

# The Indian Software Industry

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**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 firms will succeed will depend critically on their 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 IT revolution as an increasingly favoured 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.<sup>1</sup> 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.<sup>2</sup> We complemented the field research with publicly available

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<sup>1</sup> Companies were selected to cover firms of varying size, product and service focused, subsidiaries, private and public firms. We also interviewed about 18 industry professionals from US client firms. For more details, see our working paper (Arora et al., 1999).

<sup>2</sup> 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>

data on firms (NASSCOM, 1994-98), as well as information from a questionnaire survey administered to over a hundred Indian software exporters.

The Indian software industry has attracted a disproportionate amount of interest as a source of software. Its \$4 billion software revenues in 1998-99 is just a tiny fraction of the estimated world software market of over \$300-500 billion.<sup>3</sup> 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<sup>4</sup>. Tables 1a and 1b describe the growth in revenues and employment in the software industry. The Indian software industry faces a number of challenges as the labour cost advantages diminish and competition from other countries with supplies of educated and under-utilized workers increases.

The Indian success story has, been a combination of resource endowments, 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 growing demand, a number of Indian firms arose in quick time. 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 4 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

Software development can be broadly categorized into custom developed software and packages or generic software products. Software companies providing customized software concentrate on particular vertical market segments or domain areas, like retail, banking, and manufacturing. Software products may be targeted to a vertical segment or may cut across segments, but rarely to a specific user. 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 (Fig. 1). The value added is typically greater in earlier stages of development – namely requirement analysis and high level design. 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.

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. Many of these firms entered the industry during or just before the economic liberalization in 1991.

The early entrants into the industry, 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. 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. There were others such as BFL, and Satyam that were, before their metamorphosis as software firms, divisions of large and medium industrial groups. The other type of entrants was new start-ups, such as PCS, Infosys and Silverline.

Entry strategies varied and not all firms entered to provide software export services. Contrary to popular belief, as Table 2 shows, the industry is not concentrated in Bangalore, although Bangalore is certainly a very prominent location for firms in the industry. 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,

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<sup>3</sup> 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.

<sup>4</sup> 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](http://www.ieo.org/budget99/table_1_2a.html)

closely mirrors the distribution of the software industry. As Table 3 shows, engineering colleges are heavily concentrated in these two regions, which also account for the greater part of employment in the Indian software industry.

### **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, accounting for 65% of the total software revenue. There are important qualitative differences between the export market and the domestic markets. The first relates to different types of software developed. Table 4, 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<sup>5</sup>, they account for a little under 10% of exports. Over 80% of exports are software services including custom software development, consultancy and professional services.

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*

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. 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.

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.

#### *3.2 Exports*

As we have seen, Indian software exports consist primarily of software services. 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. Table 5, 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. Although Y2K projects were an important source of revenue, most of the leading Indian software firms have limited their dependence on such projects. Table 6 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.

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. Requirement analysis and high-level design is typically done either in-house or by US based consultants.

The projects undertaken 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.

Although competition from other countries such as Philippines and China is typically cited in the press, as Table 7 shows, most software exporters indicate that their main competitors are located either in the US or in India itself.

Many MNCs have set up liaison offices and subsidiaries as well. 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.

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<sup>5</sup> 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.

## 4. Supply of Factor Inputs

### 4.1 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 8 shows that estimated wage costs in India were about 1/3<sup>rd</sup> to 1/5<sup>th</sup> of the corresponding US levels for comparable work. 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, (NASSCOM, 1998, p 69). 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. Responses to our questionnaire survey indicate that 80% of the software professionals employed had engineering degrees, while 12% had diplomas from private training institutes.<sup>6</sup>

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. Despite the apparently large stock of human capital in India, NASSCOM claims that by year 2000, demand will outstrip supply<sup>7</sup>. 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. 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.<sup>8</sup> 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. A very large fraction of the over one hundred firms we surveyed mentions employee turnover and difficulty in attracting suitable employees as a major problem (Table 9).

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.<sup>9</sup>

### 4.2 Finance, Communication and physical infrastructure

Software services, especially for export, are a very profitable business with good cash flows and limited investment up front. Therefore, finance is not a major problem for software service firms. 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. 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.

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. Developing products for the US market from India is widely thought to be very difficult. Table 9 shows that it does not appear that lack of venture capital is the major constraint for developing software products.

Good communication infrastructure is considered vital for the continued growth of the industry. 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. 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.<sup>10</sup>

<sup>6</sup> This is a simple average, unweighted by employment.

<sup>7</sup> 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.

<sup>8</sup> 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.

<sup>9</sup> In a related working paper, Arora and Fernandes (1999) analyse in greater detail the human resources situation in the Indian software industry.

<sup>10</sup> In late 1998, the government of India announced that a high bandwidth (2.5 gigabyte) fiber-optic backbone would be set up. This

## 5. The Organization of Software Outsourcing to India

### 5.1 A typology and evolution 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.<sup>11</sup>

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 customer's site acting as liaisons between the project leaders offshore and the clients. 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<sup>12</sup> 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 our survey (sample of 65 software export firms), we found that on average 42.7% of the total work was done offshore. The 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.

Fixed fee contracts involve greater risk taking by the vendor in contrast to cost plus or time and material contracts. From Table 10 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.

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.

Typically, the US firm begins 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. 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 typical pattern was to have a person come over from India to pick up the problem specifications, and after doing some preliminary work, take the work offshore and get it completed there.<sup>13</sup>

### 5.2 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.

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.

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may open up many new possibilities, including a significant increase in the offshore component of software exports.

<sup>11</sup> 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.

<sup>12</sup> See Gopal (1997) for a detailed description of the division of tasks within the offshore and onsite development context.

<sup>13</sup> These include a large computer manufacturing firm, a large electronics and telecom firm and an insurance firm.

Most of the managers believed that that Indian firms could not work on 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.

A very large fraction of the managers we interviewed considered employee attrition a big problem and wanted their Indian suppliers to tackle it quickly. 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.<sup>14</sup> 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. The expertise levels of Indian firms on UNIX and WinNT platforms are considered to be on par with other US firms. 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.

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. Firms are moving up the value chain by accumulating knowledge about the industry segments for which they currently develop software. 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 most Indian firms. 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 strategies of accumulating domain knowledge and business expertise are 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. 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.<sup>15</sup>

## 7. Summary and Conclusions

The rapid globalization of the software industry in recent years has focused a great deal of attention on India whose software industry is now a small but growing part of the international division of labor in software. Our study had two major objectives: To understand and describe the main features of the Indian software industry, especially its competencies and weaknesses; and to understand its links with the American software industry and with the American economy more generally.

The results of this research illuminate a number of issues related to the Indian software industry, confirming some impressionistic accounts but contradicting others. In particular, nearly two thirds of the revenues of the Indian software industry are from exports, with a much smaller domestic market. Indian software exports consist largely of low-end software development services. Given the tight labor market conditions in the US, especially for IT workers, the availability of software development services from India has been of substantial value to many large and medium sized US firms that have been able to free up their in-house IT staff for more valuable and creative projects. Moreover, although Y2K projects were an important source of revenue, most of the leading Indian software firms limited their dependence on such projects. Similarly, experienced engineers trained in IT are now in short supply in India as well, impeding the ability of Indian software firms to offer high-end services. Consequently, the structure of the industry is likely to remain unchanged in the next 3-5 years, even as it continues to grow at a fairly rapid rate.

From the perspective of the US industry and economy, our most important conclusion is that the Indian industry is largely complementary to the US industry. Indian firms compete with US firms providing low-end software development

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<sup>14</sup> This includes the sideways movement of the head to indicate agreement, as opposed to the Western nod.

<sup>15</sup> Although our focus here is on software exports, the software industry may also see growth from other sources, including software products and more likely, Internet available services, such as medical transcription and call centers.

and maintenance services. However, many of these US firms rely on Indian programmers as well and have significant India based operations. Further, US firms are likely to increase their involvement with India, both through outsourcing and through directly setting up subsidiaries and software development centers in India.

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.

Our 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. 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.

Indian firms 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. Another hope is to create 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. 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 in the above task. These firms can act as the nucleus around which the industry can develop and mature.

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 1: India: Growth in Domestic, Export and Total Revenues, Manpower and Revenue per Employee**

Year	Exports in \$M	Domestic Revenue \$M	Total \$M	Manpower	Rev/Employee (\$)
1993-94	330	227.9	557.9	90,000	6198.5
1994-95	485	340.8	825.8	118,000	6998
1995-96	734	515.4	1249.4	140,000	8924.5
1996-97	1085	680.8	1765.8	160,000	11036
1997-98	1800	900	2700	180,000	15000
1998-99	2650	1250	3900	200,000	19,500
2000-01 (Est.)	4000	2000	6000	250,000	24,000

Source: Nasscom and CMU Software Dataset

**Table 2: 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
Other	115.3	85

Source: CMU Software dataset

**Table 3: 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 4: 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 5: Nature of Export Projects undertaken by Indian firms**

Service for Export	No. of Firms Providing Services	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 6: 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 7: 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 8: Software professionals: Comparative salaries, 1997**

Designation	United States (\$ per annum)	India (\$ 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:

Converted at exchange rate of Rs. 41.50/US\$.

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 9: Major problems for Indian software firms.**

Problem	Export	Domestic
Manpower shortage/skills	57	32
Employee attrition	44	27
Physical Infrastructure	12	12
Commercial infrastructure	24	17
Quality certification	11	6
Visas	33	NA
Finance/ Capital	20	14
Marketing access	42	17
Lack of domestic computerization	6	21
Lack of government support	10	11
Tariffs and other barriers	11	8

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

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

**Table 10: 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

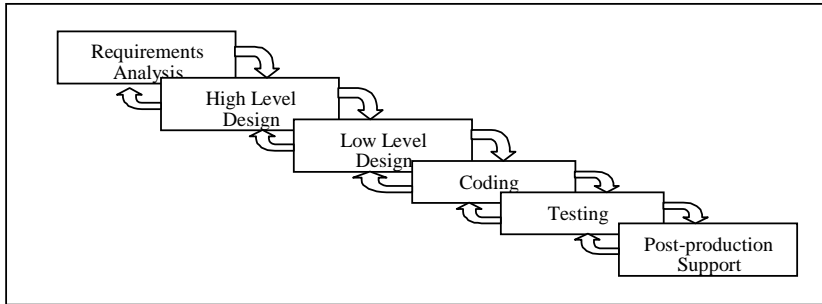


Fig 1: The Waterfall Model of Software development, Royce 1970