The Indian Software Industry And Its Prospects

Ashish Arora
The Heinz School of Public Policy and Management
Carnegie Mellon University

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I. INTRODUCTION.

India's emergence as a major exporter of software services in less than a decade and a half has excited debate about the causes of its success and ignited hopes for similar success in other industries. The subsequent growth of exports of other business services appears to validate the belief of some observers (including myself) that India's software success would have broader benefits for the Indian economy.

Despite this, there is a perennial undercurrent of concern about the prospects of the Indian software industry. The causes for concern are not difficult to find. Wages for software professionals have consistently risen year over year and employee attrition remains a persistent problem for companies. Indian exports continue to be mostly services with a modest technology content and there is little evidence of successful product development. Add to these the ever present possibility of China (or Eastern Europe or the Philippines) emerging as potent rivals, and there is much to be concerned about.

In this paper, I shall briefly describe its growth and evolution. Next, I shall identify the major factors that contributed to its success, and some possible ones that were not important. The prospects of the industry are next and in this context I shall summarize the available evidence on the extent to which India and Indian firms are participating in software innovation. This will lead to an assessment of whether the industry has and can provide higher value added products and services. Finally, I shall comment on the direct and indirect impacts on the Indian economy.

II. The Software Value Chain And Indian Exports

As is by now well known, software production and exports from India have grown rapidly, particularly since the early 1990s. The most often used source, the Indian software industry association, NASSCOM, estimates indicate that software service exports (including the category of engineering services and R&D, and software products) in 2005 was about $13 billion.

In 1996, the time when I first became interested in the Indian software sector, this seemed fantastic, in the original sense of the word. At that time, Indian exports were barely $1 billion, and though the future looked bright, a number of concerns were already being bruited about by knowledgeable observers and industry participants themselves. These included the shortage of skilled workers ("software professionals"), the terribly deficient physical infrastructure, potential competition from China and the Philippines, the development of automated tools that would substitute for the lower end of software services provided by India, and the apparent unwillingness or inability of Indian software firms to move beyond leveraging access to lower cost workers. Together, this potent mix of forces was seen as threatening the future of the industry. The prescriptions for the malaise were also clear: firms had to "move up the value chain" by developing proprietary products, and by providing more technology intensive services. Innovation was the watchword, and implicitly, most understood this to refer to new technologies or new products.

For the most part, the prescriptions have not been followed. The shortage of workers is said to loom as large as ever, the infrastructure has improved only modestly, and there are few Indian software products on the world markets. And yet, exports have increased about thirteen fold, and an entirely new sector of related business services, with revenues of about $4.5 billion, has emerged. The domestic software market has also grown, albeit more slowly, and the size of the Indian software industry is over $20 billion. This growth has enabled the industry to overtake Brazil, whose industry was of comparable size in 2001, but in 2005, at $10-12 billion, is substantially smaller.

To understand this astonishing story, we need to take a detour to understand the software sector itself.[1] Contrary to popular belief, software products such as word-processing software, accounting software or email software are not the dominant part of the industry. Rather, the bulk of the value added, and the bulk of employment, in software is generated in customizing these products, maintaining them, adding functionality, and making these products work with existing products already in use. Some, but not all, of this activity is performed by firms classified as software firms. Software using firms, which include the vast preponderance of all firms of any size in advanced economies, are responsible for a substantial part as well.

One can distinguish three sets of value adding activities in software. First, there are design and development activities, which encompass all of what one would traditionally define as software products, such as word processors, operating systems, enterprise software such as Enterprise Resource Planning (ERP) and business intelligence software, as well as middleware software products, such as some transaction processing middleware and enterprise application integration. The total value of production in the software product industry was about $61 billion

[1] The next few paragraphs draw upon Arora, Foreman and Yoon, 2006.

in 1997, employing about 240 thousand.[2] Firms that operate in this value chain include all of the well-recognized names that are traditionally regarded as "software" firms, including Microsoft, Adobe, Oracle, and SAS. [3]

Quantitatively more significant is the set of firms involved in custom programming and software analysis and design for clients, including the custom development of software products (also called “bespoke software products”). The total value created by these firms was about $115 billion in 1997 while total employment was about 1million, indicating that both revenue and employment are greater than that in the packaged software industry. [4]

The third set of actors involved in software is the users themselves. Even if one confines oneself to the activity of professional programmers and software designers employed by IT-using firms, (and ignores programming activities performed by others in IT-using organizations), the monetary value of this user based activity, though difficult to estimate precisely, is very significant. Occupation data from the US indicates that over two thirds of software professionals do not work for IT firms but instead work for IT using industries. Data from the Bureau of Labor Statistics (BLS) for 2001 indicate that about 3.8 million people were working in computer and software related occupations (including hardware designers, programmers, systems analysts, software architects and computer scientists), of which 72,000 worked in the computer equipment industry, about 1 million worked in the computer and software services sector, with the remaining 2.8 million working in the rest of the economy. Figure 1, which shows the intensity of software occupations by state for the United States, reflects this. Employment in software related occupations is geographically dispersed, rarely exceeding 3% of employment, but also rarely below 1%.

To summarize, software as an activity is widespread, roughly proportional to overall economic activity in a region. Since the leading software firms are regionally more concentrated, it must be that large part of value creation in software takes place outside of firms that comprise

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[2] Source: US Bureau of Economic Analysis Input-Output Tables. This figure includes the total value of products made in NIPA industry 511200 (Software Publishers). 1997 is the latest benchmark year for the Input-Output tables. More recent years do not separate software producers from other information publishers.

[3] Source: Bureau of Labor Statistics (BLS) data on the number of employees in software publishing industry, available at http://www.bls.gov/ces/home.htm.

[4] These calculations are based on total sales in custom computer programming services (NAICS 541511) and computer systems design services (NAICS 541512). This latter category may include activities outside of programming, such as IT systems design and integration. A conservative estimate of the value and employment of third party custom programming services uses only NAICS 541511, and yields and estimate of $86,326.8 million and 522.3 thousand, respectively.

the software industry. The value of this activity goes largely unmeasured in traditional government statistics, but it is these activities with which Indian software services initially competed, and to a considerable extent, this remains true even today. Simply put, Indian software exports were substituting for the in-house software activities of firms that use software intensively, such as banks, financial institutions, insurance, and telecommunications.

Figure 1: U.S. Software Employment as a Share of Total Employment by State, 2001

Data Source: BLS, 20(

Two other countries that have also emerged as software exporters, Ireland and Israel, have targeted a different segment than India. Ireland is host to multinationals localizing their products, plus a few innovative companies with globally competitive products, along with a host of tiny companies focused on local demand. Israel boasts a number of technology based start ups, and a few that have grown into large firms, all now with headquarters in America and R&D operations in Israel. Both Israeli and Irish software exports stumbled after the dot com bubble burst in 2000-2001 and their growth appears to have been slower ever since.

III. A Brief History

As table 1 clearly shows, the bulk of the software exports are accounted for by software services. These are a mixture of different types of activities. Indian software exports started as Indian firms "rented out" programmers to the American clients, by sending them to work for the client, typically in America itself. Athreye (2005b) claims that this model of "on-site" work, pioneered by TCS, was rapidly emulated by other firms that entered the industry in the early

1980s.[5] These entrants were of two types. There were start-ups, such as PCS (now Patni), Datamatics, and later, Infosys and Silverline, some of whom were spawned by incumbents. The second type of entrants consisted of existing firms diversifying into software, including 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 & Toubro. Others such as BFL, Sonata, Satyam and Birla Horizons began as divisions of industrial groups.

Table1: Indian IT Industry-Sector-wise break-up

USD billion	FY 2004	FY 2005	FY 2006E
IT Services	**10.4**	**13.5**	**17.5**
-Exports	7.3	10.0	13.2
-Domestic	3.1	3.5	4.3
ITES-BPO	**3.4**	**5.2**	**7.2**
-Exports	3.1	4.6	6.3
-Domestic	0.3	0.6	0.9
Engineering Services and R&D, Software Products	**2.9**	**3.9**	**4.8**
-Exports	2.5	3.1	3.9
-Domestic	0.4	0.7	0.9
Total Software and Services Revenues	**16.7**	**22.6**	**29.5**
Of which, exports are	*12.9*	*17.7*	*23.4*
Hardware	**5.0**	**5.9**	**6.9**
Total IT Industry (including Hardware)	**21.6**	**28.4**	**36.3**

Source: Nasscom (IT factsheet), www.nasscom.org (accessed 18 Sept 2006)

America based startups, such as Mastech (now IGate), Information Management Resources (IMR), Syntel, and CBSL (now Covansys), following in the footsteps of companies like Patni and Datamatics, were started by entrepreneurs of Indian origin.[6] They used their India operations much in the way that Indians software export firms did, to tap a large pool of relatively cheap but skilled workforce. For understandable reasons, they were slower in developing management capability in India. Perhaps as a result, these firms have not ascended

[5] 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 developed the ability to develop and implement large and complex projects, especially for infrastructure systems. CMC also proved to be a good training ground for managers that would later be employed by other, private sector firms. CMC is now part of TCS, a leading Indian software service firm.

[6] Cognizant, the erstwhile joint venture of Dunn and Bradstreet and Satyam, is the latest in the line of US headquartered firm with the bulk of operations in India, with an Indian emigrant as CEO.

to the very top tier of Indian firms. Nonetheless, being U.S. headquartered, they played an important role in legitimizing the use of Indian programmers by US firms when the Indian industry was young.[7]

Early export projects involved jobs such as rewriting code to migrate applications from mainframes to the then newly emerging client-server platforms. Coincidently, Indian programmers had acquired a degree of expertise in this due to IBM's departure from Indian in the late 1970s, which then required that existing computer applications used in India be transferred to other platforms such as Wang, Unisys and DEC. Naturally, in the course of moving applications, the applications were sometime enhanced and new functionality was added, a task which also fell to the Indian software firms. Other services included maintaining such applications, sometimes called legacy applications, while the client firm changed over to new systems and new applications. Later, data conversion projects, such as the well known Y2K projects, emerged.

But a substantial business consisted of simply providing temporary programmers for whatever the client needed to be done. Most of the clients were user firms, and most of the jobs involved systems that these firms needed to run their businesses. Software firms, especially firms developing software products, outsourced more sparingly, and were more likely to simply "rent" Indian programmers for tasks such as testing.

The success of the serendipitously discovered business strategy of sending small teams of programmers overseas to service the client is not surprising, at least in hindsight. Indian firms were short of capital, infrastructure and management. But far more important was that even in the early 1990s, Brand India was anything but that. Clients in America had to be cajoled to entrust their technology systems, least of all to a country which was until recently among the poorest in the world. It took time and initial successful projects before American firms would be comfortable having the projects performed in India, and managed by the Indian supplier.

Athreye (2005b) points out that Texas Instruments and COSL (part of Citibank) played an important role in pioneering the other part of the business strategy, namely of using India as a

[7] IGate's founder and CEO, Sunil Wadhwani, in an interview with the author in 1997, noted that leading American IT service providers had till then tended to ignore the hinterland – smaller firms typically located outside the large urban areas, for whom a large in-house IT staff was economically not viable but who needed to adopt IT for their business operations (not their technical operations.) These were the customers that IGate targeted. It is unlikely that such customers would have been within the reach of Indian software firms when the latter were just beginning to export.

place to develop software, not merely to hire temporary programmers. Though infrastructure constraints imposed large fixed costs on outsourced software projects, there were offsetting factors. The twelve-hour lead time difference meant that investing in dedicated satellite links would hardware facilities lying idle in the US to be used. Combined with the cost advantage in software salaries, this conferred enormous cost advantages to locating in India. The experience of COSL and TI had demonstrated that an Indian subsidiary could be a low cost way for a large corporation to develop software for sale, or to provide for its in-house software needs. Software was developed at the Indian subsidiary and then installed on-site by teams of Indian software professionals. Even so, the projects were small, and rarely mission critical or on the bleeding edge of the technology.[8] With time, firms such as Oracle were able to move responsibility for much more significant tasks to its Indian subsidiary. Dossani describes a similar evolution, but for a later date and on more compressed time scale, for business services, which once again was pioneered by American multinationals such as GE and Agilent (Dossani, 2006: 251, fig 2).

Though multinationals pioneered the offshore model, their ability to leverage it was limited by their internal market and organizational exigencies. It was left to the domestic firms to develop and exploit more fully what was to become the offshore model – developing software for clients in India, managed by the Indian firm. Athreye (2005a) credits Satyam as pioneering this model among Indian firms in 1991. The model was adopted by leading domestic firms, though they were initially entrusted with autonomy by foreign customers only for fairly small, specific and non-critical tasks. Falling telecommunications costs, helped by the growth of the STPI scheme meant that smaller firms could also profitably adopt this model.

The process was slow. As late as 1997, the median NASSCOM member firm had about 70 employees, and the largest had only 9000. In a sample of over 100 software firms in 1997 (with a median size of 200 employees, and thus nearly three times larger than the typical Indian software firm), the average size of the "most important" export project undertaken by the firm in the previous year was 510 man-months, whereas the median size was only about 150 man-

[8] In Arora et al. 2001, we report on interviews with US firms, which bear out this contention. "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 software. However, we did find … one exception: A leading computer manufacturer outsources mission critical device-driver software that is shipped directly from the Indian vendor for distribution."

months (Arora et. al, 2001). Using the sample average revenue per year per employee of $24,000, this implies the dollar value of these projects as not much greater than $100,000. Over time more important and complicated tasks were moved to India. Currently, often projects exceed $1 million, and the leading firms have signed deals for multi-year projects, each worth hundreds of millions! (See also table 9 below.)

Offshore development was substantially cheaper, although few American firms were willing to say so openly amidst concerns about alienating their own workers and to facilitate their lobbying for more work permits for Indian programmers.[9] But if cheap programmers was all that mattered, the Indian software would have not seen quite as many domestic firms, for many customers were large enough to profitably set up Indian subsidiaries. Instead, they outsourced to Indian suppliers because it appears that the latter were better at recruiting and managing Indian programmers, and in particular, appear to have become more skilled at "ramping up and ramping down" – putting together large teams at relatively short notice, and redeploying them when the project was done. They were also better able to cope with the high levels of turnover that the frothy IT markets of the late 1990s created. Simply put, Indian firms were better at managing software projects executed in India for overseas clients, using low cost and inexperienced developers and managers.

Since the foregoing point is often ignored, it bears repeating. Indian firms proved to be better at exploiting the larger supply of talented but young and inexperienced software developers that India had to offer. As service providers operating in a tight labor market with employee turnover rates approaching 40% at times, Indian software firms invested in processes that would help them cope. They learnt how to manage globally distributed software projects where part of the project team was located overseas while others were located half the world away. The big surge in CMM certification, with one Indian firm after another touting it CMM level 5 certification, at a time when scarcely a handful of US firms could, reflects these investments. However, the drive for CMM certification did not so much create this ability at managing software projects as certify it. Many observers have inferred from such certification that Indian firms produced high quality software. Interpreted broadly, this is correct. However,

[9] Their behavior, however, clearly shows the importance of lower costs. Indian vendors routinely reported tough price negotiations. During the 1990s, Infosys gave up an existing GE account rather than lower its rates. Another North American company I interviewed in 1998, a leading telecommunication company, described a typical strategy. It had two of the leading Indian firms as suppliers which accounted for much of the outsourced work, and two "lower end" suppliers with smaller contracts, primarily to keep the price pressure on the main suppliers.

CMM is principally about managing software development, not about the quality of the software code produced. Not surprisingly, the available empirical evidence suggests that CMM certification primarily benefited the firm by allowing it to take on larger projects, rather than higher prices (Arora and Asundi, 1999). In other words, it enabled firms to grow more rapidly.

The evidence also suggests that larger firms earn higher revenues per worker, and in this sense, are more productive.[10] Using NASSCOM member firms as the basis, firms in the third quartile of size earned revenues of Rs 0.62 million per employee in 1994 and Rs 0.95 million per employee in 1999. The revenue per employee in millions of rupees for the median firm was 0.33 and 0.49 respectively for the two years, or about one half that for firms in the third quartile. This superior software development management capability has stood the leading Indian firms in good stead over the past decade, even as competition from foreign and domestic competitors has intensified. As I shall argue below, this also has important implications for their future strategies and prospects.

IV. Explaining software success

- *Human capital and comparative advantage:*

The main contours of the argument must be evident from the foregoing discussion. At its base is the simple concept of comparative advantage: India was relatively abundant in the factor in which software is relatively abundant, or in plain English, software depends heavily on software developers, and Indian had many people willing (and able) to develop software for less.

Since this argument is widely accepted, at least in its simpler form of absolute advantage, I shall not dwell on it. Wages for Indian software professionals were much lower than their counterparts in developed countries. Though they have risen over time, they remain lower, although the precise magnitude of the difference is unclear, in no small measure because the typical software professional in America has much greater experience.[11]

But this is not enough of explanation. How did a poor country like India become so well endowed with human capital? What of other countries, with similar endowments, that perhaps ought also to have succeeded but did not? Why was this latent advantage not adequately

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[10] Possible economies of scale from more intensive utilization of workers or through the use of proprietary tools may also contribute to the higher labor productivity, as might differences in the capital stock employed.

[11] Athreye (2005) presents data which suggest that whereas U.S. salaries for a variety of software occupations such as programmer, project leader, quality assurance specialist and systems designer increased by about 21% between 1995 and 1999, Indian salaries increased nearly twice as fast.

exploited by established software firms or large users in America and elsewhere?

India is not well endowed with human capital by most measures. Barely 50% of the population is literate, and normalized by population, the stocks of scientific and technical personnel are modest, well below countries in East Asia. It is merely that India is (or more precisely, was during the relevant period) well endowed with human capital relative to its economic needs. Or, more provocatively, during the 1970s and 1980s, India found itself with more engineers than its stagnant domestic economy could employ on attractive terms. Many of them emigrated to America, where they rose to middle management positions in large firms.[12]

When the big surge in IT demand came in the early 1990s, these emigrants were well positioned to broker the small initial contracts with Indian software firms, or as Kapur (2002) dubs it, act as "reputational intermediaries". Some, as we have already noted, became entrepreneurs, leading the on-site model of software service exports. In more recent years, there has been a greater return flow to India, chiefly to pursue more niche, technology intensive activities. However, Kapur and McHale (2005) conclude that the return flow is as yet small. FDI from the Indian diaspora is only 5% of its Chinese counterpart and NSF longitudinal data on PhDs indicate return rates below 10%.

Initial software exports from India relied upon software developers, who had gained experience in the domestic market or by working on overseas projects. As well, talented developers and managers were hired away from other domestic sectors. However, experienced managers and developers were often snared by multinationals in India or employers overseas. The surge in exports has been fuelled by young and inexperienced engineering graduates. Over the last decade and a half, Indian engineering baccalaureate capacity has increased dramatically. This expansion has sustained the growth of Indian software exports. Sharply rising wages would have choked the growth in the industry but for the remarkable expansion in engineering education. Though the fruits of this expansion are frequently touted in discussions of the number of engineers India graduates, the fuller account is worthwhile for what it teaches us about the process of economic growth and development.

Much of what Indian software exports consist of does not require an engineering background, yet software exports from India rely very heavily on engineering graduates. A

[12] US Census data analyzed by Kapur and McHale (2005) indicate that 77% of the Indian born population in America in 2000 had college degrees, and 37% had a masters degree or higher!

survey of over 100 Indian software firms in 1997 indicate that 80% of the software professionals employed had engineering degrees, while 12% only had diplomas from private training institutes (Arora et al., 2001). In interviews, few firms admitted to hiring non-engineers, principally for the signal it might send to potential customers and recruits. The CEO of a leading firm I interviewed in 1997 conceded that he hired only engineering graduates, from the best possible schools, not because their training was relevant, but because these students tended to be smart and their backgrounds were useful in signaling quality to potential customers. Insofar as software developers had to be sent to America, an engineering degree was especially valuable in getting temporary work-permits, an artifact of the way in which American visa laws operate.

Table 2 below shows that in 1985, roughly the time when software exports begin, Indian colleges graduated about 45,000 engineers of all types. By 2004, the *capacity* had increased to nearly ten fold to 440,000. The actual number graduated was smaller, both because of the inherent lags, and because the entire capacity was not utilized. Our estimates suggest that the actual number of engineers graduated in 2004, which reflect capacity in 2000, was likely closer to 160,000-180,000 (Arora and Bagde, 2006). These figures do not reflect the large number of non-engineers who acquire computer training and skills in using relevant tools at non-degree granting institutes such as NIIT and Aptech.

Table 2: Sanctioned engineering baccalaureate capacity in India, 1951-2004

Year	Population in millions	Engineering college capacity	Engineering college capacity per million of population
1951	361	4788	13
1985	765	45136	59
1995	928	105000	113
2004	1086	439689	405

Source: Arora and Bagde, (2006) based on data from The Ministry of Human Resources Development, AICTE, NTMIS.

Almost all of the increase in engineering baccalaureate capacity was in IT relevant fields of engineering, and more importantly, in private colleges which do not receive government subsidies. During the early 1990s, the increase was also regionally concentrated. These trends are closely related. Table 3 shows the sanctioned intake capacity (for undergraduate engineering degree programs) by state. We see large inter-state variation in capacity. Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu accounted for about three quarters of the national capacity in 1987 as compared to twenty nine percent of the population, and even in 2003, accounted for just under two thirds of the capacity and less than one third of the population.

The bulk of the inter-regional variation is due to non-granted engineering colleges. In 1981, almost all engineering college capacity was in government aided colleges. Constraints on public budgets and regulatory constraints on capacity expansion by existing colleges meant new private (i.e., not publicly funded) colleges have been the main source of growth (see Arora and Bagde, 2006, for more details). Karnataka was among the first state to permit the private sector in undergraduate engineering education in 1957. Thereafter one in 1962 and two in 1963 started their operation in the state. Then a large number of private colleges entered, beginning 1979, with nine colleges opening in 1979 and eleven in 1980. The first private college started in 1977 in Andhra Pradesh and in 1983 in Maharashtra after the government introduced policy permitting such colleges. Figure 2 below shows that in 1987, the earliest year for which I was able to get data from the All India Council for Technical Education, the body responsible for sanctioning and accrediting engineering colleges in India, the share of private colleges (not funded by the government) in baccalaureate capacity in engineering varied across states. It was between 60% and 80% in states such as Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu, and substantially smaller in other states. A very similar picture obtains if one examines only IT relevant engineering fields, consistent with the observation that the initial inter-regional variation was due to differences in private engineering baccalaureate capacity, and that this capacity was mostly in the "hotter" IT relevant fields.

Note well that the growth of engineering baccalaureate capacity in the IT hub states predates by some margin the period of rapid growth of the software industry. Though accurate figures for the early period are unavailable, estimates suggest that software exports in 1985 were of the order of $25 million. Indeed, even in 1990, software exports were a mere $128 million, employing fewer than 20,000, spread between Bangalore, Mumbai, Delhi and Chennai. It is unlikely, therefore, that education policy changes were primarily intended to support software exports. Rather, it reflects differences in state policies regarding the entry of private colleges. By 1986, only six states had private colleges. Four of these, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu, accounted for the bulk of engineering college capacity in the entire country. As software exports grew, demand for engineering degrees also grew rapidly. Beginning in 1992, other states began to allow private self-financed institution and by 1999, all fourteen states studied by Arora and Bagde (2006) had allowed private engineering colleges.

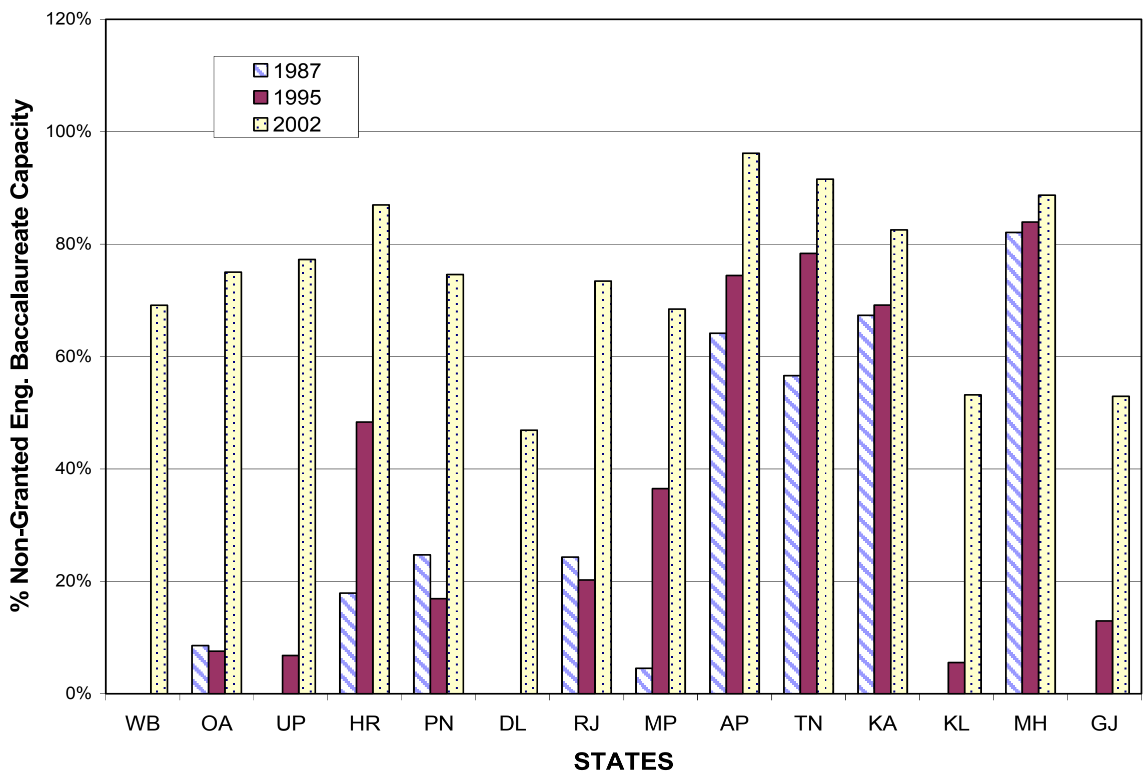
Table 3 : Sanctioned intake capacity in undergraduate technical institutions, in '00s

Year	AP	Delhi	GJ	HR	KA	KL	MP	MH	OA	PN	RJ	TN	UP	WB
1990	58	9	33	5	170	27	17	192	11	5	11	92	31	23
1991	55	10	33	6	180	28	19	199	11	5	11	92	32	23
1992	55	10	34	8	188	29	19	238	11	5	13	94	33	23
1993	55	11	36	8	172	30	19	256	11	11	14	118	33	23
1994	56	10	38	8	193	35	19	280	12	11	14	141	33	24
1995	80	13	44	9	202	45	32	309	12	19	14	185	37	25
1996	86	12	50	9	203	47	34	333	17	19	15	222	44	26
1997	130	13	54	33	238	49	48	344	33	22	15	238	49	26
1998	196	16	64	33	244	51	43	397	45	22	20	273	68	40
1999	241	21	73	47	262	67	71	429	62	22	27	366	85	45
2000	277	23	91	67	282	88	102	429	62	34	50	505	153	52
2001	440	30	106	86	356	113	109	446	88	44	63	655	213	62
2002	624	34	106	98	381	183	160	470	88	86	82	702	231	107
2003	658	35	103	101	389	199	194	475	107	107	115	707	242	107

AP: Andhra Pradesh, GJ: Gujarat, HR: Haryana, KA: Karnataka, KL: Kerala, MP: Madhya Pradesh, OA: Orissa, PN: Punjab, RJ: Rajasthan, TN: Tamil Nadu, UP: Uttar Pradesh, WB: West Bengal

Source: Arora and Bagde, 2006.

Fig 2 State Share of Private Non Granted College in Sanctioned Engineering Baccalaureate Capability, various years



Source: My calculations based on AICTE data on sanctioned capacity.

It is only to be expected that education quality should have suffered greatly during this great expansion in capacity. There is no doubt that many of the new colleges are not up to the task of training engineers, and their graduates frequently need extended periods of training by employers before they can be put to work.[13] Thus far, large Indian firms have undertaken substantial investments in in-house training, in some cases spending 3-4% of revenues on training. Some, though not all, of this could be usefully provided in college itself. Future growth of software will require improvements in the quality of Indian colleges and universities. Given an acute shortage of PhD and good quality post graduate level engineering teachers, this improvement will require investment but also some thought.[14]

To sum up, the relative abundance of India in human capital is the result of a combination of its mediocre economic performance between 1955 and 1984, over-investment in tertiary education in the 1950s and 1960s, and a market response, by Indians willing to invest precious savings in an engineering degree for their children and "entrepreneurs" who responded by starting new colleges.

Kapur (2002) and Srinivasan (2006) note that this simple appeal to comparative advantage is insufficient an explanation. Many other countries had under-employed engineers and perhaps even the diaspora to broker the software export deals, and some even spoke English. For instance, Philippines had 27% tertiary enrolment in 1991 compared to only 7% in India. Accenture had begun software development in Philippines in the 1980s itself, and there are longstanding cultural links between America and Philippines. Understandably, in 1997, many of the software firms I interviewed in India mentioned Philippines as a potential potent competitor, a fear that has not materialized. Interestingly enough, Philippines is emerging as a BPO center, suggesting that the comparison is apt. Similarly, many countries in Eastern Europe have a large number of well trained and poorly paid engineers and scientists, many of whom speak good English. Yet software exports from these countries are small. Russian software exports, though often technically very impressive, are barely over $1 billion.

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[13] It is also a tribute to the superior management capability of Indian firms that they were able to use such inexperienced and poorly trained (but bright) young men and women. In some sense, Indian firms embraced, out of necessity, the taylorization of software services while their competitors were slower to do so.

[14] A recent government initiative in which the IITs were tasked to develop video and computer based learning materials exemplifies the point. The NPTEL program, begun in 2003, has resulted in the creation of material for over a hundred courses, involving more than 300 IIT faculty. Yet, there has been very little thought given to whether any of the intended beneficiaries, including the various engineering colleges thought to be suffering from a lack of qualified faculty, will use these materials, which are to be made available free to anyone. This type of "supply side" oriented government programs, which contributed to the relative abundance of human capital in India in the first instance, does not auger well for future.

- *Protection, and learning from the domestic market?*

If simple comparative advantage is not enough, what are the missing pieces of the puzzle? The first potential one, which can be readily disposed of, is a protected domestic market, which enabled firms to develop expertise that they could leverage for exports (cf. Dossani, 2005). It is true that IBM's departure, and some fortuitous decisions to invest in Unix platforms provided useful experience to Indian programmers. But as I have argued above, Indian software exports, particularly early on, did not require deep technical skills. Rather, they relied upon a "reserve army of underemployed engineers" with the knowledge of software tools and a willingness to undertake tedious tasks. Protection undoubtedly helped produce the miserable economic performance which led to the "reserve army of underemployed engineers", but the irony here is self evident. More to the point, the growth of software exports depended upon firm capabilities in recruiting, organizing teams, and maintaining service in the face of high rates of employee turnover.

Very few firms with substantial domestic experience were great export successes, with the possible exception of TCS and Wipro. Other early entrants such as Hindtron and CMC, which focused on the domestic market, remain domestic market focused. The evidence of from comparable developing countries also provides little succor for the proponents of this view. Brazil had substantially protected its IT sector till the mid 1990s, and had, unlike India, a very sophisticated banking, telecommunication and government user sector. Though software production in Brazil was about $8-9 billion in 2002, less than 10% of that is due to exports. China too has an effectively protected market for software. Though more successful than Brazil in exports, it lags India by a substantial margin.

Undoubtedly, some firms acquired very sophisticated skills in the domestic market, but these skills were of little use in software exports, as illustrated in the following quote from the CEO of subsidiary of a very large Indian engineering firm.

> "… (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."… Domestic expertise may be useful in gaining technical expertise such as in coding and project management. <u>However domestic and export projects are two different ball games</u>."

(Interviewed by the author in Bombay, 1997, quote extracted from Arora et al., 2001. Emphasis added.).

Sometimes the argument in favor of protection or learning from the domestic market is accompanied by an emphasis on the role of domestic markets in helping develop software products. Indeed, firms such as Ramco, Sonata and Mastek did initially focus on developing products for the domestic markets but had little export success.

Athreye's study of CITIL (now i-Flex), a Citibank subsidiary, indicates that the Indian market could provide a fruitful learning base for products (in this case, a backend banking product) that could be successfully exported (Athreye, 2005b). The study also makes clear, however, that this strategy depends on a number of concomitants for its success. In this case, Citibank's own internal use of the product (albeit in India and other developing country markets) provided important legitimization. Further, CITIL's strategy was to initially focus on other developing country markets, particularly in the British Commonwealth, avoiding head to head competition with incumbent producers in developed countries, most of which were not large established firms. Only after succeeding in other export markets did CITIL enter the developed country markets, and appears to have fared well in this attempt.

- *The Role of Public Policy?*

The second candidate explanation is public policy. It is helpful, in this context, to distinguish between affirmative, sector-specific policies on the one hand, and all other policies. By the former I have in mind measures such as subsidies targeted to software exporters, or R&D investments in software. It could also include, as was true in Israel, investments in networking technologies and government procurement policies, motivated by national defense considerations, which propelled Israel into the forefront in security software and encryption technologies. In the latter category I include policies that generally improve the business climate.

Domestic and international economic liberalization, begun in 1984 and reinforced strongly in 1991, while broadly beneficial to all sectors, was especially helpful to the fledgling software industry in India, a point that Kapur (2002) argues with some force. I agree, and since this proposition is widely accepted, I shall not dwell on it. Surely providing an industry with tax incentives cannot hurt it (though it might hurt other industries), and neither can it hurt to relax onerous import restrictions and other types of regulations that strangled growth in other Indian industries. One might note that software was not very sensitive to a great deal of the pervasive regulation since it was not very capital intensive, the minimum scale of entry was small, obviating the need for bank finance, and was not likely to be hampered by union activity. It did, however, benefit from the easing of trade and foreign exchange regulations in 1991, whose timing coincided with the boom in international demand for IT skills. The element of luck, which often hovers in the background in such discussions, must firmly be brought to the forefront in this instance. Unquestionably, the reforms came at an opportune time, leaving India especially well positioned to benefit from the boom in global IT demand in the 1990s.

The role of affirmative sector specific policies is harder to dispose off as neatly since there have been a plethora of such policies, varying in focus and detail over time. Though earlier accounts characterized the policy regime facing software as one of "benign neglect" (Arora, et al., 2001), it is probably better described as inconsistent and ineffective. Athreye (2005a: table 8) details the various policy changes in import restrictions, and export incentives. With the exception of telecommunication infrastructure, most of the many policies said to have aided software were not specific to software, and in any case, were merely ameliorating bad existing policy. Hardware, the focus of much of policymaking efforts in the 1970s and 1980s, was showered by all these policies but with little to show for it.

Athreye (2005a) argues that during the crucial years of its development, the software industry flew "under the radar". The domestic market was small (and therefore there was little to be gained from protection) and as a service, it was naturally exempt from many of the laws and regulations that have stifled the growth of Indian manufacturing. Neither were the large investments in the 1960 and 70s in science and engineering directed at software. Instead, the objective was to supply the manufacturing sector, whose slower-than-hoped-for growth resulted in the excess supply of engineers described to earlier. In more recent years, of course, the software industry and its industry association, NASSCOM, have come to exercise substantial political influence and helped craft favorable public policies. But that is the consequence of its success, not its cause.

Balakrishnan (2006) makes the clearest case for targeted public policy. He notes that Bangalore was unusually well supplied with public sector R&D institutions, including nine defense related labs, which made it an attractive location for software firms, especially multinationals. Thus, he argues that India's software success testifies to the success of the government's "strategic intent".

> *Almost all private entrants, whether Indian or foreign, had started out in Bangalore* as this was seen as the locale most conducive, at least initially, to the success of an IT enterprise in India. Bangalore was India's science city, a deliberate construction of the policy of trying to establish an

> independent, world-class scientific foundation on Indian soil. By locating here, private entrepreneurs had access to scientists, engineers and management professionals who had honed their skills in the best technological environment in India, *almost exclusively created by the government*. (Balakrishnan 2006: 3870, emphasis added.)

Balakrishnan concludes the success of the software industry required a two pronged effort.

> "First, via long-term investment by the state in technical education and science and technology, with neither necessarily directed at the production of software. Subsequently, an incipient software industry with recognizably high export potential has been targeted via fiscal incentives and the provision of export-enabling infrastructure. *The emergence of a globally competitive Indian software industry serves as an interesting example of successful state intervention at a time when the model is largely out of fashion.*" (Balkrishnan 2006: 3868, emphasis added.)

There are two observations to be made in response. First, although the presence of public sector R&D labs may explain why Bangalore has emerged as an IT hub, it is not the only IT hub in India: there are five, roughly equally sized software clusters. Though Bangalore has attracted most of the hype, the data suggest that it has not been the only source of exports. Table 4 below presents data on software exports for the fourteen major Indian states over time. The data for 1996 and later comes from STPI figures. For earlier years, it is based on location of corporate headquarters and revenues for firms, gathered from NASSCOM and Dataquest. For TCS, which had software development activities in multiple regions, revenues were allocated to different locations based on company provided estimates of employment by location. Table 4 shows quite clearly that Mumbai was where most of the initial software activities were located (indeed, Infosys was started in Mumbai and later moved to Bangalore). Other pioneers such as TCS, Patni, and Datamatics were Mumbai based as well. HCL was based in Delhi, as was another early leader, IIS Infotech. Furthermore, if one aggregates Delhi, UP and Haryana, which together make up the Delhi-Gurgaon-Noida cluster, this cluster produced exports comparable to Karnataka between 1994 and 2000. Karnataka pulls away from the other clusters only after 2000, by which time the Indian software exports are already very sizable (over $8 billion by 2001).

Table 4: Indian Software Exports, by State, 1990-2003, for 14 major Indian states (in millions of rupees at constant prices of 1993-94)

Year	KA	TN	MH	AP	DL	HA	UP	WB	OA	KL	MP	GJ	PN	RJ
1990	626	374	1,571	127	301	0	129	80	0	2	0	0	0	0
1991	1,189	489	1,774	158	430	0	188	94	0	6	0	0	0	0
1992	1,595	654	2,521	242	387	119	248	143	0	13	0	0	0	0
1993	2,235	1,124	3,836	277	986	170	385	251	3	17	0	2	0	0
1994	3,079	1,800	4,771	511	2,849	248	541	319	4	19	0	10	0	0
1995	4,386	2,725	6,321	857	3,459	458	770	410	9	29	0	12	0	0
1996	7,609	4,563	9,764	1,813	5,493	745	1,288	465	15	62	0	30	0	0
1997	12,630	7,502	12,751	2,127	9,458	1,442	1,644	743	28	196	0	40	0	0
1998	24,347	9,174	14,114	4,587	17,643	7,763	7,057	1,411	565	374	106	93	56	26
1999	29,158	13,171	18,703	7,037	26,027	6,448	8,255	2,434	726	442	239	183	99	99
2000	48,681	24,435	26,853	12,103	23,869	9,108	21,935	2,946	1,256	706	314	641	314	188
2001	71,786	36,465	37,866	18,052	14,215	17,923	15,451	4,363	1,545	909	544	754	433	278
2002	81,834	43,529	40,754	22,001	17,121	20,377	17,992	7,545	1,741	958	604	609	406	269
2003	107,598	44,925	54,921	28,152	19,412	27,732	19,689	8,874	1,803	1,212	693	782	1,009	277

(Source: Arora and Bagde, 2006. See paper for details on data sources).

Table 5: Entry dates and the regional location of firms, 2001

Location	Pre-1980	1981-84	1985-91	1992-99	2000 -01
Bangalore	3	3	19	50	15
Mumbai/Pune	9	11	32	63	8
(Pune)	(1)	(0)	(8)	(17)	(2)
Chennai	3	5	9	34	6
Delhi: of which	5	4	25	63	17
(Noida)		(1)	(6)	(18)	(4)
(Gurgaon)			(1)	(9)	(2)
Hyderabad /Secundrabad		1	6	29	8

Notes: Computed from NASSCOM (2002) after excluding government departments, liaison offices and firms with missing data on years of establishment. (N=449). *Source: Athreye (2005a), table 5, and my additions*.

Complementary evidence is provided by Table 5, which lists the location of NASSCOM member firms based on headquarters till 2001. Since most firms tended to be single location firms, especially in the early years after formation, the location of the headquarters is a useful measure of software activity. Table 5 paints the same picture as table 4: Until 2000 or so, Bangalore was not markedly more attractive a location than Mumbai or the Delhi cluster.

The second reason for doubting the claim that government science and technology investments explain why Bangalore emerged as a leading IT hub has to do with the nature of software exports. As I have stressed repeatedly, software exports, especially at the start, consisted of relatively simple activities or of programmers sent to America and elsewhere. Undoubtedly, some of them were hired away from the many public sector labs, which proved to be a useful reservoir of skilled human capital. But that is it. The sophisticated capabilities resident in the public sector labs were, for the most part, irrelevant to software success, with the exception of attracting firms such as TI and Motorola to locate there. Ironically enough, these capabilities and the multinational labs they attracted may explain why Bangalore is now acquiring a reputation for being the place to do product development and other R&D intensive software activities. Unfortunately for the "public policy is the cause" explanation, this is taking place after the success of software exports.

Additional support is provided by the findings of Suma Athreye's survey of 205 software firms in 2002-03. In the survey, research links with universities and labs were ranked dead last among the factors that influenced their location decisions. Government financial incentives and presence of other firms were also ranked very low among the factors that influenced the location decisions of firms (Athreye, 2006).

Srinivasan (2006) singles out telecommunication reforms and the creation of Software Technology Parks (STPs) as key pieces of the puzzle. This is undoubtedly right. Software firms needed to interact cheaply and easily with their clients, and to work upon systems remotely. Indeed, surveys done in 1997 by me, and more recently the survey by Athreye mentioned earlier indicate that good transport and communications infrastructure is seen by firms as among the most important factors conditioning their performance.

Srinivasan's inference, however, that the initial phase of "body shopping" was a response to poor information infrastructure is off the mark. Some amount of physical proximity is inevitable. Outsourcing had, and continues to have, an important local component. One way of examining the tradability of IT services is to examine the extent to which they are clustered near local demand. If markets for IT services are local, then we should expect the entry decisions of IT services firms will depend in part upon the size of the local market. If markets are not local, then the composition of local demand should matter little: rather, suppliers should locate in low-cost regions. Using data from US Census County Business Patterns, Arora and Forman (2006) find that the elasticity of local supply to local demand characteristics is higher for programming and design (0.806) than for hosting (0.1899).

The importance of physical proximity will depend upon the nature of the service. Programming and design services involve tasks such as programming, and planning and designing information systems. These tasks require communication of detailed user requirements to the outsourcing firm in order to succeed. Hosting, on the other hand, involves the management and operation of computer and data processing services for the client. After an initial set-up period, the requirements of such hosting services will be relatively static and will require relatively little coordination between client and service provider. Thus, ex-ante we would expect that hosting activities may more easily be conducted at a distance than other activities. Indeed, Arora and Forman (2006) find that outsourcing of programming and design services is much more sensitive to local supply conditions than hosting.

In other words, sending Indian programmers to their US clients for part of the job is almost inevitable. In the Indian context, the body shopping phase was essential for another important, reason. Good telecommunications or not, outsourcing software development to India was not an easy sell in 1991, as the following comment indicates.

> "When I was out there in 1991, the country was bankrupt. We had three governments in one year, an assassination of a prime minister, and we were hawking our gold. You know, selling overseas was not a piece of cake…. if I have to present ten slides, the first eight had to be to sell India and the ninth one would say we do have an IT industry in India and unless the guy bought those nine slides, your tenth one about your company was meaningless. Because who are you anyway? Fifty people -- its no big deal. So we were building up the (India) brand from day one"

(A founder-member of NASSCOM, interviewed by Suma Athreye, 2005, cited in Athreye and Hobday, 2006)

An offer to send people over was undoubtedly more palatable to nervous American IT managers than an invitation to send the work over to India.

- Entrepreneurship and Openness

As the quote above also indicates, underlying this remarkable export success story is a perhaps even more remarkable story of Indian entrepreneurship. Even though the details of the entrepreneurial process are poorly understood one may tentatively induce two explanations for India's export success: entrepreneurship and openness.[15]

In an insightful article, Hasuman and Rodrik (2002) note that such market experiments appear to lie at the very heart of export successes from developing countries. They argue that in an uncertain world, figuring out where and how to exploit a certain type of resource abundance is not straightforward. For instance, Bangladesh's abundant supplies of cheap labor give it a comparative advantage in labor intensive products as opposed to high tech machinery. But labor intensive manufactures range from a range of textiles to diamond polishing. Even in textiles,

[15] The next few paragraphs draw upon Arora and Gambardella (2005).

where Bangladesh has focused, Bangladesh's exports to the U.S. are narrowly concentrated in men's cotton shirts and trousers and knitted hats. By contrast, Pakistan, with a similar resource endowment, exports bedsheets to the U.S. but few hats. This is not an isolated example. Hausman and Rodrik show that of the top twenty five exports of each country, there are only six items in common. They find the same pattern for other pairs of comparable countries, such as Honduras and the Dominican Republic, and Taiwan and South Korea. They conclude that in most developing economies, "industrial success entails concentration in a relatively narrow range of activities."

Moreover, what precise product lines and activities that will eventually prove to be a success is very difficult to predict. An early, but unsuccessful, attempt to exploit India's comparative advantage in labor intensive activities is illustrative. Patni Computer Systems, through its US affiliate, Data Conversion launched a project in the late 1970s for the data entry as well as code embedding for commercial databases (now Lexus-Nexus). However, steep import duties on computer equipment imports, as well as union regulations caused much of data conversion work to be shifted to China and Taiwan and the project failed. Athreye (2005) documents the many market experiments that Indian entrepreneurs engaged in, from developing products for the local (and less frequently, the export) market, to experimenting with different ways ("delivery models") for service exports.

Other countries also provide comparable examples. Breznitz (2005) shows that while it was evident that Israel's comparative advantage lay in R&D intensive sectors, it was not at all clear in the beginning that software would emerge as a prominent instantiation. Indeed, the Office of Chief Scientist did not even include software in the technologies to which R&D subsidies would be provided until 1985. Multinationals demonstrated the viability of developing software in Ireland, but it was left to some indigenous firms to demonstrate that Irish firms could develop successful software products. As Hausman and Rodrik put it, "learning what one is good at producing", which may be key to the process of economic growth in follower countries, is not yet well understood. Economic experiments or entrepreneurship is the way such learning takes place.

For export success, information from outside the country, particularly from potential export markets, may be very important. This is reflected in the sources of firm formation in the software industry in Ireland, Israel and India. Of the 38 Irish software companies for which

Sands (2005) presents data, 28 had one or more founders who worked abroad, and 38 out of 58 of the founders had worked abroad. Similarly, Arora, Gambardella and Klepper (2005) present evidence that 40% of a sample of 200 top managers of the leading Israeli software firms had earlier worked for an American company and a third had their highest degree from a US university. These percentages are markedly higher for managers in charge of finance or marketing, consistent with the idea that although Israeli entrepreneurs were technically proficient, they needed marketing and financial expertise from American managers to turn this into commercial success.

The importance of the "foreign connection" is evident in the Indian software industry as well. A number of successful software entrepreneurs in India had substantial overseas experience. For a sample of 530 firms that were members of NASSCOM in the year 2000, Athreye (2005) finds that 95 (18%) were created by existing Indian firms diversifying into software, 96 (18%) were multinationals, 44 were founded by expatriate Indians overseas, almost all located in the U.S. There are 212 (40%) *de novo* start ups, which 160 were founded by those who had worked for other software or hardware firms. It is likely that a very substantial fraction of these had worked overseas on software export projects. The foreign hand is even more visible if one confines attention to the leading exporters. Of the 20 leading exporters identified by NASSCOM, a quarter (5) were started by Indians living in America, and another 20% (4) are multinationals. Of the remaining, in virtually every case, the founders were educated or worked abroad. Since the NASSCOM list excludes leading exporters such as IBM, Accenture, HP and Intelligroup on the one hand, and Kanbay, Cognizant and Syntel on the other, the share of multinational corporations and of firms started by the Indian diaspora overseas is even higher.

Indian entrepreneurs were tested by the struggle to use inexperienced and newly minted engineers, to compete for export orders in the face of power shortages, bad roads, high employee turnover, and an initially indifferent government. To someone growing up in the India of the 1970s, where superior access to government favors passed for entrepreneurship, that such large numbers readily accepted the challenge is surprising enough, let alone that so many succeeded. However, this itself should provide comfort regarding the future prospects of the Indian economy.

- *Moving up the value chain: Software Products*

Much ink has been spilled on whether Indian software exports are low-end or not. For instance, many observers of the Indian software industry believed the growth of the Indian software industry was unsustainable unless firms began to invest in R&D to undertake sophisticated product development, because rising wages would surely undercut their existing cost advantages (e.g., Schware, 1992; Heeks, 1996; D'Costa , 1998). As one early observer put it

> Onsite working increases the opportunities for a 'brain drain' of talent, while offering programming services can become self-reinforcing with little skill being built up, so that the higher skills necessary for software innovation remain the preserve of developed countries.... (A)nd may also leave the Indian industry unable to move significantly to a different form of exports, such as package exports.
>
> (*Heeks, 1998, India's Uneven Software Exports, Working Paper, IDPM, Univ of Manchester*)

In this, they were in good company. Virtually every CEO I interviewed espoused such views. Industry leaders continue to hold to them even today, as the following quote attests.

> Indian software entrepreneurs would need to focus more on innovation of new IT products rather than on services or outsourcing if India had to be at the forefront of the IT revolution and transform itself into a software powerhouse, according to founder of Hotmail, Sabeer Bhatia.
>
> (*15 July 2005, Bangalore, **The Economic Times***, emphases mine)

Such views are sometimes part of a broader mindset wherein progress in technology intensive industries must necessarily take the form of moving up the technology ladder, to parallel (if not imitate) the activities undertaken in the rich countries. Indeed, policy makers in developing countries often point with pride to the technological accomplishments achieved in their countries, treating them as indicators of success. Considerable pride is staked on the formation of national champions and the ability to undertake high-tech projects and produce technically sophisticated products, regardless of their commercial feasibility. For the most part, as I shall show below, India has not produced technically sophisticated products and services, although there certainly are exceptions to which one can point. On the other hand, Indian software growth appears none the worse for being behind the technological frontier, though a skeptic may contend that it is surely only a matter of time before wage growth exacts its revenge.

What then are the prospects for the Indian software and for Indian software firms? It is helpful to distinguish between two distinct ways in which one can "move up the value chain".

First, one could produce software products. Products allow one to "write once and sell many times", the ultimate source of economies of scale. The reality is of course more complicated. Products, once written, have to be patched to take care of bugs and security flaws that inevitably creep in, and have to be upgraded to remain interoperable with other products, and have to have new functionality added on to keep up with the competition. Moreover, products have to be marketed, and once sold, have to be installed and integrated with existing products. All of this takes software services. A comparison of the profit and loss statements for Oracle, the leading vendor for database and other enterprise computing products, and TCS, is illuminating in this respect (See appendix table 1). Not only does Oracle expend substantial resources on services, its overall profit margins are not much different from those at TCS. The one major difference is that Oracle is about five times larger than TCS (or was, prior to its acquisition of PeopleSoft and JD Edwards).

Despite this, many of the leading Indian firms have tried to develop products, with limited success. The lack of success ought not to surprise anyone. Penny pinching and risk averse management habits ingrained while growing in an infrastructure and capital scarce and labor abundant environment are unlikely to make for successful technology innovators. Development organizations geared to fulfill requirements laid down by clients are unlikely to be able to divine the needs of as yet unknown buyers of their product, and nor are sales organizations used to answering RFQs best suited to sell a product that the customer has not yet felt a need for.[16]

Innovation, particularly technical innovation, will have to come from start ups and other entrants. Some smaller incumbents, forced by the success of the market leaders, may also specialize and choose technology intensive software services as their niche. In unpublished research, Athreye reports on a survey of 205 Indian software firms. Of these, only 52 firms or about a quarter reported any revenues from product and technical licensing and 39 of those 52 firms also earned some revenues in customized services. In other words, only 13, or around 6% of the firms were focused on products. The average revenue earned through each activity for the group of firms that report licensing revenue is 34% from customization and 29% through product licensing, and the two activities are negatively correlated in the cross-section of firms. Athreye's

[16] Indeed, Infosys now spins off promising product development opportunities, as is the case of Onmobile, which develops mobile applications.

data also suggest that entrepreneurial and spin-off firms are more likely to report licensing revenues as opposed to firms that are part of business houses or are established firms.

Table 6 lists the leading software product producers with their associated product revenues (including domestic sales). Only i-flex, a Citibank spin-off has achieved a measure of success. The other noteworthy point from the table is the virtual absence of the leading software firms. The two featured in the table, Infosys and TCS, have total revenues in excess of $2 billion, so that their product sales account for 2-3% of their total sales revenues.

Moreover, Indian firms are not alone in their failure to develop software products. The US dominates the software product market to an astonishing degree. OCED data show that the US continues to be the leader by a wide margin in the export of software products, accounting for 21.7% of total software exports but, in reality, probably produces about a third of all software exports. The discrepancy is because the second leading exporter, Ireland, is mostly a value added reseller of software products developed and designed in America by American firms. North America also represents the largest share of packaged software sales, and this percentage has been increasing over time from 47% in 1990 to 54% in 2001. Other than SAP, the German ERP producer, all the leading software product companies are American. (See Arora, Forman and Yoon, 2006, for more details.)

Table 6: Leading software product companies and software product revenues, $ million.

	2004-05	2005-06
i-flex	122.3	157.7
Infosys	44.4	74.2
TCS	41.0	53.5
3i Infotech	26.9	40.6
Cranes	27.9	34.2
Ramco	25.8	32.9
Tally	47.7	28.5
Subex	13.1	24.4
Flextronics (earlier Hughes Software Systems)	14.8	23.8
Polaris	24.6	15.4
Total	388.5	485.2

Source: DataQuest Magazine, online site accessed 26 Sep, 2006.

An important reason for American dominance is the importance of user-producer interactions, which are particularly salient for successful software product design. For example, the well known SABRE airline reservation system was an outgrowth of a chance encounter between R. Blair Smith of IBM's Santa Monica sales office with C.R. Smith, American Airlines' president, on a flight. This led to the two companies to collaborate on developing SABRE (Campbell-Kelly 2003; Copeland and McKenney 1988). As long as the lead users, particularly for enterprise software, are American, America is likely to remain the center for product innovation in software.

Firms in other countries have succeeded typically when their products were targeted to niches where incumbent American firms had not entered, or where the products are deeply technical, such as design of chip components. Such was the case for security software, where Israeli firms such as Checkpoint, seized the opening. But even when firms from outside America successfully develop a product, the typical pattern is for those firms to move their commercial activities to America.[17] This is certainly true of the Israeli and Irish firms, which have tended to retain only research activities in their home countries. For instance, Checkpoint, an Israeli firm that pioneered software security products such as firewalls, is now an American company with mostly research activities located in Israel.

This suggests a more nuanced approach to thinking about the issue of software products. As discussed at the start of the paper, software products are typically used by firms to run their business processes such as accounting, sales and marketing, purchasing, and supply chains. For the most part, such software cannot be successfully developed and sold without a deep understanding of how these users run their businesses, and without the users having some ongoing relationships with the software vendor. Business software often is bundled with a set of business rules and assumptions about business processes that must be integrated with the existing business organization, its activities and its processes. Proximity between software developers and users is particularly important for this co-inventive activity to occur. At the very least, large users are unlikely to adopt a product that will become enmeshed in their business processes without considerable assurances the support and maintenance of the products for the foreseeable future. Since America accounts for a substantial share of the software market and since most of the lead users, who play a very important role in a product's success, are American, it is difficult for a firm not substantially based in America to succeed in software product exports.

[17] This pattern is evident in the case of Talisma, which is sells a customer relationship management product. Talisma was spun off from Aditi, an Indian software firm started by Pradeep Singh, an ex-Microsoft employee of Indian origin. In 1999, Talisma was incorporated in the U.S., the founder eventually resigned from the firm in 2003 and the financiers installed a new management team. For all intents and purposes, it is now an American firm.

In turn, this raises two possibilities. First, firms outside America could develop products aimed at firms whose needs are different from American firms, as i-flex apparently did, or develop products that are not embedded in the business processes of users, as is the case for firewalls and anti-virus software. A second possibility is that firms could use India (or Israel or Ireland) as a base for doing product development and maintenance, while maintaining a substantial commercial presence in America. Indeed, this is the strategy that Texas Instrument pioneered, and many of the leading technology firms such as Motorola, Oracle, Cadence, Microsoft, Freescale and Intel have followed.

- *Moving up the value chain: R&D and engineering services*

Thus, India could host technology intensive software development, by the subsidiaries of large multinationals, or by Indian firms developing technology that is not dependent on close proximity to customers, or Indian firms doing contract research for overseas clients. The evidence suggests that both are going on.

There is anecdotal evidence that even small firms are beginning to locate product development activities with a view to increasing the pace and reduce the cost of product development. There is also some anecdotal evidence that Indian firms may be increasingly performing R&D-intensive activities, especially in the semiconductor sector. Sasken and Mindtree are the prime examples of two Indian firms that are trying to develop proprietary technology, leveraging domain expertise and profits obtained by providing R&D services to clients.

Exports of R&D Services are quite substantial. As shown in table 1 earlier, exports of R&D and engineering services were projected to amount to about $5 billion, about 80% from exports. The exact nature of such services is hard to pin down. However, sales of embedded software, for instance software written for electronic devices such as mobile phones and printers, are a substantial category. Unlike software services for business processes, this category of exports is heavily dependent on technical and engineering expertise about relevant domains such as electronics or automobiles. Table 7 lists the leading firms in providing R&D services. In addition, firms such as Persistent, IndusLogic and Aspire provide more generic product development services to clients. These are not small companies – Persistent employs over 2000, IndusLogic employs over 1000 people and reported revenues of $30 million in 2005.

Table 7: Leading Indian Engineering and R&D Service Companies

Company	Revenue (2005-06) $ million	Growth (%)
HCL Technologies	222	40
TCS	196	62
Satyam	82	53
Rolta India	31	30
Quest	15	40
Neilsoft	8	40

Source: DQ estimates, converted from rupee values at $1 = Rs 48

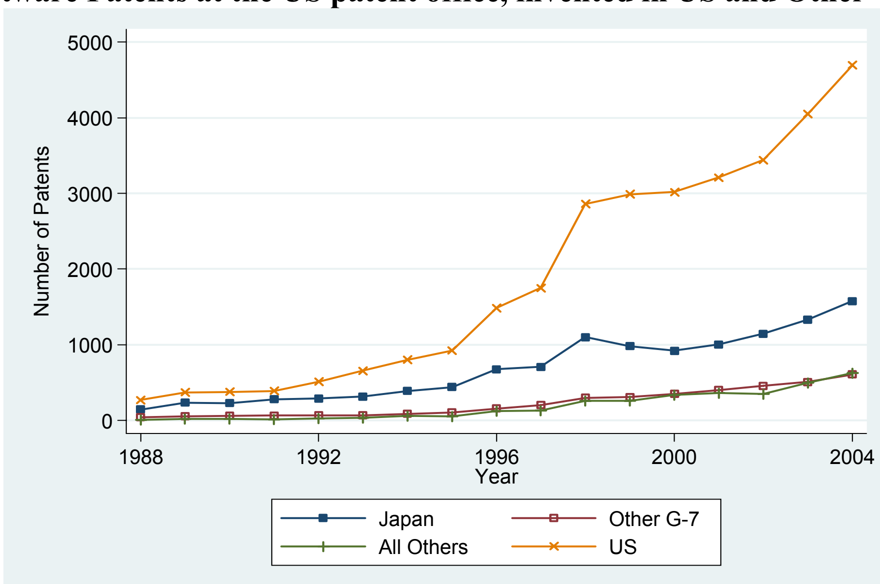
Patents statistics are another possible indicator of the extent to which India is being used as a place to do R&D.[18] Arora, Forman and Yoon (2006) use patent data examine whether, in addition to software services, software inventive activity is also globalizing. Though subject to a variety of caveats, the answer is no. There are, of course, significant limitations to the use of software patents as a measure of inventive activity. As Jaffe and Trajtenberg (2002) note, not all inventions meet the US Patent and Trade Office (USPTO) criteria for patentability, and inventors must make an explicit decision to patent an invention, as opposed to relying on some other method of intellectual property protection. Both of these issues are particularly acute in the patenting of software. Another challenge is identifying software patents. In recent years, a number of authors have begun to use patent data to examine innovation in software (cf., Graham and Mowery (2003), Bessen and Hunt (2004), Allison et. al. (2005), Thoma and Torrisi (2006) and Hall and MacGarvie (2006).

Figure 3 shows that the United States also dominates software patenting and the difference between it and the rest of the world has become very pronounced over the last ten years. In 2004, 4695 software patents were issued to inventors in the US, a larger number of patents than all other areas of the world combined (2811). Moreover, patenting by US inventors grew by nearly 20% per year, compared to 16.1% in Japan and 18.0% in other G-7 nations. These figures may reflect a "home country bias": US firms may be more likely to patent in the US market than foreign firms. However, these trends are very robust. Thoma and Torrisi (2006) examine the rate of software patenting in European patents and find very similar results: US firms are responsible for the majority of software patenting activity, followed by Japanese firms,

[18] The next few paragraphs draw heavily upon Arora, Foreman and Yoon (2006).

and then all others. Moreover, Thoma and Torrisi (2006) note that of the European patents in their database, 80.3% have also been granted by the USPTO and 73.8% have also been granted by the Japanese Patent Office.

Figure 3: Software Patents at the US patent office, invented in US and Other Countries



Source: Arora, Foreman and Yoon (2006) based on USPTO data.

Figure 3 shows the number of patents invented in the "underdog" countries, which includes India, along with US, Japan and other G-7 countries. Of the “underdog” countries, Israel is the only one among them to have a significant number of US patents. Israeli patenting activity increased from 3 in 1998 to a high of 90 in 2003. No other country has had more than 20 patents in any one year, though the number of patents invented in India has risen slightly in recent years, from an average of 0.5 throughout the 1990s to 16 in 2004.

A different way to ask the question is to look at the patenting activities of software firms, keeping mind that their patents may well fall in areas that we do not classify as software. As panel A of table 8 confirms, most of the inventive activity by software firms is by multinationals. However, as panel B shows, some Indian firms are filing for US patents as well. Given average pendencies of 2 years or more, patents granted in 2005 reflect applications in 2003.

Overall, the evidence suggests that in recent years, R&D and software related innovation activities in India have grown, albeit from a small base. However, the quantitative significance of such activities is still small. Using India to develop software for sale in distant markets poses significant challenges. One major challenge to offshoring software product development work will result from the difficulty of coordinating software development activity across a globally distributed team. As is well known, partitioning complicated software development projects across multiple team members is difficult, and often substantially increases the costs of software development (Brooks 1995). These problems may become still greater when attempting to manage such projects at a distance (Armstrong and Cole 2002; Olson and Olson 2000). Further, as Treffler (2006) notes, such contractual arrangements face many challenges, and India may be deficient in the institutional infrastructure for overcoming them.

Table 8 Patenting Activities of Leading Software Firms in India

Company	**2004-05**		**2005-06**	
	Filed	Granted	Filed	Granted
Microsoft	40	-	70	-
Symantec	47	43	57	16
ST Micro	62	32	37	14
Adobe	10	-	32*	-
Freescale	10	-	16	4
Flextronics	2	1	4	1
Cadence	1	5	--	-
Texas Instruments	35	10	-	-

Source: DQ estimates
All figures represent US patents filed by the Indian R&D facilities of these MNCs in all fields, not just software patents
*Adobe's patents represent the total number of patents filed since start of India operations

Panel B: Indian SW patenting firms

Company	**2004-05**		**2005-06**	
	Patents Filed	Patents Granted	Patents Filed	Patents Granted
Infosys	-	-	20	-
Ramco	16	-	16	-
TCS	16	5	13	4
Sasken	5	-	5	5
Mindtree	1	-	2	-
Subex	-	-	2	-
i-flex	1	-	1	-

Source: DQ estimates

- *Move up the value chain: More valuable business expertise?*

Supplying technology intensive products and services is not the only way of moving up the value chain; providing organization capability intensive services is another, and this is the route the leading Indian software firms will likely take. They may try to diversify into emerging niches without entrenched incumbents, as for instance TCS's forays into bio-informatics show. A select few may attempt to acquire the required hardware capability to become systems integrators, though that remains to be seen.

For the most part, however, the leading Indian software firms shall strive, quite sensibly so, to become capable of executing large, complex, multi-year software development, implementation and maintenance projects. In so doing, they will build upon their existing business units which focus upon serving selected industries. Indeed, this sort of "vertical" focus is more prominently visible among Indian firms which entered later, and hence, are smaller, and also less successful at competing for large multi-year projects. Examples include Cognizant in healthcare, Polaris in banking, RMSI in geographical mapping and GIS, and Geometric Software in CAD software and services.

In bidding for large scale projects, the established Indian firms will run up against established incumbents such as the global services division of IBM, Accenture, and EDS. The outcome of this impending clash is unclear, although the advantage must lie with the American incumbents. Whereas the Indian firms perhaps have an advantage in terms of superior access to the Indian labor market, the latter have much greater demonstrated expertise in large projects in a wider range of end-user sectors, established relationships with customers, and global presence. The latter also appear to have realized the seriousness of the challenge and have begun to recruit heavily in India, for the software to be developed in India itself. For instance, IBM Global Services is believed to have over 50,000 employees in India in 2007. By themselves developing software in India, American (for they are almost all American) software service and solution providers hope to lower their costs, and thereby undercut the only significant advantage that Indian software firms are thought to enjoy.

Even so, Indian firms have become experts at a "global delivery" model of software services, wherein some of the work is done offshore and some done on-site, using the large number of talented but often poorly trained and inexperienced engineering graduates, a substantial fraction of whom will stay with the firm for a couple of years before moving on.[19] As

[19] Some idea of the importance of the last point can be gleaned from the recent move at Infosys, where the company's longstanding CFO, Mohandas Pai, moved to head the human resources function, a move that would be inconceivable in an American context.

already noted, operating under these conditions, Indian firms were forced to develop management practices to cope.

This business model, which Indian firms stumbled into, is something that their foreign competitors have to learn. There is no reason why they should not be able to do so, but the Indian firms have a head start. A recent news item noted that Accenture's market value is below that of TCS and Infosys, even though Accenture is substantially larger. Given Accenture's technical capabilities, this may reflect investor skepticism about its ability to be as cost-effective in software service delivery in a geographically distributed environment. On the other hand, the Indian firms will have to learn how to operate as global companies, with a multinational workforce, a task they have only recently, and timidly, embarked upon.[20]

Table 9: Examples of large contracts obtained by Indian SW firms

Date	Indian firm	Client	Contract type	Value (million) (period)
2006	*Wipro*	*GM*		*$27-$300*
Sep 2005	*TCS*	*ABN*	*SW Dev*	*$260*
Sep 2005	*Infosys*	*ABN*	*SW Dev, maintenance*	*$140*
Aug 2003	*L&T*	*Motorola*		*$70-90 (3-5 yrs)*
Aug 2003	*Satyam*	*Certain Teed (USA)*	*Implement supply chain solution.*	*$15 (9 months)*
Jun 2003	*HCL*	*Airbus*	*Embedded SW*	*-*
April 2003	*HCL*	*B T group (UK)*	*Business telemarketing, billing conferencing*	*$ 160 (5 years)*
April 2003	*Infosys*	*BT group (UK)*	*Second service provider for BPO services*	*- (5years)*
Mar 2003	*Patni r*	*Guardian Life (US)*	*Gap analysis and implementation.*	*$35 (7 years)*
Mar 2003	*Ramco-Boeing*	*Aloha Airlines (US)*	*Technical services with main marketing by Boeing (50% of revenues for each)*	*-*
Nov 2002	*TCS & Wipro*	*Lehmann Bros.*	*IT outsourcing*	*$50-70*
Jan 2002	*TCS*	*GE medical*	*'Take or pay' model,*	*$100-120 (2 yrs)*
July 2001	*Wipro*	*Lattice Group (US)*	*Outsourcing*	*$70 (3 years)*

Based on Athreye, 2005, and author's additions.

As the Indian market grows, MNCs will start aggressively going after "local" business. For example, the 10 year deal between Accenture and Dabur for management of Dabur's IT

[20] Even Infosys, the most global of the Indian software firms, has only 3% of its employees who are not Indian nationals.

needs, the Bank of India-HP deal for branch office computertisation, $750m Bharti-IBM deal and the mega Reliance Infocomm telecom network & Reliance retail petrol pump projects with IBM are clear indicators of what can happen in the Indian landscape. The lack of hardware and systems integration capability are clearly a weak area for Indian software firms. On the other hand, this is the flip side of the coin of comparative advantage. Indian firms have certain relative strengths which imply corresponding relative weaknesses. Contrast this with the Chinese case where local business is almost exclusively the preserve of local firms, all which are incredibly diversified (Tschang and Xue, 2005), and none are internationally competitive.

Moreover, one should distinguish between the prospects of Indian firms and prospects for India as a location for software and IT. The latter is surely brighter. Leading multinationals such as IBM, Accenture and HP employ well over 80,000 in India. If Indian firms are indeed deficient in certain aspects of management, these multinationals could be the training ground for new managers and the seedbed for new startups.

A greater threat may perhaps come from the technology itself. Evangelists for service oriented architectures, software components, utility computing and so on, paint a picture of a world where users will no longer have to invest in large in-house IT infrastructures; instead, computing will be like a utility – a menu of services that organizations can use, varying the scope and scale according to need. More importantly, the tedious business of maintaining and upgrading applications, and keeping up with changes in underlying computing platforms will become much less tedious: Information infrastructure providers, such as IBM, H-P, EMC and others will take on this task for them. The market for third parties, such as TCS, Wipro, and Infosys, to customize, enhance, and maintain the existing software infrastructure will shrink quite dramatically.

That is, of course, if such a state comes to pass. Information technology has so often promised "automation" that will reduce demand for skilled (and expensive) workers only to deceive. A number of difficult problems, both technical and organizational, would have to be solved to achieve this state. Even if this state of bliss were realized, it would take a long time. Much like old soldiers, old code never dies but fades away, often very slowly.[21] Prognosticating about technology is best left to experts, but a reasonable guess is that for the next decade or so,

[21] Bresnahan and Greenstein, (1996), in a detailed study of client-servers, show that the diffusion of client-servers was slow and incomplete, and was the slowest when computers were used to run business processes. I conjecture that the spread of service oriented architectures will encounter a similar fate.

demand for software services shall keep growing. The growth in emerging markets, and especially the Indian economy may provide an additional source of demand, which will surely be satisfied by Indian programmers, albeit perhaps working for a foreign company.

VII Implications for the Indian Economy:

Impressive though the Indian software industry may be, its direct economic impact is small, though growing rapidly. Table 10 below shows that the total employment is IT Services is about 800,000, a miniscule fraction of the 340 million strong workforce. Panagariya (2006) cites data which indicated that business services (which include IT services) comprised only 1.1% of GDP in 2000. However, even as GDP has grown at a healthy clip since then, IT services have grown even faster. Data from the Ministry of Finance indicates that IT services accounted for 4% of GDP in 2004, which speaks to the astonishing growth of this sector.

Projections from the same source foretell of much greater future impact. The Economic Survey 2005 projects that value added in IT and in BPO services is expected to be 7% of GDP by 2008. Further, exports are expected to be around $60 billion by 2010, accounting for 35% of all Indian exports (MOF Economic Survey 2005, Box 6.2). This projection appears to be based on an assumption that software export revenues will continue to grow at 30% per year, an assumption that appears optimistic. If it should come to pass, this would be astonishing for a sector which even today barely employs 1.2 million people, out of a labor force of over 360 million.

Table 10: Employment in the Indian Software and Services sector

Sector	FY 2004	FY 2005	FY 2006
IT Services	614000	741000	878000
ITES-BPO	253000	316000	415000

Source: Nasscom (IT factsheet), www.nasscom.org (accessed 18 Sept 2006)

Even more optimistic are the long run projections, such as those from a study by the AIMA and BCG, cited by Srinivasan (2006), which projects that by 2020, remote service exports and in situ services to foreigners could lead to export revenues between $139 billion (if IT service exports grow by 10% between 2010 and 2020) and $365 billion (if exports grow by 20%), and additional employment of between 20 and 72 million. The employment projections appear to be the most suspect. As Panagariya (2006) notes in a broader context, this is unlikely to happen without substantial improvements in the physical infrastructure, particularly electricity, and ground and air transport.

Bottlenecks in the supply of the required human capital may also prevent these projections from being fulfilled. Even non IT business services require college graduates at the very minimum, and barely 7% of the college age population is actually enrolled in universities. India's output of master's and Ph.D.s is barely 3% that of the U.S. and more than 60% of postgraduate seats in engineering colleges are vacant. The consequent low output of postgraduates has serious implications for training of future generations. (World Bank, 2000, Annex 1, para. 23, cited in Kapur, 2001). The mounting budget deficits of the public and private sector make it unlikely that large public investments in university education capacity are forthcoming.

However, as the Indian experience with engineering education has indicated, Indians are willing to invest in education when it yields an economic return, and Indian entrepreneurs are willing to supply it. I suspect a similar process has been going on at the pre-university level, both in terms of formal schooling as well as the informal "cram" schools and coaching classes. As with the private engineering colleges, the quality of teachers and of the education provided are uneven in quality. Most private engineering colleges have virtually no research capability. Many even employ teachers with only a baccalaureate and limited expertise and teaching experience. On the other hand, the existing public funded schools and colleges are not much to write home about either, with the exception of those at the very top. Moreover, one must avoid making good the enemy of best: Compared to the alternative of relying solely upon publicly funded education (which even the Indian middle class has not done, at least for pre-university education), private schools and colleges, even of uneven quality, are a Pareto improvement.

In this respect, Panagariya (2006) makes a number of sensible suggestions including relaxing the regulation on the number of students colleges can admit in various fields, the fees they can charge and so on. The most important of his suggestions, to my mind, is relaxing the control of the University Grants Commission and encouraging decentralization of decision making and control. Here again, the software industry experience is instructive. In 1990, only six states permitted private engineering colleges. Rising inter-state competition pushed all the remaining nine states to allow private colleges by 1999. There is anecdotal evidence that suggests that in this, state governments were responding to middle class demands. The broader point is that competition between states, for talent and firms, is important and must be allowed freer reign. This will enable market forces to drive improvements in quality in education, and will have broader benefits as well.

I am, however, not optimistic that the private engineering colleges will see it in their (short run) interest to subsidize the production of masters and PhD education. If, as appears to be happening, these private engineering colleges have to compete for students, some may decide to move up-market by hiring well qualified professors, paying them higher salaries. This may provide some incentive for investment by individuals in PhDs. However, this mechanism by itself will likely be insufficient. It will require government investment and ideally even some substantial investments by the leading IT firms operating in India.

But the excitement regarding India's software exports has never been about its employment generation capability. Rather, it is an example of what was possible. In other words, it is the indirect and less quantifiable impacts that have always held the greatest attraction for me. As we concluded in Arora et al. (2001)

> (O)ur 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 are finding firms developing a variety of new software products, components and technologies. (S)oftware service firms are exemplars of organisational forms and practices that are relatively new to India. A large number of software firms are *de novo* start-ups, indicating that the supply of entrepreneurial talent appears to be forthcoming when the opportunity arises, even in new and technology intensive sectors. ... Top managers of the leading software firms have been profiled in the popular press in India and are viewed favourably 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.
>
> (Arora et al., 2001: 1287)

This faith appears to have been vindicated. Athreye (2005) argues that the organizational capabilities, developed by the Indian software firms are generic in the sense of being applicable to sectors other than software. This is true in areas such as engineering services, where leading software firms such as HCL and TCS have a substantial presence (see table 7 above). This is also true in the more rapidly growing area of business process services. Indeed, some of the entrants into the BPO sector have been IT firms. Table 11 shows that of the top leading BPO firms in India, two of the top five and four of the top ten are also leading software firms. These account for nearly a quarter of the employment of this group. The table also shows the diverse sources of firm entry, and how closely it mirrors the sources of firm entry into software – startups, spinoffs, business houses and multinationals.

Table 11: Leading BPO Firms in India

	Empl	% voice	Start Year	Software	Origin
Genpact	26000	20	1997		Spin-off (GE)
IBM Daksh	18000	67	2000	Yes	
Wipro	16000	86	2000	Yes	(Acquired Spectramind, a startup)
WNS	10000	30	1996		Start up – Diaspora
Convergys	10000		?		MNC
HCL BPO	10000	70	2001	Yes	
Intelnet	9500	60	2000		Startup – HDFC
Mphasis	8300	80	1999	Yes	Spin-off (Citibank)
Aegis	8000	75	2004		Business House (Essar)
Sutherland	8000		1986		MNC
Hinduja TMT	7500	70	2001		Business House
ICIC One-Source	7300	70	2001		
EYesL	7300		1999		Start up – Diaspora
Progeon (infosys)	7000	18	2002	Yes	
24/7	7000		2000		Startup – Diaspora
TCS	5000	15	?	Yes	
Efore	3200		1999		Startup-Diaspora
Vcustomer	3000		1999		Start up – Diaspora
Sitel India	3000	73	2000		MNC
Transworks	2235	78	1999		Business House (Birla)
GTL	1700	90	1999		
Datamatics	1125	0	1991	Yes	
Techbooks		0	1988		
Efunds					MNC

Source: The list of BPO firms and their size is from Dataquest magazine, the origins are based on information available from company websites.

There are even more intangible, but no less important, impacts. Software made the "Brand India" a respected one, paving the way for other sectors. For instance, there is a small but growing set of firms that develop semiconductor technology and provide affiliated services. The Indian Software Association estimates that about two hundred semiconductor companies currently operate a facility in India, and of these, about sixty percent are involved in chip design (the remainder do software development). The membership of the ISA itself consists of over a hundred firms, most of which are American firms in semiconductor design, manufacturing and design tools and services. Of these, about half are American firms. A fifth are firms headquartered in America with CEOs of Indian origin, and another fifth are Indian firms, including HCL, Wipro and TCS. The success of software exports surely played a role in signaling the potential of India as a location for such activities. The software industry also led the fight for regulatory reforms, in areas such as liberalizing access to the stock market and listing requirements. It also led the way in corporate governance, with their emphasis on transparency and ethical management.[22]

But perhaps the most important of all is that software showed to potential entrepreneurs what is possible with talent, luck and hard work, that success is not reserved for those with connections or for those born to wealth (Kapur, 2002). Hitherto, wealth was acquired in India by breaking laws or at least bending them to one's convenience; software was the first instance where wealth was created honestly and legally, and more important, visibly so. Hitherto commercial success in India had invited envy, cynicism and even outright hostility, and only rarely, admiration. While envy and hostility are by no means gone, there is much more of admiration, and more importantly, a desire for imitation.

[22] A recent news story reports that Infosys fined a member of its board of directors for not following procedure in a trade involving the companies stock. http://news.oneindia.in/2006/08/31/infosys-fines-director-breaching-code-conduct.html

Appendix Table 1: NASSCOM Top twenty Indian IT service exporters, 2005-06

Name of firm	Year Est.	Origin/type of firm	Notes
TCS	1968	Business house	Founder US educated
Wipro	1980	Business house	
Infosys	1981	Spin-off (Patni)	
Satyam	1987	Business house	Founder US educated
HCL	1991	Entrepreneur	
Patni	1978	Entrepreneur	Diaspora
I-flex	1989	Spawn (Citibank)	MNC spawned
Tech Mahindra	1988	Business house	
Perot Systems	1996	MNC	(earlier joint venture with HCL)
L&T Infotech	1996	Business House	
Polaris	1993	Entrepreneurial	
Hexaware	1989	Entrepreneurial	(Venture funded)
Mastek	1982	Entrepreneurial	
Mphasis BFL	1992	Spin-off (Citibank)	Diaspora
Siemens		MNC	
Genpact	1997	Spawn (GE)	MNC - Diaspora
IGate	1993	Entrepreneur (US based)	Diaspora
Flextronics	1991	MNC	(Hughes Software) - Diaspora
NIIT	1981	Entrepreneur	HCL spawned
Covansys India	1985	Entrepreneur (US based)	Diaspora (CBSL)
Accenture		MNC	
IBM India	1987	MNC	
Cognizant	1994	Spawn (Dunn & Bradstreet)	Diaspora
HP Globalsoft	1988	MNC	Digital Globalsoft
Syntel	1980	Entrepreneur (US based)	Diaspora
Kanbay	1991	MNC	Diaspora founded

Appendix table 2: Oracle and TCS incomes statements, 2004.

Oracle Corporate Income Statement

REVENUES	**2004**
New license	3,541
License updates	4,529
Software	*8,070*
Services	2,086
Total rev	**10,156**
Operating Expenses	
License updates and product support	547
Sales & Market	2,136
Cost of services	1,770
R&D	1,278
G&A	561
Total Expenses	6,292
NET INCOME	**2,681**

TCS Income Statement

REVENUES :	**2004**
Consultancy services	1461
Sale of equipment and software licenses	*108*
Other revenues	13
Total revenues	**1583**
Operating expenses:	
Selling, G&A expenses	314
Cost of services	760
Cost of equipment and software licenses	97
R&D	7
Net income	**405**

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