The Indian Software Industry

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Abstract

This paper reports on the results of research on the Indian software industry, carried out at Carnegie Mellon University. We use a variety of sources, including a questionnaire survey of Indian software firms, and field visits and interviews with industry participants, observers, and US based clients. The Indian software industry is remarkable in a number of respects. It is service rather than product oriented, heavily export oriented, and is largely managed by professional and entrepreneurial managements. Also, domestic market experience and expertise appears to have very little benefits for successful importers. Although the industry has grown in spectacular fashion, sustaining this performance will pose a number of challenges. In order to counteract the widely reported shortages of skilled software professionals and the possible competition from other low wage, human capital rich countries, Indian firms are trying to move up the value chain by acquiring deeper knowledge of business domains and management capability, and to reduce costs by developing superior methodologies and tools. Whether and how many firms will be a key test of the management skills and willingness to invest along a number of dimensions. From a social perspective, the disconnect between domestic and export markets is a major challenge, but one that the growing diffusion of computers and the improvement of the communication infrastructure should make easier to confront. In the end, the greatest impact the software industry is likely to have on the Indian economy is indirect, in its role as an exemplar of the new business organisational form and as an inspiration to other entrepreneurs.

1.   Introduction

Technological revolutions sometimes bring unexpected opportunities for countries. India, a relative laggard among developing countries in terms of economic growth, seems to have found such an opportunity in the information technology revolution as an increasingly favored location for customized software development. India's success at software has led to speculation about whether other developing countries can emulate its example, as well as whether this constitutes a competitive challenge to software industries in the developed world.

In this essay, we focus on the Indian software export sector. After briefly describing the main features of the industry, we analyze the major challenges it faces and its prospects for the future. We also briefly discuss the implications of the Indian experience for other developing regions and for software industries in the developed world. Our analysis is based on field visits to over 40 Indian firms in Bangalore, Bombay, Hyderabad and Delhi, where we interviewed nearly 75 senior managers and software professionals.[1] These interviews were loosely structured around a questionnaire that we developed in consultation with industry experts and were followed by interviews with fifteen U.S. based firms that had outsourced software development to these firms in India.[2] We complemented the field research with publicly available data on firms (NASSCOM, 1994-98), as well as information from a questionnaire survey administered to over a hundred Indian software exporters. Finally, we had brief structured interviews with 60 software development professionals in Indian firms to understand better where and how they are trained and the nature of the work they do.

In 1995, the global market for computer services was estimated by IDC[3] as being over $220 billion. Of this, a substantial fraction involved outsourcing of some part of the software development and maintenance process: Custom software development was estimated to be nearly $16 billion, systems integration at $32 billion, IT consulting at $11 billion and business service outsourcing at $9 billion.

A growing fraction of the outsourcing is taking place across national boundaries against a backdrop of shortages of skilled professionals in the developed countries. A study based on responses to a telephone survey of 532 companies with more than 100 employees concluded that there were an estimated 346,000 IT positions currently vacant in the U.S., in three core IT occupational clusters (programmers, systems analysts, computer scientists and engineers). In addition, there were another 240,000 vacancies in areas such as technical writing, training, and sales (ITAA, 1998).[4]

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[1] These companies were selected so as to cover various dimensions - firm size, product and service focused, subsidiaries, joint ventures and independent, domain specialists and generalists and private and public firms. We also interviewed about 18 industry professionals from US client firms.

[2] The questionnaire, along with other background information about the project and some of the outreach activities is available on the project website, at http://www.heinz.cmu.edu/project/india.

[3] International Data Corporation: a U.S based firm that deals with the dissemination of information on the IT industry worldwide.

[4] Other industry commentators have also linked the rise in offshore outsourcing to the shortage of software talent. Barr and Tessler, (1996 and 1998) claim that the shortage is part of a secular trend that had, in the past, been disguised by cuts in defence spending in the US between 1988 and 1993, that resulted in 75,000 programmers being laid off in Orange county alone. The shortage was further masked by downsizing in the IS departments of many major corporations. http://www-scip.stanford.edu/scip/avsgt/how1197.pdf.

The Indian software industry has attracted a disproportionate amount of interest as a source of software, given that its ~$4 billion software revenues in revenues in 1998-99 was a tiny fraction of the estimated world software market of over $300- 500 billion.[5] There are some compelling reasons, nonetheless, for the attention on India. The Indian software industry has captured a significant portion of the world trade in software services. One estimate suggests that India has 16% of the global market in customised software, and that more than 100 of the Fortune 500 had outsourced to India (Dataquest, 31 July, 96; pp 43-44). Perhaps most of impressive of all, the industry has grown at over 50% per year over the last five or six years, and if current trends persist, software exports may account for a full quarter of Indian exports within the next five years[6]. Tables 1a and 1b describe the growth in revenues and employment in the software industry.

Currently, software exports contribute to around 5 per cent of India's total exports. The industry association also indicated a target of garnering 23 per cent of customized software market and 5 per cent of products and packages market in the global IT economy by 2003. Nasscom also projects that software exports will constitute about 25 per cent of India's total exports by 2003.

These projections are likely to be excessively rosy.[7] The Indian software industry faces a number of challenges as the labor cost advantages diminish and competition from other countries with supplies of educated and underutilized workers increases. However, even if the projected goals are only partially achieved, the Indian software industry will still have achieved a substantial role in the world software industry, especially in customized software and software services. If the projected trends in demand for skilled workers hold, demographics alone should continue to ensure the survival and growth, albeit perhaps at a reduced rate, of the Indian software services industry.

The Indian success story has, for the most part, been a combination of resource endowments (created in part by a policy of substantial investments in higher education), a mixture of benign neglect and active encouragement from a normally intrusive government, and good timing. By the late 1980s, India was graduating approximately 150,000 English-speaking engineers and science graduates, with only a limited demand for their services from the rest of the economy. By the late 1980s as well, India's economic liberalization was also well under way. Around this time, the information technology revolution in the developed world had begun to take root and shortages of skilled programmers and IT professionals were beginning to develop. By this time a number of Indians were working in very substantial numbers in US firms. Some of them played an important, although as yet undocumented role, in bridging the gap and matching the buyers in the US with the suppliers in India. Responding quickly to the

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[5] One must note that this does not include the software developed by users themselves, nor does it include embedded software. This implies that the figure is an under-estimate. Indeed, the estimates of the size of the market are not very precise or reliable.

[6] To put things in perspective, the Indian industry sector grew at an average rate of 7.6 % while the service sector grew at an average rate of 8.2% over the same period. Source: A Report on the Indian Budget 1999-2000 Table 1.2a also at http://www.ieo.org/budget99/table_1_2a.html

[7] Indeed, in the early part of 1999 there has been a marked slowing down of demand for custom software development, enterprise software and supply chain management software. Coupled with reductions in spending on information technology in the financial sector, this has reduced the anticipated growth of most Indian software firms in the short run.

growing demand, a number of Indian firms arose in quick time. Contrary to its normal practice, the State encouraged this growth by considerably simplifying the process for obtaining the numerous clearances and permits that any firm in the organized sector in India typically needs.   Finally, given the many weaknesses in the Indian financial system, Indian entrepreneurs greatly benefited from the low levels of initial investment required to start a software services firm.

   Section 2 places the development of the Indian software industry in an international and historical context. Section 3 discusses the main features of the industry. Section 5 distills our findings on the supply of human capital, finance and infrastructure to the Indian software industry. Section 5 describes how software outsourcing to India is organized, and the following section tries to assess future prospects for the industry. Section 7 summarizes the discussion and concludes.

2. Background

2.1 Packages, Services and Custom developed software

   Software development can be broadly categorized into custom developed software and packages or generic software products. Customized software development involves close interaction between the development team and the end-user. Typically, software companies that provide customized software concentrate on particular vertical market segments or domain areas, like retail, banking, and manufacturing. The software developed is specific to those clients or domains. Software products may be targeted to a vertical segment or may cut across segments, but rarely to a specific user. In some cases, business software products, such as ERP packages that manage the flow of inputs, work in process and shipments in a company, are very large and complex. These require a great deal of customization before they can be used. Often, this customization is done by outside software consultants. Information technology consultants, such as Anderson Consulting, provide "solutions", which may involve some combination of custom developed software and commercial off-the-shelf software and hardware products.

   Software development involves a number of stages: Conceptualization, requirement analysis, high-level design, low-level design, coding, testing and support. These stages roughly correspond to stages described in the waterfall model of software development [8] (Fig. 1)(Royce 1970). The value added is typically greater in earlier stages of development – namely requirement analysis and high level design. Traditionally firms have designed the software in-house and outsourced the coding and support. However, increasingly, consulting firms are undertaking all stages of software development. As we discuss Indian software firms largely provide services rather than products. Further, Indian software exports consist largely of low-level design, coding, and maintenance services.

2.2 A historical perspective

   The Indian software industry consists of a large and growing number of firms: Using NASSCOM membership as a measure, the number of Indian software firms has grown from around 430 in 1996-97 to over 620 in 1997-98. Table 2 shows that many of

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[8] An alternate model of software development is the Spiral Model (Boehm, 1981).

these firms entered the industry during or just before the economic liberalization in 1991, and few have exited. A few big companies, with a large fringe of small and medium sized companies dominate the industry. According to NASSCOM figures, the top 25 companies accounted for 58.67 percent share of software exports revenue in 1997-98. Nearly one fourth of companies have sales of less than Rs.10 million (about $250,000).

The market leaders in the Indian software firms are, for the most part, relatively new themselves. What is more, with a few exceptions, notably Wipro and Satyam, these firms specialize in software alone. This is in marked contrast to early entrants into the industry, who had close links with computer hardware development. Heeks (1996, p. 69) notes that Tata Consultancy Services, (TCS) was the first firm to agree to export software in return for being able to import hardware, in 1974. TCS, currently the largest Indian software firm, employs around 9000 people.[9] Once software exports took off, a large number of firms entered the industry. Entry barriers were low because firms could start small, since initial investments required were fairly small, little more than office space and communication facilities. With the growing need for maintenance services many firms began by providing these services, often by sending software programmers to the client on a temporary basis.

The entrants were of two types. The first type were existing firms diversifying into software. These included computer hardware firms, such as HCL and Wipro, as well as firms with large in-house data processing and system integration capabilities such as Larsen & Tubro (LTITL). There were others such as BFL, Sonata, Satyam and Birla Horizons that were, before their metamorphosis as software firms, divisions of large and medium industrial groups.[10] The other type of entrants was new start-ups, such as PCS, Datamatics, Infosys and Silverline. Current managers at a large number of software firms worked in these companies earlier in their career. Indeed, one of the best-known software exporters, Infosys was founded by a group of seven PCS managers who broke away from PCS. Infosys's first contract was a support and maintenance contract with a client in the apparel industry for whom PCS had finished a large project.

Entry strategies varied and not all firms entered to provide software export services. Some firms entered to develop packaged or shrink wrapped products, as well products for specific industries or products such as enterprise resource planning products, but by the early to mid 1990s, software service exports increased greatly in importance. The result was a great deal of turnover among the leading software firms in India, as shown by the table 3 below. Over the last couple of years, signs of maturity are appearing. Although entry in the industry still appears to be strong, there are suggestions that the market leaders are beginning to identify niches and areas of specialization, in

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[9] Patni Computer Systems (PCS), a privately held firm, was another early entrant. It started with a data conversion project because India was seen as a cheap supply source at the time. However, steep import duties on computer equipment imports (including keyboards and CRT screens), as well as union regulations, caused much of data conversion work to be shifted to China and Taiwan. PCS also formed an alliance with Data General, a mainframe computer firm, whose equipment PCS marketed and for whom PCS also provided some programming services. This hardware tie-up is apparently typical of other older SW firms (e.g., TCS-Burroughs, TUL-Unisys, Hinditron-DEC, and Datamatics -Wang)

[10] In addition to these firms that focused on software exports, there were others that served domestic users, most notable Computer Maintenance Corporation, or CMC. Responsible for maintaining computer systems after IBM left India, CMC has grown to over 2000 employees and developed the ability to develop and implement large and complex projects, especially for infrastructure systems. CMC has also proved to be a good training ground for managers that would later be employed by other, private sector firms.

terms of technologies or functions, as well as vertical domains (industrial sector). More recently, a couple of Indian firms, BFL and IIS Infotech, have been acquired by a Dutch bank and a British software service company respectively. However, a major consolidation still appears to be some time away, in large measure because demand is still growing rapidly and economies of scale are relatively unimportant, particularly for low level coding and maintenance.

Contrary to popular belief, as table 4 shows, the industry is not concentrated in Bangalore, although Bangalore is certainly a very prominent location for firms in the industry. Instead, locations such as Bombay, Pune, Madras and Hyderabad are important as well. However, with the exception of the region around Delhi, there are no noticeable clusters in the northern or the eastern regions of India. The distribution of engineering colleges, concentrated in the western and southern regions, closely mirrors the distribution of the software industry. As table 5 shows, engineering colleges are heavily concentrated in these two regions, which also account for the greater part of employment in the Indian software industry.

2.3 The brief international comparison.

The Indian industry is comparable to that of the Irish and Israeli software industries in terms of revenues and exports. However, the level of earnings per software professional appears to be substantially below that in Israel and Ireland. All three, India, Ireland and Israel, have some common characteristics including an abundant supply of manpower from a highly educated, and relatively inexpensive, English speaking work force. Each country also has some special characteristics that have enabled it to emerge as significant players in the world software markets, albeit in different types of activities and domains. Table 6 shows the growth in exports and total revenues for the Israeli software industry. Israel has emerged as a source of entrepreneurial firms developing software *products* in areas such as security and anti-virus technology. There are about 300 software houses in Israel, employing nearly 20,000 people, with total revenue of over $1.5 billion. Many of these firms receive venture capital financing from the US and some are listed on the NASDAQ. A large fraction of the firms are engaged in developing software packages, often technically highly sophisticated, for export markets. Many of the world's largest computer companies including Microsoft, IBM, Digital, Hewlett Packard, National Semiconductor, Motorola and others have set up software development centers in Israel. IBM employs 300 scientists and engineers at its design facility in Haifa, while also in Haifa, Microsoft set up its first research and development facilities outside of the U.S. Motorola and National Semiconductor have major design centers in the country, while Intel is currently investing in its largest R&D center worldwide in Israel.

These features reflect the large number of technically skilled people with high entrepreneurial drive available in Israel. Reportedly, about 20% of Israel's population consists of those who arrived in the last five years. These immigrants doubled the number of technicians, engineers and scientists. Israel now has 135 engineers and technicians for every 10,000 people[11], compared with only 18 for the U.S (Economist, Feb 20, 1999, p 27.). And venture capital has flowed. There are said to be over 50 venture capital funds operating in Israel and more than $4 billion was invested in high technology start-ups in Israel in 1998.

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[11] India has around 40 engineers for every 10,000 people.

Table 7a and 7b provide data on the growth in exports, total revenues, firms and employment in the Irish software industry. The Irish industry employs over 18,000 people, with 1997 revenues of over $1.5 billion as well. The software sector comprises more than 600 companies, of which about a fifth are overseas firms. The relatively high degree of foreign ownership, particularly among the larger establishments is consistent with Ireland's emergence as a favored location for multinational firms. Apart from a relatively large, relatively inexpensive, English speaking workforce, the attractions of Ireland include a variety of tax incentives and Ireland's membership in the EU (convenient for exports to other EU countries). As one might expect, nearly 70% of Irish exports are to the EU, of which more than half are directed to the UK. Technology based sectors, notably electronics and software, and chemicals account for 43% and 25% of Irish exports. The Irish software industry develops software products as well as provides a variety of software development and support services. A few Irish software firms are listed on NASDAQ and almost all the ancillary/support companies are accredited to the highest international standards, such as ISO 9000. With some exceptions, however, the Irish software industry does not appear to be as innovative or entrepreneurial as Israel.

Note that India has the largest number of people working in the industry as well as apparently the highest rate of growth of revenue, but also the lowest revenues per employee. Whereas the Irish and Israeli firms appear to earn as much as $100,000 per employee or more, firms in the Indian software industry earn only about $15,000. This difference is intriguing, and a matter of some concern for managers and policy makers in India. The difference is particularly intriguing when comparing the Irish and Indian case. The Irish industry also appears to have a significant focus on software services and contract software development, somewhat similar to the Indian industry. Some of the difference may be due to the greater cultural similarity between Ireland and the US and Western Europe and the ability of Irish firms to operate in higher value added stages of the software development cycle. It may also be that the Irish software firms have been able to differentiate their services through domain or technological expertise, as compared to Indian firms, which have, until recently, been unable to distinguish themselves from their competitors.[12] If true, this would imply lower price cost margins, and hence, lower revenues per employee for Indian firms. The low revenue per employee figure for Indian firms suggests that their customers are able to capture a substantial fraction of the value generated from the outsourcing.[13]

3   Characteristics of the Indian Software Industry

The Indian software sector displays many unusual features from an Indian perspective. The most obvious one is its export orientation. Given India's size and history of inward development, most industries tend to be driven by the domestic market.

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[12] A part of the explanation lies in the extremely low rates for domestic software services, of the order of $10,000 per person. By comparison, the rates for domestic work in Ireland are likely to be considerably higher. Tax considerations may also have caused some firms to book revenues in Ireland that were generated elsewhere in Europe. The importance of such accounting practices in accounting for the apparent differences in rates is unclear.

[13] In related study, Arora and Asundi (1999) find that firms' efforts to differentiate themselves through ISO9001 quality certification are rewarded primarily through greater volume of sales rather than through higher price cost margins.

However, exports account for 65% of the total software revenue.[14] Not only that, software exports have grown somewhat faster than the domestic market, so that the share of exports has actually increased over time.

There are important qualitative differences between the export market and the domestic markets. The first relates to different types of software developed. Table 8, gives the composition of the domestic and export software development and services market. The domestic market has a higher proportion of revenues from the sale of software packages and products. Whereas products accounted for nearly 40% of the domestic market, they account for a little under 10% of exports. Over 80% of exports are software services including custom software development, consultancy and professional services. Even though the bulk of the product revenues in the domestic market are probably accounted for by imported software products, Indian firms have produced some moderately successful products, such as accounting packages and word processing packages in Indian languages, for the domestic markets. A number of medium-sized firms make products for the Indian and Middle East markets which are very specific to the business culture etc. In the area of ERP packages, a couple of firms are trying to compete with global giants like SAP, BAAN and PeopleSoft in the domestic market.

The second difference between the domestic and export sectors relates to the stages of software development as described earlier. Indian firms usually provide low-level design, coding and some types of testing services for export. For domestic clients the industry provides a wider range of services that usually spans the entire lifecycle of software development. Some of the domestic projects are much larger and more challenging than export projects, with the screen based trading system for the Bombay Stock Exchange and the Reservation System for Railways, both by executed by CMC, an experienced public sector firm, being two recent examples.

3.1 Domestic

In Table 8 we see that most of the firms operating in the domestic sector sell software products and packages. A large fraction of the domestic software industry consists of resale of software packages developed by foreign, principally US, firms, thus overstating the extent of software written for the domestic market. On the other hand, there is a great deal of in-house software written by users, especially large Indian firms that is not being captured by these figures.

A number of Indian software firms have also developed software packages aimed at the domestic market. However, with very few exceptions, these packages have not been very successful. A number of firms had targeted the domestic market for products and services in the late 1980s. Some produced packaged software products for the domestic market, including a word processing packages for Indian languages, while others focused on developing custom software for domestic clients. For the most part, these efforts were not very remunerative compared to the export market.[15] This points to

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[14] There are a couple of caveats to this observation. The domestic sector revenues include those from reselling imported software packages and therefore overstate the extent of software development in India for the domestic market. On the other hand, the figures exclude the possibly considerable amount of software developed in-house by users.

[15] There are a few exceptions, possibly the most noteworthy being a subsidiary of Citicorp, which has successfully exported its banking products to a large number of developing countries. Other firms have also targeted other developing countries as outlets for specialized products for the financial, banking and

the higher profitability of exports of software services compared to other types of software development and even firms that are product focused have added software services and consulting to fund product development (see also Udell 1993).

Although it is tempting to point to weak intellectual property rights as a culprit for the failure of Indian firms to develop successful packages, our interviews suggest that at least as important, if not more, has been the lack of experience, especially design and marketing experience, necessary to produce a successful product. In many cases, firms simply overestimated the willingness to pay and underestimated the difficulties of developing and supporting products. The reluctance of Indian users to pay large sums for software products has undoubtedly been very important, as has the slow rate of computerization of the Indian economy. Consequently, most of the established firms have turned to providing services for the export market.

Firms that have had domestic experience with consulting do not appear to derive any advantage from it in the export market. Given the simpler and more routine tasks involved in current software exports, the sophisticated capabilities and expertise that firms had developed from serving domestic customers have not been of great value to them in the export market. The CEO of a software subsidiary of a very large Indian engineering firm, explicitly noted that the considerable experience his firm had in executing large in-house software development projects was of limited use in exports.

> "As far as functional skills are concerned, these differ from country to country and client to client and there is a learning curve there. Domestic expertise may be useful in gaining technical expertise such as in coding and project management. However domestic and export projects are two different ball games."

3.2   Exports

As we have seen, Indian software exports consist primarily of software services. Further, although some of the leading firms are beginning to differentiate themselves from the rest, Indian software export firms are remarkably similar in terms of their activities. Thus the activities carried out by most firms in India are essentially maintenance tasks for applications on legacy systems such as IBM mainframe computers, development of small applications and enhancements for existing systems, migration to client-server systems, often referred to as porting or re-engineering. The Year 2000 (Y2K) problem has also opened a large market for firms that were traditionally doing mainframe based maintenance projects. Table 9, displaying results from our survey, shows that application solutions are the most common type of export, followed by reengineering (also called porting) and conversion projects, such as Y2K projects. Moreover, although Y2K projects were an important source of revenue, most of the leading Indian software firms have limited their dependence on such projects.

Managers at most of the US firms we interviewed agreed that the type of work outsourced was neither technologically very sophisticated nor critical to their business.[16]

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hospitality industry. Firms like TCS and Infosys have their own banking packages, which they have exported to other "commonwealth" countries with reasonable success.

[16] The managers at a leading electronics and telecom firm said they outsource work related to sophisticated but mature digital signal processing software to their Indian subsidiary. The telecom firms we interviewed outsourced domain related software maintenance or tool development for the maintenance or enhancement of existing applications. The manager at a value added telecom services firm said that they were outsourcing testing of their existing software and to some extent maintenance of their old UNIX based

Requirement analysis and high-level design is typically done either in-house or by US based consultants. However, smaller firms may rely more heavily upon their Indian suppliers, as was the case of a small firm developing medical software.

Not only is the work outsourced technologically undemanding, the projects are typically small. The mean number of man-months involved in the most important export project for firms that participated in our questionnaire survey is 510 man-months, whereas the median is only 150 man-months. Note that since the question related to the most important project, it implies that the typical export project is quite small, even for the large firms.

Table 10 shows that the US accounts for over half of all export revenues (58% in 1997-98), compared with 21% for Europe and 4% for Japan. Many of the larger US firms we interviewed are knowledgeable about outsourcing software development and the strengths and weaknesses of Indian software services firms. Some of these firms have also outsourced software development to firms based in other countries like the Ireland, Philippines, Russia and South Africa.

The US is not only a major market; competition from US based service providers is a major source of competition. Although competition from other countries such as Philippines and China is typically cited in the press, as tables 11a and 11b show, most software exporters indicate that their main competitors are located either in the US or in India itself. However, with few exceptions, most of the US based competitors are themselves firms that extensively recruit Indian software professionals. Only the largest of Indian firms could hope to compete against established US firms.

Many MNCs have set up liaison offices and subsidiaries as well. A number of them sought domestic partners. Initially, the partnerships were to sell the MNC products (both hardware and software packages). Increasingly, however, the objective is to use India as a place for software development as well, rather than merely as a place to sell. Some companies have established, or are in the process of doing so, software development centers in India, and are exporting packages or components of systems to other countries from India. The work being done at these development centers is fairly sophisticated. For instance, the operating system for the "network computer" introduced by Oracle is said to have been designed entirely in India. Similarly, the Texas Instrument R&D center in India is capable of fairly sophisticated work, including analogue chip design. Other prominent MNCs operating in India include Motorola, Siemens, Hughes Network, Computer Associates, Microsoft and Cadence.

As well, there are a number of US firms that have established large Indian operations. Firms such as Mastech, Information Management Resources (IMR), Syntel, Cognizant (a subsidiary of Dunn and Bradstreet) and CBSL use their India operations much in the way that Indians software export firms do, to tap a large pool of relatively cheap but skilled workforce for providing software services to US based clients. These firms are similar in many respects to the Indian software firms. Virtually all are headed by entrepreneurs of Indian origin, and started their existence, as did many of the leading Indian firms, by supplying software professionals such as programmers and analysts to

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software. However, we did find one exception to the idea that the outsourced projects are not mission-critical: A leading computer manufacturer out sources critical device-driver software that is shipped directly from the Indian vendor for distribution.

clients in the US. As Indian software exporters establish overseas subsidiaries, the distinction between the two will tend to diminish.

4.   Supply of Factor Inputs

4.1.1   Human Resources
It is widely believed that the key to the success of the Indian software exports is the supply of trained, low cost software professionals. Table 12 shows that estimated wage costs in India were about $1/3^{rd}$ to $1/5^{th}$ of the corresponding US levels for comparable work. Other estimates suggest that the difference is smaller, and that once all costs are factored in, the cost of software development is only ½ of US levels.

The size of the talent pool complements the cost advantage. In 1997, the total number of software professionals in India was estimated to be about 160,000 compared with 140,000 in the previous year, with a median age of 28.4 years (NASSCOM, 1998, p 69). Virtually all of these professionals have either engineering or computer science degree or a "Masters in Computer Applications (MCA)". India graduates about 155,000 engineers of various sorts, and another 200,000 diploma holders per year. About 60,000 of these enter the IT sector.

Most of the leading firms recruit either engineers or students with degrees in mathematics or science. Many also have in-house testing and training programs. Few of the firms we interviewed admitted to hiring graduates from private training institutes. However it would appear that some of the smaller and younger firms do hire graduates from these institutions, as do some domestic market focused firms. Responses to our questionnaire survey indicate that 80% of the software professionals employed had engineering degrees, while 12% had diplomas from private training institutes.[17] Though the Indian software industry tends to recruit primarily engineering graduates, the bulk of the work is relatively non-technical and requires mostly logical and methodical work and a familiarity with software development tools and languages. However, a large number of engineering and science professionals also had diplomas or certificates in software development from private training institutes. Given the large number of science and arts graduates, and the widespread availability of private training, the pool of potential software professionals is much larger than merely the engineering graduates. As one CEO we interviewed put it

> "Take somebody from a good college (any of the top 20 colleges in India), give him 3 months of orientation and they are ready to take up a programming assignment. *I don't need all these engineers …. but. I don't want to be branded by my customers as a guy who hires NIIT graduates*." (emphases added.)

However, software firms are reluctant to tap this pool because of the potential negative signals to their customers.[18]. This is a clear instance of a "race to the top" rather than a race to the bottom. With only limited market power, Indian software exporters, firms try to distinguish themselves from the competition by pointing to the quality of their processes and people, and when possible, their experience. Firms also have quality concerns. Managers we interviewed believe that an engineering education imparts a set

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[17] This is a simple average, unweighted by employment. The weighted average is likely to be
[18] U.S. visa restrictions are another reason why firms prefer engineering graduates.

of problem solving skills, methods of thinking logically and learning tools that help quick adaptation to changes in technology, domains and tasks. Since Indian firms provide services across a range of platforms and domains, this is an important asset. The CEO of a small firm developing innovative products stated: "*[B]ecause things are changing so fast in this industry, knowledge of a particular operating system, a particular language, a particular technology is not as important as the ability to learn and adapt to change.*"

The problem thus appears to be that relying upon engineering graduates alone is not capable of meeting the demand while students trained by private training institutes are not seen as being appropriate for export services. Thus, despite the apparently large stock of human capital in India, NASSCOM claims that by year 2000, demand will outstrip supply. The NASSCOM study projects an annual demand of about 75,000 by the year 2000. The tight labor market conditions are reflected in the 20% increase in wages and in attrition rates that are said to be nearly 20-25% for the industry[19]. We believe that demand already exceeds supply for experienced project managers. Many of our interviewees mentioned their difficulty in recruiting professionals with 4-6 years experience, even though nearly 40% of the workforce is reported to have 4-6 years experience. The loss, through immigration, of experienced software professionals to the U.S through the H-1B visa route is responsible for a substantial part of the shortfall.[20]. The entry of new firms exacerbates the demand for domain knowledge and managerial expertise. (Nidumolu and Goodman 1993).

Despite paying substantially above Indian standards, virtually all firms find it difficult to retain talented professionals. Virtually each of the over one hundred firms we surveyed mentions employee turnover and difficulty in attracting suitable employees as a major problem (Table 13). High rates of employee turnover constitute one of the most important challenges to the ability of Indian firms to progress beyond providing low-end software coding, development and maintenance services. Firms are responding to the problem of employee attrition in a number of ways. One popular way is by providing opportunities to work in the US. Many managers also stressed quality of life issues. Some firms stressed their ability to provide a career path for their employees, wherein they could move to being managers and would not have to remain programmers, apparently something valued by Indian professionals. Interestingly enough, few claimed to pay more than their competitors to attract and retain workers. A number of firms were actively considering stock options for their employees, something that few firms in India do, with Infosys being an important exception. However they faced some legal restrictions on their ability to use stock options to compensate employees. However, these restrictions have been eased somewhat over the last couple of years.

Some of the firms expressed the need to make the organization individual independent by addressing the loss of knowledge due to employee turnover. Thus one CEO told us that although, *"Our attrition is ... better than average…. It is difficult to retain segment [of the workforce with] 6-8 year's experience.   We are tackling this by making organization individual independent, and stressing training & process methodologies."* Our

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[19] A report published by the Export-Import Bank of India (1996) estimates that in order for the industry to grow at the rate of 50% annually, the number of software professionals involved in the software export sector has to grow at an annual rate of at least 30% over the next five years.

[20] Mr. Clyde Jones, Chief of Consular Services, U.S Consulate India estimates that around 30,000 H1-B visas were granted in 1999, mostly for software professionals (The Economic Times, 1999.) Chennai, (the only city in the south that has a U.S Consulate) reportedly accounted for 20,000 of these.

sense, however, was that efforts at insulating the organization from employee turnover are very much in their infancy, and firms are still very vulnerable to this problem. The loss of employees is especially severe among consultants (programmers and analysts) sent overseas to work onsite in the US, and our interviewees believe that a very substantial fraction quit within two years.[21]

The other part of the solution is on the supply side. As noted earlier there are a large number of students trained by private, training firms such as NIIT and Aptech, which has resulted in high profits and growth for these firms. Indeed, as table 14 shows, the training sector industry has grown along with the software industry, with total revenues in 1997-98 estimated at Rs 8.56 billion, about $225 million, up from Rs 6.6 billion the year before. Although nearly 90% of the revenues are from the individual training sector, corporate training is also growing rapidly.[22] While the general perception appears to be that such graduates are not well suited for software development, they appear to be well suited for tasks such as providing support and maintenance, for back office operations, and for a variety of IT enabled services such as medical transcription and claims processing for the insurance industry.

Furthermore, we did find evidence that some large and reputable firms had tie-ups for professional practice with graduates from private training institutes and frequently ended up recruiting these graduates. The increase in certification courses such as the Microsoft Certified Software Engineer/Developer (MCSE/D), Certified Novell Engineer (CNE), and IBM Net Professional certification should also help enlarge the pool of potential employees.

In addition, there are a number of public sector and industry initiatives to increase the supply of software professionals. The government has recently announced the establishment of Indian Institutes of Information Technology, along the lines of the well-known Indian Institutes of Technology. A number of engineering colleges have increased their emphasis on information technology and, in some cases, have started IT management programmes. A number of private sector, for profit, institutes providing graduate level education, such as a joint venture between the Mahindra Group and British Telecom to teach methods and techniques for software development, are coming online.

A potentially serious constraint on the ability to rapidly increase the output of trained software and computer engineers is the shortage of engineering doctorates being awarded in India. Recent data show that the PhDs awarded in engineering disciplines have fallen from their high of 675 in 1987 to 375 in 1995. Concurrently, the number of engineers with postgraduate training has also risen only slowly, from a little over 12,000 in 1987-89 to a little over 17,000 in 1990-92. Surveys of the IITs shows that a very large fraction of postgraduates enters the IT sector, in some cases as many as 90%! Although there are a substantial number of engineering doctorate holders of Indian origin working outside India, a long run solution will require an increase in the postgraduate research and training infrastructure.

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[21]   However, high turnover is also common in US software developers and in other service industries such as accountancy firms, and as the CEO of the rapidly growing software services firm put it-"*Paying a premium price for talented people. This is a worldwide phenomenon. ... I am not worried*"

[22] Many multinationals have started authorized training centers (ATC) that provide their own certified courses. These include IBM Global services, Oracle, Microsoft, Adobe, Cadence, Lotus, and Sony.

4.2 Finance

Software services, especially for export, are a very profitable business with good cash flows and limited requirements for up front investment. Therefore, finance is not a major problem for software service firms, unless a firm wishes to expand rapidly or wishes to expand overseas. Obtaining finance is, however, a major concern for firms developing software products.

Many of the firms we interviewed appeared to rely on equity financing as the primary source of capital although they had other diversified sources of finance such as loans and lease finance. Others relied upon financing from their parent firm or from business groups with which they were affiliated. 56% of the firms we surveyed indicated that they relied upon personal funds for startup finance.

The picture is very different for firms developing software products. In contrast to services, a substantial investment is required to develop the product, and even more to market the product. Firms that are trying to develop software products do face an acute problem of getting finance, in part because the inexperience and conservatism of Indian venture capital funds. A venture capitalist affiliated with a well-known Silicon Valley venture capital firm agreed with the view that venture financing in India for startups focusing on packaged products is limited. He indicated that for a variety of reasons having to do with tax laws, it is more efficient to make equity investments in a U.S firm rather than an Indian firm but to then have a wholly owned Indian subsidiary to make its financial reports in India and get tax exemptions. He also noted that most startups are funded by debt rather than equity. Therefore, having a service component to a product strategy made sense since services provide a relatively easy way of entering the market and gaining experience. Services also provide cash, which startups are unable to get from elsewhere. This venture capital fund has a portfolio of firms developing software products, registered abroad, but which is Indian insofar as their founders are Indian. These firms carry out a significant portion of the development work in India.

A manager for a venture fund run by a public sector investment bank noted that although they had invested in as many as 32 firms in the past, only 5 were product focused, the rest being software service firms focusing on exports. However, this venture capital operation no longer invests in startups. Instead, they fund expansion or new product development by existing firms with good track records, or by proven star managers in the industry. Funding investments are in the range of Rs.15 to 20 million ($400,000 to $500,000) but the firm can come back for more as soon as the financing is exhausted.

Given the problems in raising money and in tapping public equity markets, some firms have adopted a strategy of using services to finance product development. An interesting example is a firm started by an entrepreneur who had worked for many years in a large US software firm who was financing the venture himself, but was also using supplying software services to his earlier employer to generate revenue. A firm affiliated with a large banking group also used its earnings from its services business to fund product development.

The problem, it appears, is as much on the demand side as on the supply of venture capital. Venture capital funds associated with well-known Silicon Valley venture capitalists, such as Draper International, have only been able to use 60% of the allocated funds. In addition to the usual problems involved in setting up businesses in India,

venture capitalists are interested primarily in products developed for large markets, and therefore, for products that can succeed in the US. Developing products for the US market from India is widely thought to be very difficult. Table 13 shows that it does not appear that lack of venture capital is the major constraint for developing software products.

4.3   Communication and physical infrastructure

Good communication infrastructure is considered vital for the continued growth of the industry. This is most obviously the case in software service exports, and especially for offshore software development. Overall, the data communication infrastructure in India is expensive and in limited supply. It appears that the problem has a significant institutional component, with government agencies like the department of telecommunication and VSNL, until recently the sole ISP in India, unwilling to give up their stranglehold on telecommunications.

Some US based clients do find the slowness of the networks and the general problem with the communication infrastructure a major irritant.[23] However, as with finance, most firms consider the problem of communication infrastructure to be less important than the problem of finding and retaining qualified software professionals, and the problem of physical infrastructure such as roads and power. Rather, most Indian firms seemed quite content with what was available. Two inferences, quite different in implication, are possible. First, that communication infrastructure is adequate, or that firms have found ways around the high price and low availability constraint. The other is that the offshore component of the tasks being carried out in most Indian firms requires only limited communication so that the existing bandwidth is adequate. Consistent with the latter interpretation is that export projects are simple and small and reasonably easy to specify in detail in advance.[24] Clearly, the poor communication infrastructure has affected the diffusion of the Internet domestically, and through that, has discouraged the growth of new firms that could provide software services for and through the Internet.

5.   The Organization of Software Outsourcing to India

5.1   A typology of software exports

Software exports can be divided into three categories based on where software is developed and how the development is managed and organized. The first category is *onsite consultancy* or *onsite projects, where* the Indian company provides the US client with software professionals with the particular technical skills asked for by the client. These skills could vary from mainframe related software to specialist expertise in UNIX and WinNT platforms with JAVA programming skills. [25] In essence, the entire project is executed at the client's site. The client manages the project, controlling the deliverables and deadlines. The software is developed according to the client's processes and a more

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[23] The managers at one of the largest US software firms said that the connectivity to India was poor and the networks were very slow, making onsite presence almost a requirement.

[24] In late 1998, the government of India announced that a high bandwidth (2.5 gigabyte) fiber-optic backbone would be set up. This may open up many new possibilities, including a significant increase in the offshore component of software exports.

[25] A common term for some of these "onsite projects" is "body-shopping" wherein all that the client gets is programmers. There is no value-add in terms of accumulated knowledge/expertise.

accurate description would be to label these supply of staff augmentation services to overseas clients.

The second category of exports has a mix of work done offshore (i.e., in India) as well as onsite. In this model, the Indian company sends a few software professionals to the client's site for requirement analysis or training in a particular system. These professionals then bring back to India the specifications for the software and have a larger team develop the software offshore. If the project is large, a couple of Indian professionals remain at the customers site acting as liaisons between the project leaders offshore and the clients. Sometimes these onsite professionals are needed for emergency operations and for reassuring the client that the project is proceeding according to schedule. To execute such projects, a firm needs not only skilled professionals, but also a software development process and methodology, and an ability to manage software development. Unlike in onsite projects, the Indian firm provides technical and managerial expertise as well.

The third method of software export is in the form of an Offshore Development Center (ODC/OSDC). An Offshore Development Center[26] is a popular organization form especially for firms based in the U.S and Europe and who wish to take advantage of the skilled talent pool and lower wages in India. An offshore development center involves an umbrella contract with a long-term agreement on prices for time and materials (usually standardized on a man-hour basis). In this method of outsourcing, a large fraction of the project is executed offshore and the Indian firm is responsible for adherence to schedules for delivery. From time to time, the client sends projects to the center. For each project, the negotiations are largely restricted to the resources and time that will be required. In some cases, the place where the work is done is physically separate (from the rest of the Indian company) and secured. Many of the established Indian software firms will have more than one development center, and we interviewed firms that had five or six offshore development centers or more. Firms that have been outsourcing software to Indian firms for a long period prefer this form of organization since they are confident of the Indian firm's capabilities and rely on their processes for delivering software. Working together over time reduces the time for training as well as knowledge transfer[27].

From our survey (sample of 65 software export firms), we found that on average 42.7% of the total work was done offshore. The distinction between offshore and onsite work is important because billing rates differ considerably between the two. Our interviews suggest that one man-year of onsite work is billed at about $90,000-$100,000 while comparable offshore work is billed at $25,000-$35,000. The bulk of the difference is accounted for by the higher cost of living in the US, as well as greater overheads and communication costs. Offshore work is widely believed to be more profitable for the vendor. However, there are some important limits to the extent of offshore work. An important reason is the need for face-to-face communication. Another reason has to do with incentives: Since many projects are cost plus ("time and materials" is the term

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[26] See Gopal (1997) for a detailed description of the division of tasks within the offshore and onsite development context.

[27] "Knowledge transfer" is a term used by software professionals in India for the process where the professional visits the client site to understand sufficiently the problem specification so that he can bring back those specifications offshore to execute the project satisfactorily.

widely used in the industry), clients have to trust the supplier to not overcharge them (Gopal, 1996; Bannerjee and Duflo, 1998).

Fixed fee contracts involve greater risk taking by the vendor in contrast to cost plus or time and material contracts. With greater risk also comes greater control over the organization and management of work. Although systematic data are not available, the available evidence suggests a steady increase in the fixed price component of work. Bannerjee and Duflo (1998) present data from a sample of 236 contracts (not including offshore development center contracts) from 125 software companies. They find that 58% are fixed price contracts, while another 27% are "mixed". Only 15% of the contracts are pure time and material contracts. This tends to exaggerate the differences because the dynamic nature of software development results in changes in requirements and specifications, resulting in frequent time and cost over-runs, which are often shared between the Indian vendor and the overseas client. From Table 15 we see that 53% of the firms we surveyed indicated that their most important export project in the last 12 months was a cost plus contract. 42% of the firms had a fixed price contract for their most important export project. Interestingly, 32% of all the firms also claimed that their contract contained a penalty or incentive clause related to quality or schedule.

5.2   Nature and the evolution of export contracts

The process of selecting Indian firms to outsource work varies across firms. Often, an Indian employee of the client firm played a key role, as was the case at a leading software product firm – the Indian firms they outsource to had been founded by people who had worked for the US company earlier. In a couple of cases (a large retail firm, and a telecom services firm) the Indian vendors were recommended internally and chosen after an evaluation of their capability. Large established firms were typically more systematic. The project director of an airline obtained a list of 17 vendors from which they short-listed 7, and checked references for the final selection. The manager of outsourcing at a telecom firm interviewed 30 firms before finally choosing 4 firms. In one case (an insurance firm) the firm in India marketed themselves well enough to bag a contract.

Typically, the US firm begin by outsourcing a fairly small, and in some cases, redundant project to the Indian vendor, with the objective of gauging the capabilities of the vendor and assessing whether to proceed or not. Not only are the initial outsourced projects small, much of the work boils down to the Indian firm supplying software programmers to work onsite -- on the client site, and under the latter's supervision and management. Indian software firms that have progressed beyond this stage have typically taken care to provide well-trained and motivated professionals. They then persuade the client to allow some of the work to be done offshore, in India. The shift to offshore work requires substantial investment in physical infrastructure (including secure physical and computing infrastructure that some clients demand to protect their intellectual property). It also requires that the Indian firm be able to demonstrate the project management capabilities required to execute even small projects.

Among the US based clients we interviewed, the typical pattern was to have a person come over from Indian to pick up the problem specifications, and after doing

some preliminary work, take the work offshore and get it completed there. [28] Where work is executed offshore, weekly conference call meetings are held and a regular status report is submitted to ensure a smooth running of the operation. The telecom firms we interviewed have relatively greater experience in offshore outsourcing to India. Apart from having a vendor representative working onsite, they electronically transmit tasks and get most of the work done offshore. In contrast, managers at a large software product firm said that given the rapid pace and nature of product development, they mostly relied upon onsite work. In effect, they use their Indian vendors as a staff augmentation agency, while for the Indian firm, this is an opportunity to train its staff in the tools and methodology used at one of the largest software producers in the world.

5.3 US experience with software outsourcing to India

The most frequently cited reasons for outsourcing have to do with the shortage of skilled professionals in the US – Firms claim that they simply cannot find enough software professionals fast enough. In addition, firms outsource because they do not want to invest in in-house capability in areas outside their core-competence (such as developing applications for old computing platforms) and to free their in-house IT staff from mundane maintenance tasks for more creative projects. Firms engaged in developing software products emphasized the need for accelerating product development in the face of ever-shorter product lifecycles.

In some cases, US firms outsource to Indian firms to get access to more specialized engineering talent, particularly in the area of telecommunications. Other reasons include the option of round the clock operations and the ability of Indian vendors to assemble "functional" teams of engineers at a very short notice. One reason that we expected to hear, but frequently did not, was outsourcing to reduce costs. Many of the respondents downplayed this issue, insisting that cost was a relatively minor consideration. This appears to be a response to the prevailing concern in the US about the possible harm to US engineers from software outsourcing and inflow of foreign software programmers. It is also inconsistent with the extensive price competition that prevails in the Indian software industry.[29] Most of the US managers we interviewed commented on the excellent programming and coding skills available in India. They also noted that their Indian vendors were good and willing learners, and receptive to new ideas, and flexible in terms of the software and hardware platforms for which they provide services.

Our interviews with US firms also revealed a number of areas of dissatisfaction. Many of the interviewees thought that the Indian firms had no domain knowledge and poor management skills. Even a highly rated Indian subsidiary of a leading electronics and communication firm was considered 4-5 years behind the latest communication technologies. Most of the managers believed that that Indian firms could not work on

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[28] These include a large computer manufacturing firm, a large electronics and telecom firm and an insurance firm.

[29] For instance, one of the telecom firm we interviewed had an explicit strategy of having a low cost firm that is seen by industry participants as largely in the business of "bodyshopping" among its list of preferred vendors as a way of promoting competition and keeping prices down. This firm's policy was to ensure that its business accounted for a substantial (but less than 50%) share of the vendor's revenues and that no single vendor had more than 25% of its business. These policies ensured that it had considerable bargaining clout in the pricing negotiations with its Indian vendors.

high level specifications or project definition stages of a project, although for the most part, this belief had not been tested. Many were critical of the Indian system of promoting software programmers to managers based on seniority rather than on proven managerial ability. Interviewees felt that this weakened project management. Indian firms, on the other hand, cited this practice as a way of providing a career path to their professionals and a major part of their attempts to hold down employee attrition. Indian productivity levels are lower as well. For instance, managers at the electronics and telecom firm also mentioned that they found that they needed to assign more engineers to task in their Indian subsidiary than would be assigned in the US.

A very large fraction of the managers we interviewed considered employee attrition a big problem and wanted their Indian suppliers to tackle it quickly. Some of them recounted experiences where virtually the entire project team left after the first six months, causing substantial delays. A manager at one of the telecom firms that had had considerable experience with Indian software vendors spoke at some length about how frustrated he was with the apparent inability or unwillingness of Indian firms to move up the value chain. He claimed that his firm would like to be able to outsource more software design and development tasks to its Indian vendors. In particular, this firm would like its suppliers to display more initiative in identifying business problems that it faces and propose solutions. Even though this manager claimed to be willing to help the suppliers to acquire such capabilities, in his view, the suppliers were not responsive enough to this opportunity.

In addition, there were a number of cultural and political issues that US managers perceive as irritants or barriers. One such issue is the apparent unwillingness of Indian software professionals to point out potential problems up-front, and in general, an unwillingness to say no for fear of offending the clients. Another related weakness is the lack of familiarity of many Indian firms and professionals with the work culture and work norms in the West, and especially in the United States.[30] Other difficulties included resistance within the US to foreign programmers, poor telecommunication infrastructure, and the delays in obtaining the required visas for Indian programmers.

6.   Indian Software: Potential and Prospects

Supplying programmers or doing simple coding or code conversion does not require a great deal of knowledge about the customer's business domain or specialization in specific technologies. Lacking such expertise and experience, Indian firms have been willing to adapt to any new domain. The most important determinant of competitive success appears to have been the ability to provide trained software programmers at low cost upon demand. Table 16 shows that a large fraction of firms provides services for a large number of industries, including manufacturing, banking and insurance, retail and distribution, and transport. In addition, our field visits indicate that a number of large telecommunication firms are important customers for Indian software firms.

In addition to serving a number of industries, most firms also claim to provide services for most platforms. There has been a steady move from mainframe-based systems to open systems. Indian firms jumped onto the open systems bandwagon early in the history of open system and in the past few years most of the firms have gained

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[30] This includes the sideways movement of the head to indicate agreement, as opposed to the Western nod.

experience on Windows platforms and a few firms only provide services for Windows and NT platforms. However, the larger firms have projects that span most platforms and provide services on IBM mainframes, Unix Workstations and Windows NT platforms. The expertise levels of Indian firms on UNIX and WinNT platforms are considered to be on par with other US firms. Some Indian software firms are now beginning to specialize somewhat in order to build domain specific competencies. Others are focusing on building more generic competencies not related to industries but to technical areas related to software development such as networking, systems software, software tools and conversion and porting. The evidence suggests that some of the established firms are growing in their ability to handle larger and more complex projects than in the past. As US and European firms have become more experienced in outsourcing to India and better able to assess the capabilities of the Indian firms, they have been willing to let a greater fraction of the work be performed offshore. This saves money and economizes on scarce managerial resources. Further, there is evidence of long-term relationships. Of the firms we surveyed, over 93% said that their most important export contract involved work for a company they knew earlier or was part of an ongoing relationship with the client.

Though most of the export work is not technologically very sophisticated, we did find instances of some Indian firms writing device drivers for UNIX and PC based systems. Some of the larger firms like TCS and Wipro have research divisions. We also interviewed some smaller and less known firms that are trying to distinguish themselves from the pack by not providing the typical code conversion or porting services, and instead are trying to operate in specialized technical or industrial niches. Professionals in such firms are conversant with the latest technologies like OCXs, Internet based ActiveX controls, CORBA/DCOM based systems and Java based applications.[31] Since the advent of object oriented languages and Java, many firms have invested in training developers in these new areas. Some firms have started executing projects in Java and have shown a measure of expertise in these new platforms.

6.1   Business Strategy:

The existing software service exporters face two major challenges that are closely related. First, the difficulty in attracting and retaining talented software professionals, and second, the challenge of developing beyond competing on low costs alone in an environment with rapidly rising labor costs. As the CEO of the firm that had initially focussed on products for the domestic market but is now a leading software services exporter put it:

"[T]he value proposition in the outsourcing model we currently follow is that outsourcing, particularly, offshore outsourcing, is cost effective. We are leveraging that we have a technical resource pool, which is in short supply in most markets. … But that is not a sustainable model 7 years from now."

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[31] Recent news reports indicate that Wipro has developed semiconductor design cores for licensing in the US. Another licensing agreement involves Canon, which licensed the *Document Management Systems* technology of Newgen Software Technology for $2 million royalty for five years (Computers Today, March 1998). In the area of other systems software, there are firms (like Deldot Systems) working on networking software and Anti-Virus packages (like N&N Systems). However most of the firms working on the "niche" areas service the domestic market and do not have a significant presence abroad.

The most frequently cited reasons for the unsustainability of the present outsourcing model include rising wage costs and competition from other countries such as Philippines and China. The leading Indian firms have responded to this challenge either by trying to move to higher value added consulting by developing domain expertise or by developing proprietary software tools that can lower the cost of providing the service, offsetting the higher wage costs. These strategies are, of course, not mutually exclusive. Firms are moving up the value chain by accumulating knowledge about the industry segments for which they currently develop software.[32] This can be understood by re-visiting the software development (Fig 1). At present, Indian firms provide services for the lower portion of the waterfall model and "moving up the value chain" involves providing conceptualization, requirement analysis and design services as well. However, some believe that such a strategy, which ultimately involves getting involved in business process reengineering for overseas clients, is not feasible for Indian firms. The CEO of one such firm, a wholly owed subsidiary of a very large Indian engineering firm, believes that it is better remain a subcontractor to the established systems integration and IT consulting firms in the West.

"It is much better to piggy back on the Big Six who have large organizations, credibility and have done this [business process reengineering] for years. Better for us to do level two work on logical and physical systems … maybe the implementation part but onsite… (*Our parent firm*) has ES 9000s and IBM mainframes. It was the first firm to use IBM mainframes in India for a very long time … . We have the most qualified experts on IBM mainframes. So as far as legacy maintenance on IBM mainframes is considered we know the technology inside out. … (But) technology is not such a critical factor as compared to understanding business practices."

The better-established firms we interviewed, however, seemed to believe that they could successfully develop the ability and credibility for providing IT and business consulting services to clients worldwide. The first step in such a move up the value chain, namely requirements analysis and design, requires that one understand what the client wants and to translate that into a design for a software system. In turn, this requires both greater technical capability as well as greater knowledge about the business processes of the client. Thus, one CEO we interviewed spoke of getting his people to be able to talk in customer's vocabulary and not a developer's, or as he put it, "one needs the mindset of solution orientation and not development orientation."

Needless to say, this is easier said than done. Most of the larger firms believe that they have the experience, methodological maturity and managerial capability to make the transition, but that they need to add to their domain expertise and marketing ability. The high turnover in employees makes the accumulation of such expertise particularly challenging because the loss of each employee also implies the loss of experience and expertise accumulated by the employee.

Partly in response, firms are trying to embody some of their knowledge in software tools that a firm can use to provide better service to its clients, or reusable software code that has to be customized to the specific requirements of the client. For

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[32] One of them for example, wanted to, focus on vertical markets to move up the value chain using skills in Y2K and existing client-server skills for migration. It wanted to diversify its service focus by doing system software in order to capitalize on its core competencies-such as software development in application software. Some firms mentioned the need to diversify their growing businesses to other countries and markets to spread the risk. (Infac, 1998 p.p. 15)

instance, some firms have developed specialized tools that help them search more efficiently for the year 2000 or Y2K problem. Similarly, other firms are developing suites of tools that help them standardize and partially automate tasks such as porting software from one platform to another (such as from mainframes to UNIX workstations or Windows). Other firms have developed reusable code for e-commerce solutions.

Both strategies – accumulating domain knowledge and business expertise, and developing reusable code and tools – have promise. However, although many of the managers we interviewed mentioned these strategies, there was much less detail on how the strategy was to be implemented. For instance, a key to the strategy of building domain and business knowledge is the retention of experienced personnel. Only a couple of the firms we spoke with could articulate the concrete steps they had taken to retain their key executives. We did not find much evidence of other attempts to reduce dependence on people, such as by building a database of customers and prospective clients, or a database to capture experiences gained during export projects.

The point is that executing these strategies is not easy. Firms will have to invest a great deal in hiring, training and retaining their employees, in expanding overseas and establishing subsidiaries in countries such as the US and Western Europe, as well as in acquiring the technological and business expertise needed. Furthermore, such investments will have to be made for long periods, possibly well in advance of any return on the investments. As noted above, thus far Indian firms have been able to enjoy high profits without having to expose themselves to such risk. Thus, although most of the established firms have these strategies, relatively few are implementing these with any credibility.

Failure will imply that the firm will face increasing wage costs with relatively static billing rates (price per unit of effort). This will inhibit the firm's ability to attract talented professionals and retain them, reducing its attractiveness to overseas clients. When talking of failure, one must distinguish between the industry as a whole and individual firms. Although many, perhaps even most, of the established firms may fail to move up the value chain, the few that do succeed are likely to grow much larger and more prominent. These firms will also be able to execute large, complex projects on their own with little or no supervision from US clients. In time, they may even be able to anticipate the business needs of their clients and offer them solutions. These firms can acquire other Indian software firms (or their assets), or employ the latter as subcontractors.

Thus, not all (or even most) of the established firms need succeed for the Indian industry to successfully move to the next stage. However, at least of few of the established firms must. Else, they will have to give ground to lower cost competitors from China, Philippines and Eastern Europe. In this scenario, there is a real danger of the industry actually shrinking. Many of the clients outsource with a view to discovering the capabilities of their suppliers (the Indian software firm supplying the software development services) with a view to progressively increasing the number and complexity of the projects outsourced. If the supplier fails to meet the expectations, even the simpler projects may be taken away and given to other suppliers, who may be in other countries.

Although our focus here is on software exports, the software industry may also see growth from two other sources. One source is the growing potential of Internet

available services, such as medical transcription and call centers. After initial disappointments, a number of new product-focused firms have entered the industry. A couple have successfully attracted venture capital support and funding, a process in which Indians living and working in the US, particularly in the IT sector, have played an important role as investors and facilitators. Some of these product-focused firms have moved their headquarters and some of their operations to the US in order to be close to their potential customers and sources of finance, and many others are likely to follow suit. However, most continue to retain ties to India, including having development operations. As the domestic market grows, some firms may also produce products tailored to domestic users and export those products to other developing countries.

7. SUMMARY AND CONCLUSIONS:

The picture one gets of the Indian software services industry is a mixed one. On the one hand, there is a great deal of excitement, in its rapid growth and its export success. On the other hand, the kind of work being performed is fairly mundane with only limited potential for sustained growth. In the last couple of years, there is some evidence that the established Indian firms are maturing and growing in their ability to execute larger and more complex projects, as well as execute higher value added parts of such projects (such as requirement specification and high level design). The domestic markets provide far more challenging projects but the links between the domestic market and exports is, at present, very tenuous. There is little evidence for the idea that experience with complex domestic projects has had a high payoff in the export market or that the "learning to walk on two legs entry strategy"(Schware 1992) was being practiced by Indian firms. Indeed, many firms that began with a domestic market focus seem to have moved away towards less challenging but more lucrative export tasks. The sustained growth of the Indian economy over the last 4-5 years may increase the attraction of the domestic market but it seems likely that exports will continue to account for a large fraction of Indian software industry.

From the viewpoint of the US industry, the picture is also mixed. Insofar as the Indian figures imply that software development is being done very cheaply, US based clients benefit. Undoubtedly, this also helps keep wage growth of US software professionals in check, although none of the firms we interviewed would admit to this. It appears that US based software professionals (many of whom are of Indian origin) are being used in more productive ways with Indian programmers carrying out many of the more mundane and tedious tasks. The effects of any further restrictions upon H1B visas for Indian software professionals are likely to be quite complex. On the one hand, it will staunch the flow of experienced Indian software programmers, pushing up wages for US based software programmers. Visa restrictions will also favor offshore software development in the medium term, which will have the opposite effect on the wages of US software professionals. They are also likely to further push Indian firms to explore markets in Japan and Western Europe.

An increase in offshore software development will also benefit Indian firms investing in providing software development and consultancy services of various kinds. As some Indian software firms have noted, stricter visa restrictions will help with the drain of trained professionals to the US, holding down software wages and salaries in

India. Insofar as Indian firms succeed in developing the competencies required to increase productivity, their clients in the US and elsewhere are likely to benefit as well from an increased supply of such competencies. Some of this would be at the expense of mid-level to small consulting firms that currently provide services similar to those provided by Indian software firms at present or in the near future. In other words, our sense is that trade related restrictions (such as the H1B visa cap) are not the answer to the problem from the U.S perspective although such a cap would benefit Indian firms with large off-site facilities.

These observations are consistent with the other research in this area (e.g., Heeks, 1996, D'Costa 1998). Both of these authors have argued that the export orientation and routine tasks that exports involve have limited learning potential for Indian firms. Heeks has noted that the reported export revenues are misleading insofar as a substantial fraction of these are accounted for by onsite work, that in turn requires that a substantial fraction of the revenues be spent outside India. D'Costa has highlighted the limited potential for leapfrogging of most export-oriented activities in which Indian software firms are currently engaged. The responses by clients (self selected by the Indian firms) convey the sense that their Indian suppliers are competent (by and large) at providing a limited range of services but have not moved to where the suppliers offer solutions to client problems.

The solution that many Indian firms have offered has two components. First, they hope to use their existing links to acquire domain knowledge and knowledge about the businesses that their clients are in, and to use that knowledge to move up the value chain. In essence, they hope to become IT consultants offering business solutions. The second component is the creation of proprietary tools, methods and reusable software code that can be customized according to the clients' needs. This "productization" of what was formerly a service will, it is hoped, increase the revenue per employee and will counteract the increasing shortage of skilled software professionals and rising wages.

Success is far from assured. There are two critical factors. The first is the response of incumbent consultants, both of the traditional variety (e.g., Deloitte & Touche, Anderson Consultancy) as well as firms like IBM and Oracle that are developing large IT consultancy businesses. The incumbent consultants are likely to prevail in any direct competition but may not be willing to compete for the less lucrative and less familiar markets that the Indian firms are likely to target. The second critical factor is the ability of the Indian software firms to manage this transition. Although it is too early to tell, it is likely that a substantial fraction of the existing firms will fail to overcome the challenges. If the Indian software industry is to take the next step up successfully, it is vital that at least a few of the established firms succeed. These firms can act as the nucleus around which the industry can develop and mature.

However, our optimism about the beneficial impact of the Indian software industry on the Indian economy in the long run is not based entirely on the quantitative importance of the relatively smaller number of successes among software service exporters. We think that in the shadow of the much more prominent software services firms; we shall find firms developing a variety of new software products, components and technologies. Further, the software service firms are exemplars of organizational forms and practices that are relatively new to India. A large number of software firms are *de novo* startups, indicating that the supply of entrepreneurial talent appears to be

forthcoming when the opportunity arises, even in new and technology intensive sectors. These software firms are relatively flat organizations, with young management teams, informal but professional management styles, and with an emphasis on efficiency, punctuality and other virtues that an export orientation brings. Top managers of the leading software firms have been profiled in the popular press in India and are viewed favorably by many Indians, particularly in comparison to traditional Indian business leaders. Further, this industry has pioneered equity stakes and stock options for employees in India, and many of these companies are star performers on the Indian stock market. Thus, unlike in the past, the fruits of the success of the industry have been shared far more broadly. The implications of the success of this industry, at a time of slow but far ranging changes in the Indian economy, can be immense and far-reaching.

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Table 1a: India: Growth in Domestic, Export and Total Revenues

Year	Exports in $M	Domestic Revenue $M	Total $M
1993-94	330	227.9	557.9
1994-95	485	340.8	825.8
1995-96	734	515.4	1249.4
1996-97	1085	680.8	1765.8
1997-98	1800	900	2700
1998-99	2650	1250	3900
2000-01 (Est.)	*4000*	*2000*	*6000*

Source: Nasscom

Table 1b: India: manpower and Revenues/man-year

Year	Manpower	Rev/Employee ($)
1993-94	90000	6198.5
1994-95	118000	6998
1995-96	140000	8924.5
1996-97	160000	11036
1997-98 (Est.)	*180000*	*15000*

Source: Nasscom and CMU Software dataset

Table 2: Age distribution of Nasscom member firms in 1997 (n = 426)

Year of Establishment	Number	Age (years)
1980	31	19
1981-85	33	14-18
1986-1990	111	9-14
1991	27	8
1992	43	7

1993	31	6
1994	49	5
1995	38	4
1996	48	3
1997	15	2

Source: CMU Software dataset

Table 3: Top eight Indian software exporters

Rank 1980-81	1985-86	1989-90	1994-95	1997-98
1 TCS	TCS	TCS	TCS	TCS
2 TUL	TUL	TUL	TUL	Wipro
3 Computronics	PCS	COSL	Wipro	Tata Infotech
4 Shaw Wallace	Hindistron	Datamatics	Pentafour	Pentafour
5 Hinditron	Infosys	Texas Instruments (TI)	Infosys	Infosys
6 Indicos Systems	Datamatics	Digital (DEIL)	Silverline	Satyam
7 ORG	DCM DP	PCS	Fujitsu	Tata IBM
8 System	COSL	Mahindra-BT	Digital (DEIL)	CMC Ltd.

Source: Heeks (1996), page 89 for data up to 1994-95, and CMU Software Dataset for 1997-98

Table 4: Revenue distribution of Nasscom member firms (n = 405) by geographic region, in 1997

Region	Revenue ($M)	Number
Mumbai	539.8	86
Bangalore	323.6	84
New Delhi	152.9	72
Noida & Gurgaon	132.9	23
Chennai	130.9	34
Hyderabad	62	21
Pune	57.7	21
Calcutta	44.8	26
Gujarat	3.1	13
Kerala	1.4	7
Other	8.3	18

Source: CMU Software dataset

Table 5: Number and Capacity of Engineering Colleges in India, Approved up to 1998-99, by region.

Region	Number of Colleges	Sanctioned Capacity (# of students)	% of Sanctioned Capacity at Self-Financed Colleges
Central	50	9470	0.52
East	25	4812	0.26
North (incl. North-West)	140	25449	0.42
West	140	34165	0.74
South (incl. South –West)	308	82597	0.79
Total	663	156493	0.69

Source: Ramarao, 1998.

Table 6: Israel: Growth in Export and Total Revenues

Year	Exports ($M)	Total ($M)
1989	65	380
1990	89	450
1991	110	540
1992	135	600
1993	175	700
1994	220	800
1995	300	950
1996	400	1100
1997	540	1300
1998 (Est.)	*700*	*1500*

Source: Israeli Association of Software Houses, Israel

Table 7a: Ireland: Growth in Export and Total Revenues

Year	Exports ($M)	Total ($M)
1991	2266.3	2436.7
1993	2594.5	2805.7
1995	3959.3	4221.3
1997	5942.5	6283.3

Source: National Software Directorate, Ireland

Table 7b: Ireland: Employment and Number of Firms

Year	No. Of Firms	Total Employment
1991	365	7,793
1993	417	8,943
1995	483	11,784
1997	679	18,300

Source: National Software Directorate, Ireland

Table 8: Composition of Indian software development and services(domestic and exports)

Software Activity	Domestic Software (%)	Export Software (%)
Turnkey Projects	28.6	31.5
Professional Services	4.1	48.4
Products and Packages	52.0	8.8
Training	6.1	1.5
Support and Maintenance	3.2	3.0
IT Enabled services	6.0	6.8

Source: Nasscom

Table 9: Nature of Export Projects undertaken by Indian firms

Service	Number of Firms Providing Services for Export	Percentage
Network designing and engineering	19	20.4
Conversion project	25	26.9
System integration	22	23.7
Application solution software	71	76.3
System /Utility software	28	30.1
Application tools	22	23.7
Operation and network mgmt	7	7.5
Help desk operation	12	12.9
Datacentre management	12	12.9

Source: CMU Software dataset -- CMU Survey of the Indian Software Industry. N = 93

Table 10: Destination of Indian software exports, 1997-98

Destination Region	% of Export Revenues
USA	58
Europe	21
SE Asia	6
Japan	4
Australia & New Zealand	2
West Asia	2
Rest of the world	7

Source: Nasscom

Table 11a: Location of primary competitors of Indian software firms

Location of Competitors	Number of Firms	Percentage of firms
India	75	82%
Israel	12	13
Ireland	12	13
USA	58	63
Singapore	19	21
Philippines	6	7
Eastern Europe/ Russia	10	11

Source: CMU Software dataset -- CMU Survey of Indian Software Industry. N = 92

Table 11b: Perceived location of primary competitors

One of Top 3 locations

	Small	Medium	Large	%small	%medium	%large
India	39	21	15	81%	75%	94%
USA	27	17	14	56	61	88
Other countries	24	14	9	50	50	56
Total in category	48	28	16			

Source: CMU Software Dataset -- CMU Survey of Indian Software Industry. N = 92

Table 12: Software professionals: Comparative salaries, 1997

Designation	United States	India
	($ per annum)	($ per annum)
Programmer	32,500 - 39,000	2,200 - 2,900
System Analyst	46,000 - 57,500	8,200 - 10,700
Programmer Analyst	39,000 - 50,000	5,400 - 7,000
Network Administrator	36,000 - 55,000	15,700 - 19,200
Database Administrator	54,000 - 67,500	15,700 - 19,200
Help-desk Support Technician	25,000 - 35,500	5,400 - 7,000
Software Developer	49,000 - 67,500	15,700 - 19,200

Note:
1.   Converted at exchange rate of Rs. 41.50/US$.
2.   Figures are starting salaries for large establishments employing more than 50 software professionals. These could be marginally lower for smaller organisations. Salaries for a particular designation would vary due to factors such as educational and experience profile of the professional; platform of operation; nature of assignment (contract/full-time); location of the employer; and additional technical/professional certification.
Source: INFAC, Mumbai

Table 13: Major problems for Indian software firms.

Problem	export	domestic	Total
Manpower shortage/skills	57	32	89
Employee attrition	44	27	71
Physical Infrastructure	12	12	24
Commercial infrastructure	24	17	41
Quality certification	11	6	17
Visas	33	NA	33
Finance/ Capital	20	14	34
Marketing access	42	17	59
Lack of domestic computerization	6	21	27
Lack of government support	10	11	21
Tarrifs and other barriers	11	8	19

Note: The firms were asked to indicate their top three problems.

Source: CMU Software dataset -- CMU Survey of Indian Software Industry. N = 104

Table 14: Growth of the Training Sector

Training	1996-97 ($M)	1997-98 ($M)	Growth(%)
Corporate	11.67	21.43	84%
Individual	145.24	182.43	26
Total	156.81	203.86	30

Source: INFAC, Mumbai

Table 15: Fixed fee versus Time and Material export contracts

	All firms	Small (56 firms)	Medium (32 firms)	Large (14 firms)
Time and materials contract	53%	52%	53%	57%
Fixed fee contract	42	45	41	36
Firms that have had both	3	2	3	7
Other	2	2	3	0

Note: Respondents were asked about the nature of their most important export contract.

Source: CMU Software dataset - CMU Survey of Indian Software Industry. N = 102

Table 16: Industries served by Indian software exporters.

Domain Area	Number of Firms	Percentage of Firms
Banking	45	50%
Medical	23	25.6
Retail, Warehousing	47	52.2
Multimedia and Entertainment.	27	30
Education	23	25.6
Travel and Tourism	16	17.8
Manufacturing	46	51.1
Government related	22	24.4
Transport	27	30

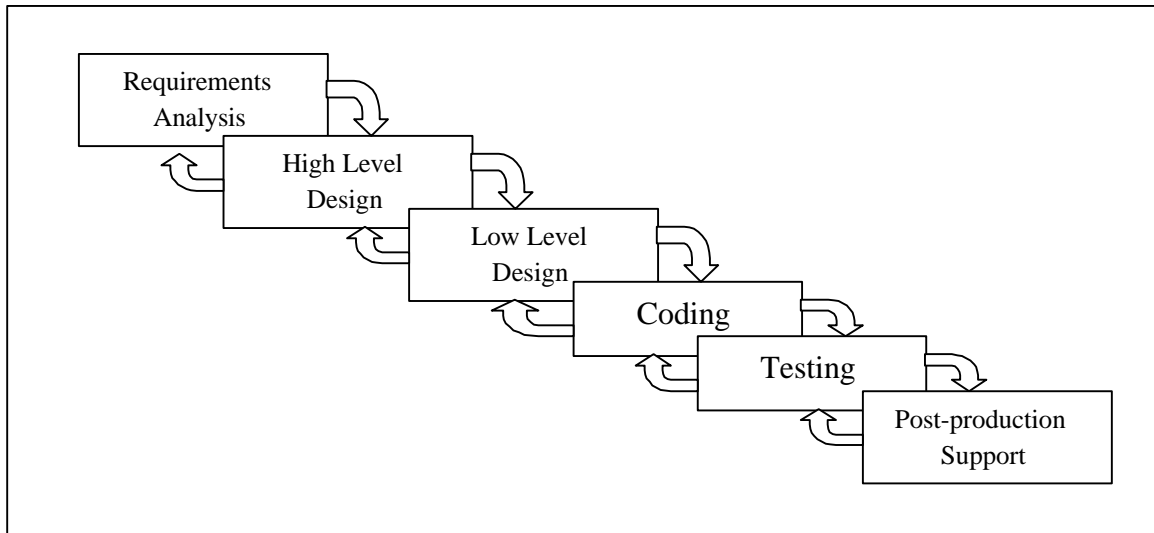Source: CMU Software dataset -- CMU Survey of Indian Software Industry. N = 90

Fig 1: The Waterfall Model of Software development