (46)	14 (56)
Export markets, 1998-No. of companies (percent)			
US	109 (79)	133 (87)	55 (93)
Europe	91 (66)	118 (77)	53 (90)
Asia	87 (63)	112 (73)	46 (78)
Application areas, 1998 (percent of cos.)			
High	Web Appl. (61)	Web Appl. (73)	Manufacturing (85)
↓	Manufacturing (55)	Manufacturing (71)	Finance/Bkg. (85)
↓	Finance/Bkg. (51)	Finance/Bkg. (64)	Web Appl. (78)
↓	⋮	⋮	⋮
↓	Library Mgmt. (11)	Printing/ Pub. (17)	Library Mgmt. (19)
↓	Printing/ Pub. (11)	Defence (16)	Printing/ Pub. (14)
Low	Textiles (8)	Textiles (9)	Textiles (12)
Specialization, 1998 (percent of cos.)			
High	Web Technology (62)	Web Tech. (80)	Maintenance (85)
↓	S/W Prod. Dev. (55)	S/W Prod. Dev. (68)	Web Technology (83)
↓	E-Commerce (47)	E-Commerce (68)	S/W Prod. Dev. (76)
↓	⋮	⋮	⋮
↓	CD-ROM/Mult. (4)	CD-ROM/Mult. (13)	CD-ROM/Mult. (10)
↓	Data Processing (4)	Chip/Microproc.(10)	Games/Graphics (3)
Low	Games/Graphics (1)	Games/Graphics (3)	Chip/Microproc.(3)
Business areas, 1998 (percent of companies)			
Products	102 (74)	130 (85)	51 (86)
Projects	108 (78)	142 (93)	58 (98)
Services	94 (68)	135 (88)	53 (90)

Figures reported are number of companies.
Percentages of total number of firms are reported in square brackets.

Projects dominate the choice of business areas for all the three categories of firms. However, for foreign firms, the second choice is products, followed by services; for domestic companies, it is the other way round. Even so, a larger proportion of domestic firms prefer to work in product development than foreign companies. As suggested by Arora *et*

al. [2001], it is possible that these companies prefer to work in projects and services, in order to generate capital to plough back into their product development activities. This hypothesis also fits in well with the observation that 'maintenance' is the most preferred area of specialization for the domestic firms with foreign subsidiaries. In so far as working in high-end product development is associated with the highest degree of knowledge enhancement and innovations, it is encouraging that a comparatively high proportion of both domestic and foreign firms are engaged in this business activity.

Probably, the most significant difference in the cross-sectional profiles of output performance of Indian software firms is in productivity of these three categories of firms (Table 12.2C). The average productivity (revenue per software employee) of domestic firms is substantially higher (32 percent) than that of foreign firms, though the standard deviation is also high. The average productivity of the domestic companies with foreign subsidiaries is slightly higher than that of all the domestic companies.

While the average long-run growth rate (annual compounded growth rate, 2000-01 over 1997-98) is also significantly higher for domestic companies, the average growth rate of domestic companies with foreign subsidiaries is lower than that of the foreign firms. However, the cross-sectional distribution of growth rates for domestic companies has a thicker upper tail than that of the foreign companies, as evident from the substantially higher third quartile. The export intensity of foreign companies is higher, on an average, and the third quartile at 100 percent indicates that more than a quarter of these companies export 100 percent of their software products and services. Consequent to the higher revenues of the domestic companies, their market share is also higher; the market share of the domestic companies who have foreign subsidiaries is even higher.

On the basis of this profile, it would seem appropriate to conclude that the superior factor endowments of the domestic companies (particularly those with foreign subsidiaries), combined with their diversified positioning with respect to application industries and areas of specialization, and probably a higher focus on product development, have enabled them to perform better than their foreign owned counterparts, on the average. In particular, there is a 33 percent productivity gap in favor of the domestic companies with foreign subsidiaries vis-à-vis the foreign firms, on average. The question is, does this performance gap hold

Table 12.2C: Cross-Sectional Variation in Firm Characteristics — Output

Parameters	Foreign firms	Domestic firms	Dom. firms having foreign subsidiaries
No. of companies	138	153	59
Revenues (Rs.mn.)			
2000-01	809 (1,507)	1,498 (3,957)	2,348 (4,266)
[Q1, Median, Q3]	[90, 200, 726]	[100, 235, 825]	[150, 603, 2457]
1999-00	483 (822)	937 (2,486)	1,537 (2,581)
1998-99	316 (508)	650 (1,866)	1,029 (1,769)
1997-98	199 (285)	446 (1,251)	650 (1,144)
Exports (Rs.mn.)			
2000-01	741 (1,351)	1,258 (3,733)	1,921 (4,026)
[Q1, Median, Q3]	[78, 150, 647]	[57, 135, 611]	[80, 390, 1256]
1999-00	423 (756)	753 (2,238)	1,168 (2,336)
1998-99	304 (469)	602 (1,784)	817 (1,581)
1997-98	200 (261)	424 (1,180)	518 (1,009)
Long run gr. rate	85.8 (224)	103.5 (151)	79.8 (70)
[Q1, Median, Q3]	[26, 47, 85]	[39, 62, 105]	[39, 62, 107]
Exp. intensity, 99-00	88.2 (19)	65.2 (35)	71.4 (32)
Market share			
2000-01	0.21 (0.4)	0.40 (1.0)	0.62 (1.1)
[Q1, Median, Q3]	[0.02, 0.05, 0.21]	[0.02, 0.06, 0.18]	[0.03, 0.14, 0.68]
1999-00	0.20 (0.3)	0.38 (1.0)	0.63 (1.1)
1998-99	0.20 (0.3)	0.41 (1.2)	0.65 (1.1)
1997-98	0.20 (0.3)	0.44 (1.2)	0.65 (1.1)

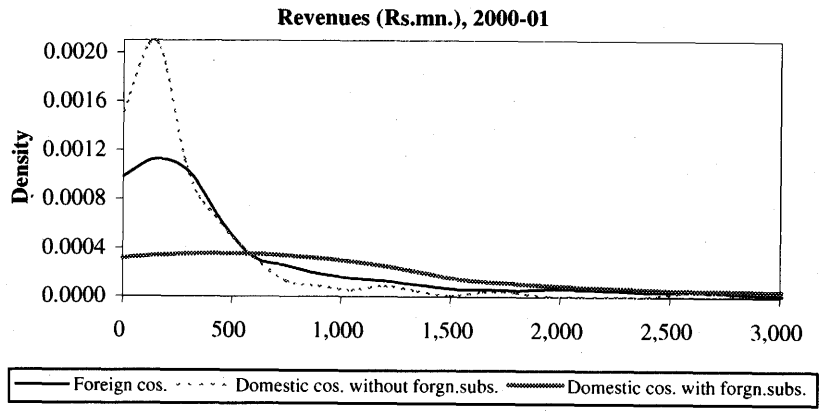
Figures reported are sample averages (standard deviations in first brackets).
Quartiles and median are reported in square brackets.

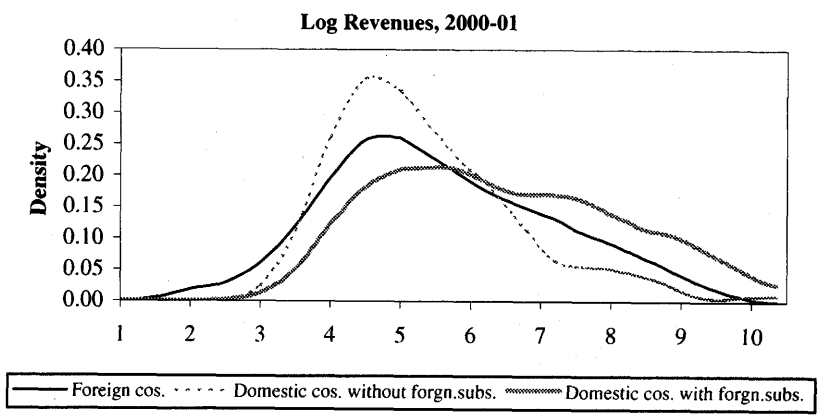
prospects for a move up the value chain?[12]

Further, as noted earlier, the variation amongst the domestic firms with foreign subsidiaries over the cross-section is considerably higher than that of the foreign companies. It is possible therefore, that within-industry dynamics may restrict substantial possibilities of learning and value-creation. To analyze this issue further, we explore the entire cross-sectional distributions of the output variables. Figure 12.2 displays kernel density estimates of the cross-sectional distributions, for foreign firms, domestic firms without foreign subsidiaries, and those with foreign subsidiaries, with respect to some of these variables where significant differences are profiled.

The density estimates of the output variables (particularly those relat-

Figure 12.2: Foreign Firms and Domestic Firms with and without Foreign Subsidiaries





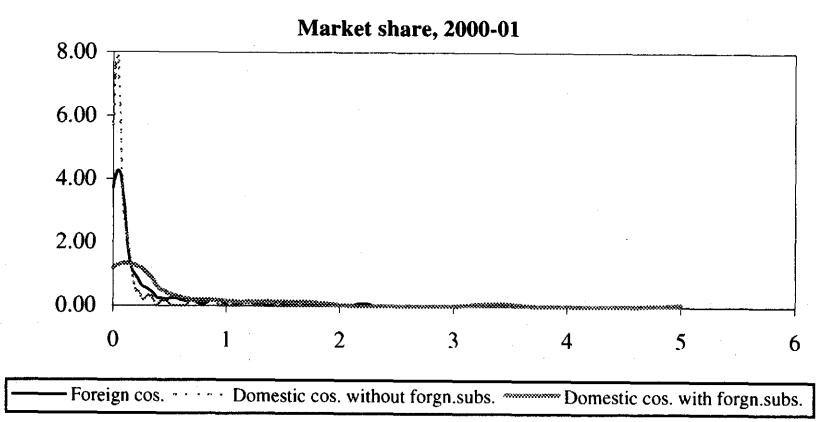
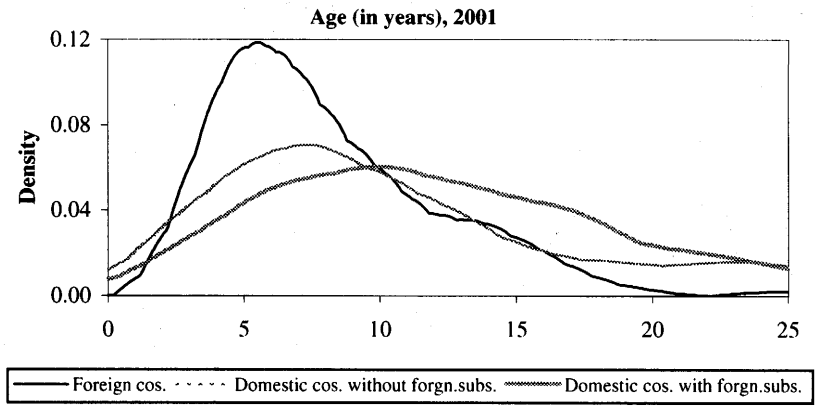
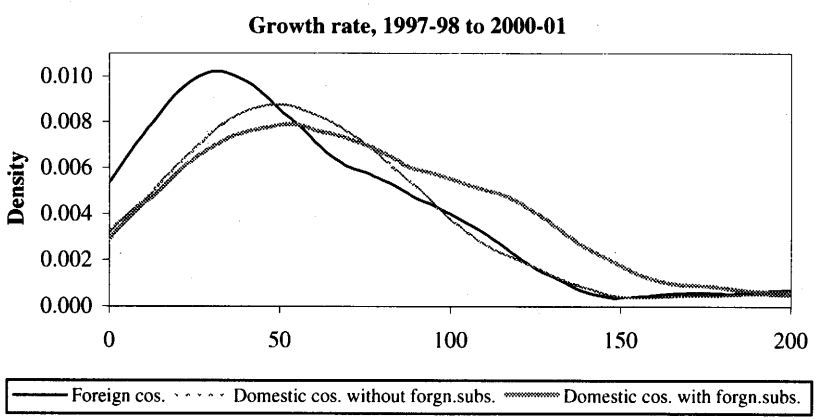
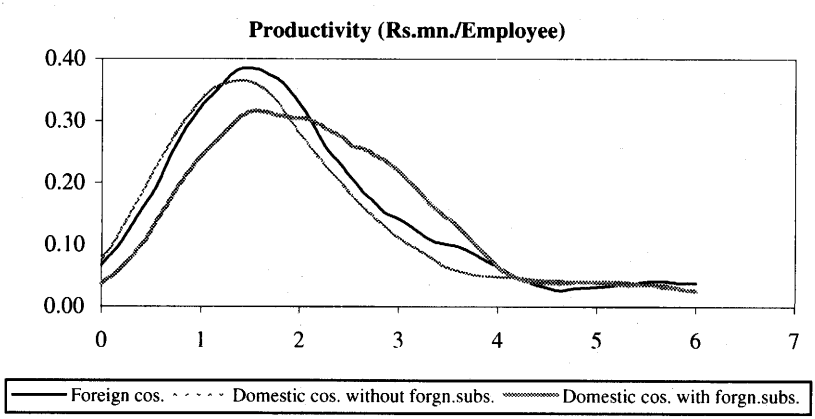


Figure 12.2 (continued)







ing to log-revenues, long-term growth rate and productivity) for domestic companies with foreign subsidiaries reflect a comparatively thicker upper tail, and probably a hint of bimodality.[13] This feature would appear to be the resultant of some of these firms tearing away from the mainstream and moving toward the high-end of the market. Probably, the move up the value chain for these companies is made possible through participating actively in accumulating tacit knowledge essential for increasing returns, through local collective learning at more established high-tech clusters around the world. If this were indeed true, this would be welcome news for the Indian software industry. How far this is indeed true will be clear in the near future.

4. CONCLUSIONS

Has the rise of IT as a general-purpose technology afforded more equal opportunities in development to developing countries such as India, at least those with large pools of human capital? We conclude with two points.

First, as Sutton [2001] points out, one of the most important handicaps that developing country firms face lies in the costs they face due to unhealthy regulation and corruption. Inefficiencies in infrastructure (power supply, communications) add to these. In most developing country industries, where firms draw inputs from other domestic firms, these costs are too high to be internationally competitive. One advantage of software as a sector is the virtual absence of backward linkages, making it possible to maintain the software industry as 'an island of competitiveness' notwithstanding the rest of the economy (Ghemawat and Patibandla [1997]).

Secondly, the central question in a view of development that places technology and knowledge center-stage is whether firms in poor countries have a route available to them to increase their learning capabilities and become dynamically efficient. In all production technologies there are natural hierarchies of capabilities, ranging from the simpler to the more difficult. Even in industries where international co-production is logistically feasible, the division of international labor specializes difficult, skill-intensive activities to advanced firms and high-wage workers in advanced country firms, and easier routine tasks to firms and workers in developing countries. The question is whether developing country firms can promote themselves in the value chain by leveraging their rela-

tionships with international high value firms.

In the context of the IT industry, where the nature of the product admits, more than in any other, conditions for a distributed production relationships between firms from developed and developing countries, there is a greater potential for firms to learn through continuous international interaction. But it is clear that the learning process bears more fruit when developing country firms also pursue a strategy of international location: we have presented evidence of the returns to Indian firms from promoting production subsidiaries abroad. The causality in this loop can run either-way and both: firms that locate production abroad may gain in productivity; the most productive firms may be the ones to locate production abroad. Either-way, these results underscore the importance and the rewards, in a knowledge intensive industry, of engaging in learning in the most proactive way.

Notes

[1] OECD [1997] reports that, average employee compensation in Asia in 1993 was only half that in Europe (and only a third or a fourth that of Europe in certain countries), and labor productivity in Asia was 73 percent that in Europe. On the other hand, the average annual growth rate was almost thrice as high as in Europe, and while in the early 1990s, profit ratios in Europe turned negative, the IT industry in Asia was registering moderate profitability around the same time.

[2] Ghemawat and Patibandla ([1997], [1999]) offer the hypothesis that prospering high-tech industries in LDCs that are international trade oriented contribute more to the domestic economy compared to inward-looking industry clusters. On the other hand there is also the problem of misallocation of human capital from other sectors of the economy (Balasubramanyam and Balasubramanyam [1997], [1998]).

[3] The argument in this section drows upon Sutton [2001].

[4] Sutton [2001] points to a 'low capability' trap and draws on the example of the Indian machine tools market, where most users find CNC machine tools uneconomical given the wage levels. Only if the general level of industrial development advances (with corresponding increase in wages, and costs of other factors of production, as well as incomes), will demand shift toward 'second generation' varieties. Producers may get trapped with obsolete technology unless they invest in new technology ahead of demand.

[5] Sutton distinguishes between two types of markets. In 'high tech' industries,

competition in 'capability building' will shake out all but a limited number of competitors. The key driver of competition is the degree to which products associated with different technical trajectories are good substitutes in demand. If the effectiveness of firms' investments is high, the number of viable firms in a competitive market will be small. Consequently, if entry in such an industry is high, not all firms will survive. This is the type of market where across all technical trajectories, or sub-markets, demand is substantially based on either a single criterion, or only a limited set of criteria (for example, CPU in a computer). A variant of such a market structure arises when the trajectories are linked strongly, not in terms of product substitutability in demand as in the above case, but from the supply side. Here, there are significant scope economies in capability building (advances in capability in one trajectory automatically enhances capability along another trajectory). This is particularly true of the information technology industry, the choice of technical trajectories (activities/strategies) in which, and the resultant impact on performance, will be analyzed in this paper.

[6] For example, the operating system for the 'network computer' introduced by Oracle is said to have been designed entirely in India (OECD [2000]).

[7] Bajpai and Shastri [1998] provide a classification of software specialization according to levels of skill/tacit knowledge required.

[8] Our sources included the NASSCOM directory (NASSCOM [2000]), the India Infoline and Myiris investor information services, articles and special issues in several news dailies and magazines, as well as firm Websites.

[9] Since the comparison is only within Indian companies, input endowments with respect to communication and other infrastructure may be more homogeneous.

[10] Software services have traditionally formed the backbone of the business (particularly export business) of Indian software firms. This trend could partly be due to the reluctance of overseas clients to have their software developed at far-away locations (D'Costa [2000]), and has been partly constrained by the availability of substantial capital required for software development (Arora *et al.* [2001]).

[11] In terms of revenues per employee, Arora *et al.* [2000] report that, while the Israeli and Irish software industries earn as much as US$100,000 per year per employee or more, firms in the Indian software industry earn only about US$15,000-$20,000.

[12] According to Patibandla, Kapur and Petersen [2000], a part of this competitive advantage derived from higher productivity may be wiped off, in time, by increases in labor cost. Patibandla and Chandra [1988], and Patibandla, Kapur

and Petersen [2000] feel that the road to the move up the value chain is to create appropriate employee management policies to further enhance productivity and reduce information asymmetries between employees and employer.

[13] Bimodality is often an indication that the population may be a mixture of two sub-populations, with well-separated sub-population modes. If the sub-population modes are not sufficiently separated, the overall distribution can be unimodal, but may have a characteristically drawn out modal region.

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