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The Indian software industry and its evolving service capability

Suma S. Athreye

This paper examines the growth of dynamic capabilities among firms in the Indian software industry by looking in some detail at the changing constraints, opportunities and competition facing incumbent firms. It emphasizes the important role played by tight labour market conditions in inducing investment in process capability and the role of entrepreneurial experimentation in evolving a business model (outsourced software) that was best suited to limited resource advantages of Indian software firms.

1. Introduction

The growth of the Indian software industry has been a phenomenal success when measured against standard indicators such as growth in sales, employment and exports, and especially when contrasted with the performance of other industrial sectors in India. Even measured against successful new exporters of software, such as Israel and Ireland, the Indian software industry stands out in terms of the volume of employment created and the indigenous nature of its growth.

The largely untold story of the Indian software industry centres on the abilities of the pioneer firms in the industry who learnt how to transform the programming skills of their labour force into firm-specific capabilities, and to become credible rivals of firms such as Accenture, EDS and IBM Services in the outsourced-software market. The particular strength of Indian firms was their ability to assemble teams of talented engineers and deliver a technical, outsourced service to exacting and different customers anywhere in the world. They also leveraged their capabilities for maximum economic value through the adaptation and perfection of a new business model. This model was based around an outsourced service offering, and different variants of it were developed by Indian firms as new economic opportunities arose. Over time, one variant of this outsourcing model commonly known as offshoring, has come to be applied to other domains and areas: call centres, financial services and other forms of content management services of large firms that can be done remotely. As a result, India now enjoys a 'created' comparative advantage in outsourced services and offshoring.

An interesting aspect of the history of outsourcing is that the factors that were crucial to the emergence of outsourced software exports from India were quite distinct

from those that sustained the competitive edge of Indian software firms, and hence the growth of the industry overtime. For example, while abundant (and cheap) human capital were the basis of India's early software exports, the growth in software exports was based on improved productivity of the industry. We argue that this improved productivity was due to the development by Indian firms of dynamic capabilities, which enabled them to use changing economic opportunities to carve out a niche in the export of outsourced services.

This paper describes the evolution of outsourced service capabilities in Indian software firms, and studies the factors that were important in this evolution. Since the industry is relatively young vast amounts of diverse information can be drawn on—business association statistics, business and trade press reports and the actual experience of managers in software firms gathered through detailed interviews. The Appendix lists the main sources of quantitative and qualitative information used in this paper.

The paper is organized as follows. Section 2 briefly reviews the literature on firm capabilities. Section 3 describes the salient features of India's software growth and Section 4 identifies four phases of growth. Each phase can be seen as replying to a different configuration of policy and demand factors which had implications for the evolution of the industry. Section 5 argues that growing competition in the labour market through the 1990s induced firms to invest in process management and organizational capability. Section 6 concludes by summarizing what can be learnt about capability formation in developing economies from the Indian software case study.

2. Dynamic capability and competitive advanatge

The literature on firm capabilities originated in the writings of Penrose (1959), who posited that the growth of firms was conditioned by their particular inherent resources and a desire to exploit these more fully. A rich tradition of literature on strategic management built on this perspective to predict what strategies firms would employ for growth (e.g. diversification as in Rumelt, 1984) and the problems involved in growth strategies that stretched the core competencies of firms. Little attention was paid in this literature to the mechanisms by which such capabilities came into being. Nelson and Winter (1982) argued that each firm's access to technological and organizational knowledge is different and conditioned upon its past learning. In their view, firms typically mastered a technology or a production practice through physical investment in machinery, in training people to operate it, and through trial and error, which pushed to the limits their use of the production process. This kind of learning and the consequent stretching of profit possibilities in production is 'localized' within firms and difficult to imitate by other firms, thereby explaining the persistence of leadership by some firms. The persistence of firm rents (profits) in the longer term stemmed from the inimitability by rival firms of unique resources. This perspective underlines the heterogeneity of firm capability as well as its stickiness.

However, as Teece *et al.* (1997: 529) point out, 'competitive advantage is not just a function of how one plays the game; it is also a function of the assets that one has to play with and how these assets can be deployed and re-deployed in a changing market'. Teece (1998: 72) defines dynamic capabilities as 'the ability to sense and then seize new opportunities, and to reconfigure and protect knowledge assets, competencies, and complementary assets and technologies to achieve sustainable competitive advantage'.

Accordingly, the dynamic capabilities framework outlined by Teece *et al.* (1997) proposes a triad of factors that influence the development of a firm's competitive advantage: the firm's internal processes (organizational and managerial); the firm's (asset) positioning in the market; and the paths open to it consequent on the first two factors. Often the paths open to firms may be quite narrow, making value-augmenting strategic change slow and incremental.

These sources of rents are subject to internal and external influences. For instance, policy changes may affect the amount of external assets available to firms,[1] new entrants might imitate or innovate and open up new paths for deployment of the firm's resources, and the availability of human capital and expansion in the scale of production will provoke a response from the firm's internal processes.

Perhaps one of the most important factors in the deployment and re-deployment of capabilities is the possibility of leverage. Which product market niche or business model best utilizes the internal and external assets of the firm? Teece (1998: 72–75) notes the importance of sensing and seizing such advantage in realizing the best value for a firm's resources in a knowledge economy. In turn, this recognizes the value of entrepreneurial processes as well as strategy within firms in finding the best leverage for their knowledge assets.

Among studies on successful catch-up by latecomer firms that have employed a dynamic capabilities perspective in evaluating how developing economy firms gained competitive advantage, Mathews (2002) emphasizes the importance of linkages (to foreign markets through multinational clients), leverage (of existing cost advantages) and learning (of technology and processes) as being central to the success of East Asian firms. Similar processes were also true of dynamic capability building in Indian software firms. The main advantage enjoyed by Indian software firms in the 1980s was the cost advantage of cheap engineering talent. By the end of 2001, the leading Indian firms possessed unique capabilities in outsourcing across a range of services to large multinational clients.

Thus, the evolution of the Indian software industry provides an opportunity to explore the mechanisms that underlie dynamic capability building within firms in developing economies.

[1]See the discussion on institutional assets in Teece (1997: 522). This includes access to external stock market listing and the ability to use foreign exchange to buy firms in other countries.

3. Salient facts about the growth of Indian software

Figure 1 plots the spectacular growth of software revenues between 1984 and 2002. Several important features of India's software growth are discernible here. First, export sales have been crucial to the rise in industry revenues. More than two-thirds of the software industry's sales in 2000 were due to export sales, and this percentage continues to climb with exports accounting for nearly 80% of industry sales in 2001–2002. Second, sharp growth in the mid 1990s and the slowing down of growth after 2000 can be seen. Thus, the compounded annual average rate of growth of software revenues for the 1995–2000 period was 37.5% per annum, compared with 14.5% per annum recorded in the period 2000–2002.[2] Third, the long tail: few realize that even as far back as 1984 Indian software was producing export revenues. Although in comparison to the revenues earned in the mid-1990s this early revenue was somewhat insignificant, it did exist, suggesting that the industry was established more than a decade before the export boom.

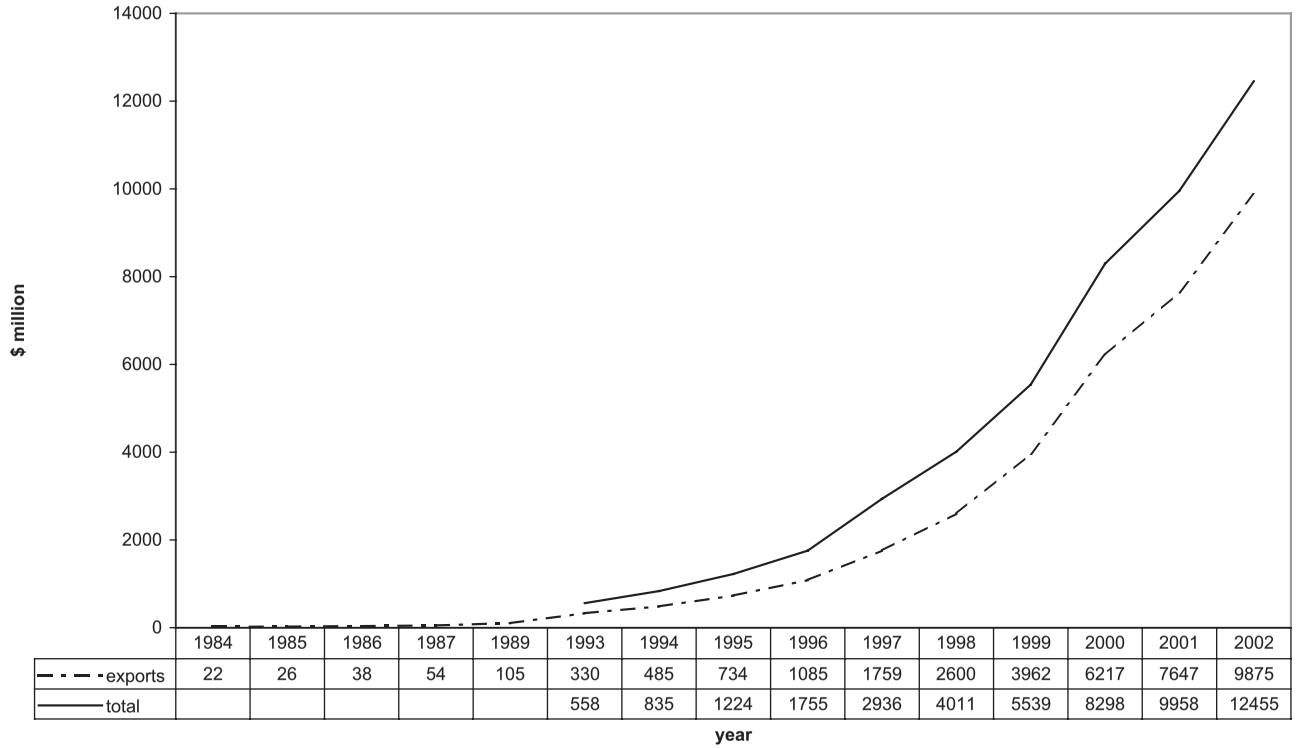
What is different or special about the Indian software industry? The predominance of exports marks it out as an export-led industry, but even when compared with other successful exporters such as Israel and Ireland, Indian software growth is different.

Unlike Israel's industry, the Indian software industry was built mostly around customized software services rather than products. The customized software services market is a large-volume market. Many types of services, such as those involved in the maintenance of data/legacy systems, are low-value services. The Indian software industry has for the most part specialized in these relatively low-value activities and this low-value content of the software services industry is reflected in the level of productivity. Table 1 shows the revenue per person for Indian software, which is much lower than the figures for Ireland and Israel. India's average productivity is growing: Table 1 shows that the annual average rate of growth of software revenues per person in 1993–1998 was more than 16% per annum.

Unlike the Irish software industry, domestic rather than foreign firms led Indian software growth. India's software exports are largely the products of Indian firms. Of the top twenty exporters in 2000–2001 listed in Table 2 only five firms are subsidiaries of foreign firms. A number of different types of entrants were attracted by the profit opportunities presented by the software industry in India. These included multinational subsidiaries—foreign (US) firms set up by expatriate Indians, subsidiaries of Indian business houses and entrepreneurial firms often set up by IT professionals. Indeed all these types are represented in the list of leading firms in Table 2.

It is significant, however, that among the leading firms entrepreneurial firms were almost as important as business house firms. Table 3—based on a classification of firms in the industry association directory (National Association of Software and Service Companies, or NASSCOM) according to entrant type, namely entrepreneurial,

[2]Since these are estimated on dollar values, they correct for the impact of the sharp devaluation of the rupee in that period.



	1984	1985	1986	1987	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
exports	22	26	38	54	105	330	485	734	1085	1759	2600	3962	6217	7647	9875
total						558	835	1224	1755	2936	4011	5539	8298	9958	12455

Figure 1 The growth of software revenues in India, 1984-2002.

Source: Figure 1 is based on two sources of data. Data for 1984-89 are as quoted in Lakha (1994), While data for 1993-2001 are based on NASSCOM reports.

Table 1 Revenues per person in Indian software

Year	Revenue/employee ($)
1993	6200.00
1994	7076.27
1995	8742.86
1996	10968.75
1997	14833.33
1998	15600.00
1999	34606.9
2000	35129.55

Figures for 1999 and 2000 are computed by adding revenues and employment of all firms in the NASSCOM register, while those for earlier years are calculated by using the total revenue and employment figures for the Industry. The two sets of figures are not directly comparable.

Source: author's computations based on NASSCOM (various years).

business house subsidiaries, multinational firms, and so on—shows this clearly (see Table A1 for the classifications employed). The last two columns report on the share of industry revenues and employment by type of entrant in 2000–2001. Industry revenues are fairly evenly shared between foreign firms (including those owned by US-based expatriates) and entrepreneurial firms, followed by business house subsidiaries. Thus, in 2000–2001, more than two-thirds of industry revenues accrued to domestic firms.

Lastly, the Indian software industry has retained a largely competitive structure. We can see from Table 4 that the top five and top ten firms have always accounted for a low proportion of industry sales (reported in the last two rows as CR 5 and CR 10). The table also reports the market shares of the top ten firms (in 2000) over the period 1994–2001. There are signs of a Schumpeterian creative destruction. New entrants, such as Cognizant and IBM India, were soon among the top ten revenue earners.

4. Evolution of the Indian Software industry: phases of growth

Characterizing any growth process by phases is an arbitrary imposition since growth is an ever-unfolding process, with each new stage building upon the previous one in many and complex ways. Periodization usually reflects what the writer wants to highlight—in this case the strategies of individual firms as they responded to changing

Table 2 Top twenty exporters and the origins of the firms (ranked by annual revenue), 2000–2001

Name of firm	Year established	Origin/type of firm
Tata Consultancy Services	1968	Business house subsidiary
Wipro Technologies	1980	Business house
Infosys Technologies Limited	1981	Entrepreneurial (IT professionals)
HCL Technologies Limited	1991	Entrepreneurial (IT professionals)
Satyam Computer Services Limited	1987	Business house
IBM India Limited	1987	Multinational subsidiary
Cognizant Technology Solutions	1994	US firm with Indian back office
NIIT Limited	1981	Entrepreneurial (IT professionals)
Silverline Technologies Limited	1992	US firm with Indian back office
Pentasoft Technologies	1995	Business house subsidiary
Pentamedia Graphics	1976	Business house subsidiary
Patni Computer Systems	1978	Entrepreneurial (IT professionals)
Mahindra British Telecom Limited	1988	Joint venture
HCL Perot Systems	1996	Joint venture
DSQ Software Limited	1992	Business house subsidiary
Mascon Global Limited	1995	US firm with Indian back office
Mascot Systems Limited	1993	US firm with Indian back office
Tata Infotech Limited	1977	Business house subsidiary
I-flex Solutions Limited	1989	Spin-off from MNE subsidiary
Mphasis BFL Limited	1992	Joint venture

opportunities offered by the external economic environment. Changes in the external environment came from two directions. First, there were policy-induced changes as the Indian economy moved from regulation, to de-regulation and liberalization, as shown in Table 5 below. Second, there were changes in the world demand for software services as computerization spread across the Western world.

It is useful to think in terms of the following four periods in the evolution of the industry:

1. pre-1984, when the major thrust of government policy was towards achieving self-reliance in hardware capability and the most significant event for fledgling software firms was the dramatic exit of IBM, in protest at the Foreign Exchange Regulation Act (FERA) rules;
2. 1985–1991, when the worldwide crash in hardware prices and de-regulation of import licensing policy in India coincided with an acceleration in demand for software programming services as large multinational firms moved from mainframe to client–server systems. From 1986, software policy was de-linked and made independent of policy directed at the indigenous hardware sector;

Table 3 Entry dates and composition of firms, 2000–2001

Type of entrant	Year established					Number of firms	Share in revenues	Share in employment
	Pre-1980	1981–1984	1985–1991	1992–1999	2000–2001			
Business house firms	10	2	10	60	5	112	26.24	26.89
Multinational enterprises	1	3	24	80	20	128	11.29	16.28
US–Indian	0	0	10	38	10	58	7.87	7.87
Entrepreneurial firms	1	1	4	13	3	22	1.44	.85
Entrepreneurs with prior IT experience	11	8	46	129	35	229	36.99	34.10
Others	7	2	5	26	3	44	8.08	7.97
All firms						657		

For classification of type of entrant, see Appendix. 'Others' includes joint ventures and PSU. Shares of employment and revenue do not add up to 100 because of missing data on year of establishment. Ten multinational subsidiaries were established in 1991, and 25 were established following the second wave of liberalization of foreign investment rules in 1995–1996.

Source: author's computations based on NASSCOM (2002).

3. 1992–1999, which saw full financial liberalization in India, large-scale entry by multinational firms and a phenomenal growth in demand for software services. In the policy arena, innovative attempts were made to develop the telecommunications infrastructure and to broaden low-cost access to the internet through the establishment of the Software Technology Parks of India (STPI) scheme;
4. 2000 onwards, which saw a slowdown in the demand for software services, (but an expansion in the demand for outsourcing more generally), forcing some consolidation in the industry.

The changing constraints and opportunities in each phase of growth had many implications for the direction of the software industry's evolution. The main developments that occurred are discussed below.

4.1 Early entry: pre-1984

In the 1970s the Indian government tried to encourage exports by allowing those who developed software for export to make computer hardware imports. Export performance

Table 4 Looking back: instability of market shares over time of the top 10 firms in 2000–2001

Firm	1994–1995	1995–1996	1996–1997	1999–2000	2000–2001
TCS	13.44	12.28	11.43	8.35	8.32
Wipro	5.01	5.64	4.44	4.41	5.21
Infosys	2.13	2.23	2.28	3.62	4.91
HCL	7.63		4.68	2.60	3.38
Satyam	1.31	1.20	2.54	2.78	3.36
IBM India	n.a.	n.a.	n.a.	1.22	2.20
Cognizant	n.a.	n.a.	0.75	1.70	1.87
NIIT	1.99		3.37	3.07	1.81
Silverline	2.10	2.05	1.23	1.80	1.73
Pentasoft/Pentafour	2.26	2.69	2.72	3.27	3.22
CR 5	0.336	0.256	0.266	0.222	0.252
CR 10	0.449	0.342	0.373	0.316	0.345

Market shares are firm sales as percentage share of total industry sales revenue for that year. Pentafour Technologies was split into two firms, Pentasoft and Pentamedia. For comparability, the sales revenues of the two firms have been added up in the later years. The CR 5 and CR 10 ratios are computed as the proportion of industry sales with the five and ten largest (by sales) firms.

Source: Computed from NASSCOM registers, various years.

remained poor and Mr Menon, who headed the Department of Electronics in 1975–1976, singled out the inability of Indian software to break into markets as the main factor constraining software exports (see Subramaniam, 1992: 138). The tedious procedures governing foreign exchange and the inevitable delays in obtaining permissions for imports also prevented early software firms from moving rapidly in constantly changing markets.

The departure of IBM in 1977, in protest at the FERA rules, which required it to reduce its equity holding to 40%, was the single most important event during this phase. IBM's departure created an import substituting opportunity for domestic manufacturers of computers. The exit of IBM also provided an opportunity for foreign companies such as Burroughs and ICL to push sales of their computers in India. Both types of companies depended upon programmers in India to write software conversion programs that could be used by clients (ex-IBM) to switch to their particular computer systems.

Domestic demand for software also came from the public sector's attempts to build nuclear and space capabilities, and demand for programming and maintenance from banks and other mainframe users in India increased. A few high-profile public projects, such as the computerization of Air India reservations, the computerization

Table 5 Policy changes affecting the software sector: 1972–1999

Policy and year	What the policy did
Software Export Scheme, 1972	Permitted the imports of hardware for purposes of hardware development on condition that the price of hardware was recouped within 5 years through foreign exchange earnings.
Liberalization of policies related to software industry, 1976	Hardware import duties reduced from 100% to 40%. Faster clearance of software export applications. Software could take advantage of export incentives including location in Export Processing Zones. Non-resident Indians were allowed to import software for purposes of export. Export obligation was 100% of all output produced.
Software Export Policy, 1981	Import duties on hardware raised to encourage use of indigenous computers. Firms allowed to import hardware to write software for both domestic and export purposes. Software exporters could also import 'loaned' computers.
New Computer Policy, 1984	Import procedures simplified. Import duties on hardware reduced from 100% to 60% for software developers. Access to foreign exchange was made easier for software firms. Income tax exemption on net export earnings halved from 100% to 50%. Software exports were sought to be promoted through satellite based communication links with overseas computers, and the national computer network Indonet was made available for exports from public sector and small firms.
Software Policy, 1986	Software growth for the first time regarded as independent of hardware growth in the domestic economy. Imports of hardware liberalized and duties on them abolished for exporters of software. Export obligations for hardware importers increased: export obligations ranged from 250 to 150% of foreign exchange used, to be repaid to the government in 4 (rather than 5) years. A penalty was payable for non-fulfilment of the export obligation. Imported software attracted a 60% duty on its value. Special export obligations governed the use of dedicated satellite links.
Software Technology Parks (STPs) of India, 1988	Established under the Department of Electronics of the Government of India, the STPs were autonomous bodies to encourage and support small software exporters, by giving 100% export-oriented firms a tax-free status for 5 years within the first 8 years of operation. In addition, they were provided with office space and computer equipment, access to high-speed satellite links and an uninterrupted supply of electricity. STPs also

Table 5 Continued

Policy and year	What the policy did
	provided services such as import certification, software valuation, project approvals, market analysis, marketing support and training and 'single window clearance' for projects. STPs connected by an integrated network, so subscribers can lease a point-to-point digital channel, and have access to the internet with their own TCP/IP number, providing e-mail, remote log in, file-transfer services and access to the WWW.
	Export obligations applied to firms in the STPs using telecom infrastructure.
New Economic Policy, 1991	Devaluation and partial convertibility of the rupee.
	Abolition of foreign exchange for travel tax.
	Reduction in telecommunication charges for satellite links.
	Export obligations on STPs removed.
	Reduction of hardware import duties.
Import duties on imported software, 1992–1995	Reduced to 20% on applications software and 65% on systems software in 1994.
	Reduced to 10% on both in 1995.
Income-tax exemptions, 1993–1999	Software exports were exempt from income tax and this tax-free status was confirmed every year till 1995 after which it became open-ended. There is talk of ending this status in 2001.

of the ASIAD games results and the computerization of the Indian railways, provided valuable learning opportunities for the first domestic firms (author's interviews). Thus, software programming in India started early and, despite a small domestic installed base of computers, Indian firms were exposed to a large variety of software platforms and a range of projects that varied in their complexity. Thus a range of programming skills and knowledge of software languages was accumulated by Indian firms.

The dependence of software on hardware components during this period however, constrained potential entrants to the industry. Industrial policy did not help to overcome this problem. As India was still trying to build a domestic hardware industry through import substitution, duties on hardware components were high, and importers had to comply with a complex set of rules and regulations in applying to make imports of hardware and components. The period 1980–1985 saw many policy attempts to make software development grow at the pace set by the growth of the indigenous hardware industry. Thus, the Software Policy of 1981 emphasized the generation and export of software using India's existing computing capacity, rather than on the basis of imported computers. The 1984 Computer Policy retained the export obligations and

import tariffs that the industry was subject to. The only positive aspect was that since software was a service activity it was free from the restrictions of production licensing. This attracted to the sector entrepreneurs with access to private finance and some big business houses.[3]

Indian firms faced other constraints as well. The basic infrastructure required for software production, namely stable supply of electricity and good communications, was available only in some regions e.g. the Mumbai-Pune region, Bangalore and Delhi. In the early 1970s there was also a large technology gap, and though domestic firms clearly saw the strategic value of alliances with foreign firms as being a mutually beneficial way to upgrade their technological knowledge, only a few firms had access to foreign firms willing to enter such alliances (author's interviews).

Foreign revenues were a relatively small proportion of total revenues in the 1970s and in interviews it was estimated that only about a third of all revenues came from exports. The few software projects executed abroad by Indian companies in this early period often took the form of data conversion projects executed for the foreign firm on its premises—hence the term *on-site projects*. In the on-site model for software service delivery, the software exporting firm provided the personnel to execute the project while the client firm provided the specifications and in many cases the capital equipment needed. Payments for labour in this model were made according to time use. The on-site model was popular for two main reasons. First, it was often easier to 'hire in' the services of an engineer rather than trying to do the work in India. In this way the software skills of Indian programmers could be ratcheted up to reap maximum benefit and neither the supplier nor the buyer had to bear the higher costs resulting from the protection for domestic hardware manufacture and import regulation. Second, in the on-site model the client was assured of constant monitoring—an important guarantee in a period when Indian exports had the reputation of being of poor quality. In interviews, however, managers of firms also stressed the advanced nature of some of the work done in these early export projects, particularly as many of them involved simulating different operating systems on the mainframe computers the software company had.

Working within these infrastructure and policy constraints, the single major achievement of the early Indian firms was that they developed the ability to put together a team of talented software programmers and earned a reputation for delivering highly bespoke (technical) projects to large foreign firms operating with a variety of software systems. This owed much to the strategic vision of one firm—the industry leader and pioneer Tata Consultancy Services.

[3]Indian industrial policy during this period operated licensing for production capacity and for purchasing imports. While software was free of production, licensing it continued to be subject to import licensing.

4.2 New entry and experimentation: 1985–1991

The spread of computerization in the USA and in Europe received a major boost with the advent of the personal computer and networked computers in the mid- and late 1980s. The shift to networked computing in the late 1980s opened up a huge new source of demand for customized software that allowed firms to migrate from mainframe to networked systems and to the installation and maintenance of enterprise resource systems. On the policy front, the Software Policy of 1986 broke with tradition in allowing software to grow independently of domestic hardware. Hardware imports were de-licensed and made duty free for exporters, though such imports continued to include export obligations. World hardware prices fell dramatically lowering the entry costs of setting up in the software sector in India. At about this time the government also experimented with preferential procurement of domestic software and imposed a duty on all imported software.

Fortunately the 'freeing' of software policy occurred at a time when India still enjoyed a huge cost advantage in the form of low software salaries. A salary survey undertaken by *Dataquest* and published in 1989 reveals that the salary of a computer professional was around Rs. 8,000 a month ($5486 per annum), well below salaries in other industries. Posts in the Middle East had salaries of Rs. 14 000 per month ($9600 per annum) and included benefits and were tax free. In the same period, Microsoft was offering $40 000 plus re-location expenses and a green card for Indian software engineers.[4]

Foreign firms quickly realized the cost advantages of employing Indian programmers to write software programs. Thus, Texas Instruments and COSL established operations in India, despite the considerable restrictions on foreign investment that were still in operation in this period. US multinationals in particular balanced infrastructure constraints with the benefits of the time difference between India and the USA. The 12 h lead enjoyed by Indian firms allowed them to utilize hardware facilities lying idle in the USA. The time difference effectively extended the US working day for the client firm. The expenditure on a dedicated satellite link was more than compensated for by the cost advantage of software salaries in India.

Indian software firms, many of whom were already involved in the maintenance of mainframe systems, slowly tapped into the emerging global demand often based on their good reputation with previous clients. The tasks involved in writing migration software were sufficiently routine to be outsourced, but they required knowledge of diverse software languages and protocols that Western firms wanting to computerize their operations would have found expensive to acquire. The domestic market too saw some change. The advent of microcomputers and personal computers coupled with the fall in hardware prices facilitated the spread of computing to small users in the domestic market. The installed base of computers between 1983 and 1987 in India is

[4]Dataquest figures are as cited in Subramanian (1992). Conversion rate used Rs. 17.5 = $1.

estimated to have grown from 3500 systems to 26 560 systems (estimates from Lakha, 1994). It was possibly this that gave rise to expectations of creating a mass market in Indian packaged software products, though duties of 60% on imported software may also have played a part.

Lower hardware costs encouraged entrepreneurial entry into the sector (Table 3). New entrants also investigated diverse product spaces. The first product firms (such as Sonata and Mastek) appeared with product offerings for the domestic market. Mastek was also the first to experiment with a product model based on the use of software tools (author's interviews and CMU interview notes, please see Appendix for description of data). Infosys and Wipro also developed products in this period and NIIT (National Institute of Information Technology), an educational training company, grew substantially.

On the whole the software product model was a failure. The technological capability needed to write a software product was simply not enough. The domestic market for products was not deep enough and the foreign market was hard to penetrate. The lack of access to risk capital to absorb early investments, and the lack of marketing ability are often cited by firms as major reasons why they failed in the product segment. Some firms also found that their products were being overtaken by those of foreign competitors (author's interviews and CMU interview notes). One firm suggested that lax intellectual property rights (IPR) protection always made software products less profitable as Indians had got 'used to getting their software free'.

Many of the constraints faced by software product firms were bypassed in the outsourced service model. Here the structure of costs was mostly variable and service projects paid for their costs as they neared completion. Reputation and investments in quality substituted for large marketing outlays. Interaction with demanding foreign customers encouraged and informed firms about what investment was needed in quality and process control. The per unit profits on service exports were far more stable than those on domestic products or services, and services firms saw steady growth.

As a consequence of this entrepreneurial experimentation with product and service models, the on-site services model emerged as the dominant business model by the end of the 1980s. The basic value proposition and capability that prevailed was the ability to deliver a working team of software professionals capable of undertaking any software engineering job, to any part of the world.[5] NASSCOM estimates suggest that in 1988 nearly 90% of software revenues came from on-site work. Even firms that had started in products, such as Sonata and Mastek, changed to the on-site services model by the mid-1990s. Since the successes and failures were visible to all firms, entrepenuership in the industry played a crucial role in alerting firms to the right opportunities to leverage the technical skills built in the previous period.

[5]Author's interviews. Infosys has also often emphasized it's 'global delivery model', which they describe as 'producing where it's more cost effective to produce and selling where it is most profitable to sell'. See Shekar (1998).

4.3 Imitative entry and financial liberalization: 1992–1999

The year 1991 saw many policy-induced changes in the Indian economy, including sharp depreciation of the rupee and the liberalization of financial flows. The depreciation of the rupee kept wage costs in dollar terms down in the domestic economy, even as software salaries were beginning to rise. The software industry also saw an important policy innovation in the form of the STPI scheme. Designed to overcome infrastructural constraints imposed by poor access to telecommunications, exporters could register with their regional STP for satellite links, and operate via the web, for a fraction of what it would have cost them to have their own dedicated lines. This dramatically decreased the cost of telecommunication access and increased its coverage so that offshore operations came within the reach even of smaller firms. Desai (2003) argues that many firms switched to web-based export delivery made possible by the STPI scheme.

The experience of Citibank and Texas Instruments had demonstrated that an Indian subsidiary of a multinational corporation (MNC) could operate as a low-cost outsourcing centre for its global software needs. Throughout the 1990s, when foreign investment norms were liberalized, a steady stream of multinational subsidiaries entered the market, often manned by Indian software professionals and management. Software was usually developed in the Indian subsidiary and teams of Indian software professionals travelled to the different countries to install it. While domestic firms such as TCS and later Infosys had already demonstrated the profitability of the on-site model with some offshore elements, the operations of MNC subsidiaries identified the major elements of a successful offshore model: investment in telecommunication links, and good process management.

Domestic firms were quick to seize the opportunity to reap greater profit offered by the offshore model and they contracted with foreign firms to provide software services written at their own centres located in India, usually for a fixed price. These Offshore Development Centres (ODCs) were usually dedicated to serving one firm, and large firms like Wipro and TCS established dedicated offshore development centres for each of a number of large multinational clients. The benefits to the foreign firm in operating with an Indian ODC lay in the lower fixed costs they had to maintain—it was definitely cheaper in areas defined as non-strategic than setting up their own subsidiary. ODCs only had total autonomy for small, specific and non-critical tasks. Some Indian firms sought to reduce the risk involved in dependence on a single customer by signing up with a several multinationals. This possibly provided economies of scope, and the development of some generic project management skills.

Entry into software increased, as did the heterogeneity of entrants. The selling strengths that the different types of entrants brought to the basic model of outsourced software were all quite different. MNCs relied upon their own internal markets and grew with stable revenues. Business houses competed with established firms for different

sets of customers, based on reputation. Firms established by expatriate Indians with a US front office had good market access. Yet, despite this heterogeneity of entrants (and their potential resources and capabilities), there were no significant differences in the revenues per employee across the different types of firms when factors such as age, size and certification are controlled for.

The competitive pressure exerted by this new entry however, forced the market leaders to adopt differentiation strategies. One such strategy was to acquire quality certification, such as that proposed by the SEI-CMM.[6] This signalled the commitment to provide reliable and error-proof services and a willingness to be scrutinized. By the end of 1998, more than half of the SEI-CMM 4 and 5 rankings were awarded to Indian software firms. Another differentiation strategy was to acquire domain expertise, often through collaborations and the careful choice of partners within the so-called development centres. Although the actual distribution of contracts does not show this, the intentions of the leading companies, presented in company annual reports and declarations to shareholders, suggests that there was selectivity in the choice of domains: TCS and Infosys concentrated on the domains of finance and insurance, Pentafour concentrated on creating digital assets in animation, Satyam sought to concentrate on software for automated systems in transport manufacturing, and Wipro focused on telecommunications and research and development (R&D) services.

Infosys became the first Indian firm to be listed on the NASDAQ, though it did not make any acquisitions until recently. Other firms soon followed. Listing in overseas markets added visibility and credibility to their technical services business.[7] In turn, the availability of various stock exchanges attracted venture capital financed funding and encouraged some start-ups in the software services sector by providing exit routes for entrepreneurs. Despite this, product firms (who most needed risk capital) still had difficulty finding venture capital firms willing to invest in them (for examples, see Krishnan, 2002).

By the end of this period, the Indian software industry had built up both a general capability (for outsourced service delivery) and various firm-specific capabilities (particularly in software process management). Firms with better-developed process management ability were able to improve their productivity. Table 6 shows in the median and third quartiles respectively the growing divergence in the characteristics of a typical firm and that of leading firms. The third quartile firms show larger-scale, higher capital intensity of production and higher productivity than the median firm.

[6]The Capability Maturity Model (CMM) is a structured process for software development associated with the Software Engineering Institute (SEI) at Carnegie Mellon University. It consists of five 'maturity' levels. Companies or units assessed at levels 4 and 5 are capable of controlling, managing and improving software development practices.

[7]See Shekar (1998) and Palepu and Khanna (2001). Both argue that the prime purpose of the Infosys listing was not to raise capital, but to increase visibility and be counted on par with other global firms.

Table 6 Characteristics of a typical firm in the median and third quartile

	1994–1995 ($n = 105$)	1996–1997 ($n = 225$)	1999–2000 ($n = 390$)
Median firm			
Size of authorized capital ($000)	248.41	352.11	928.07
Sales revenue ($000)	891.72	1080.56	1153.13
Export revenue ($000)	636.94	704.23	633.41
Total employment	85.00	115.00	96.50
Employment of software professionals	66.00	90.00	64.00
% of software professionals in total employed	77.60	78.26	66.30
Revenue per employee ($000 per person)	10.51	9.30	12.06
Third quartile firm			
Size of authorized capital ($000)	1206.69	1352.11	2552.20
Sales revenue ($000)	4554.14	3661.97	3712.30
Export revenue ($000)	3662.42	2552.11	3155.45
Total employment	230.00	315.00	230.00
Employment of software professionals	192.00	218.00	163.00
% software professionals in total employed	83.5	69.2	70.9
Revenue per employee ($000 per person)	19.75	11.55	16.24

[a] Calculated on firms with no missing data.

[b] A typical median firm is a firm that has median values for all the characteristics and similarly for the third quartile firm. This is a statistical artefact for benchmarking purposes rather than an actual firm.

At the same time, the median firm (representing the average Indian firm) also registered growth in productivity and scale—evidence of the growth of general outsourcing capability in Indian software.

Though experimentation with business models continued into the late nineties, it was different from the previous period in that it was more path-dependent. Domestic firms concentrated on developing more profitable variants of the outsourced service model that had emerged as being the most cost-effective in the early 1990s, applying it to different domains and to R&D services, moving up from on-site to offshore project execution, and moving from time and materials costing to fixed price contracts. There

were two outliers to this general rule: the successful development of a banking product by COSL (Flex-cube) and the less successful development of an ERP product (Marshall) by Ramco. Both products were targeted at smaller overseas customers rather than the domestic market.

4.4 Consolidation and slowdown: 2000 onwards

The slowdown in demand swiftly followed the dot.com crash and the recession in the USA. In anticipation of this event, attempts had been made to tap into other markets such as the European, Japanese and African markets. On the policy front, the long-awaited bill allowing private investment in telecommunications was passed. As a consequence, the costs of connecting to the internet fell sharply for all software producers.

Two main developments have marked the period since 2000: the growing size of outsourcing deals secured by the largest domestic software firms and the growing offshore component of revenues. It has been reported that top Indian companies were routinely winning multi-year offshore contracts valued at about $75 million, or 300 man-hours, values much higher than the $10–15 million contracts of the late 1990s which also were shared between many more firms.[8] Table 7 lists some of the deals reported in the national press, with their value and number of years involved.

The size of single outsourcing projects, the length of the time commitments, the size of offshore operations and the fixed-price nature of the contracts are the remarkable features of these contracts. To put these factors into perspective, it is useful to contrast them to the dimensions of a typical export project reported by Arora *et al.* (2001: 1274) based on interviews conducted in 1997 when billing by Indian firms was typically based on time and materials costs:

> Not only is the work outsourced technologically undemanding, the projects are typically small. The mean number of man-months involved in the most important export project in 1998 for firms that participated in our questionnaire survey is 510 man-months, whereas the median is only 150 man-months. Since the question related to the most important project, it implies that the typical export project is quite small.

The data in Table 7 thus testify to the growing process capability of the leading Indian software firms and the success of their attempts to increase value-added by integrating software writing services and front-end services such as customer management and technical assistance. Leading software firms seem to see business process outsourcing work as part of their strategy towards adding value based on the goal of becoming end-to-end consultants. Other firms have concentrated on expanding their more profitable offshore operations. NASSCOM estimates that the share of offshore revenues

[8]NASSCOM vice president Sunil Mehta, as reported in *The Washington Times* (2002).

Table 7 Large contracts bagged by Indian software firms reported in national newspapers (2001–2003)

Month and year	Indian firm	Contracting client firm	Contract type	Value (period)
August 2003	L&T Infotech	Motorola	Unknown	$70–90 million (3–5 years)
August 2003	Satyam	Certain Teed (USA)	Outsourcing contract to implement end-to-end supply chain solution. Fixed cost	$15 million (9 months)
June 2003	HCL	Airbus	Embedded software	–
April 2003	HCL	British Telecom Group (UK)	Outsourcing contract for business telemarketing, billing and conferencing work	$160 million (5 years)
April 2003	Progeon (subsidiary of Infosys)	BT group (UK)	Second service provider for BPO services	–(5years)
March 2003	Patni Computer Systems	Guardian Life Insurance Co. (US)	70% offshore contract for gap analysis and implementation of IT systems in the market place	$35 million (7 years)
March 2003	Ramco-Boeing	Aloha Airlines (US)	Technical services with main marketing by Boeing (50% of revenues for each)	–
November 2002	TCS & Wipro	Lehmann Bros.	IT outsourcing	$50–70 million annually
October 2002	Wipro	Ericsson	'Total' R&D outsourcing with Wipro taking over the Ericsson R&D centres in India	–
July 2002	Wipro	Transco (UK) (formed as a result of merger between Lattice group and National grid)	Application, maintenance support and integration services around SAP tools	$20 million
January 2002	TCS	GE medical systems	'Take or pay' model, whereby GE is committed to making a fixed payment irrespective of work done by TCS	$100–120 million (2 years)
July 2001	Wipro	Lattice Group (US)	Outsourcing	$70 million (3 years)

Source: author's compilation based on newspaper clippings.

in software services grew dramatically from 38% in 1999–2000 to 57% in 2002–2003. Other domains where the offshore model could be applied have been explored. These include the provision of e-services, web hosting, data transcription and e-CRM. These new areas have received an unexpected impetus from the recession, which has heightened foreign firms' sensitivity to cost pressures. Lastly, with the improvement in access to venture capital and corporate venture funds, a third strategy for value addition is being explored in new niche markets in technologically new areas such as DSP (digital signal processing) software, embedded software and system on chip (SOC). Firms in these areas are increasingly turning to a product-based model incorporating some kind of IPR protection.[9]

5. Tight labour markets and the pressure on organizational capability

The large-scale outsourced business model demands certain complementary organizational capabilities: the ability to scale up quickly in response to growth in demand; human resource management capability; software process management capabilities (to ensure fewer errors and greater reliability of the service product); and lastly, given that customers are largely overseas, the ability to manage global operations. Indeed, the offshore business model would not have succeeded without these parallel organizational capabilities. The period from 1991 to 1999 saw the development of such capabilities in a large number of Indian software firms.

The interesting question is what forced so many Indian firms to develop such capabilities? The huge mass of unemployed engineers in India did not encourage firms to invest in such capability. Indeed, it would have been far easier to employ one low-cost programmer after another than to invest in incentives and the development of organizational capability. The former was the strategy adopted in firms involved in the other successful Indian export sectors—gems, jewellery and leather exports—to remain price competitive. Software firms, however, chose the high road to export competitiveness, investing in developing organizational capabilities. To understand why, we need to look more closely at the labour market facing software firms and recognize the changes it experienced over the 1990s.

As the cost–quality advantage of Indian programmers became acknowledged, there was fierce competition for them from foreign competitors who persuaded their governments to increase visa quotas for Indian programmers, from MNC subsidiaries which established firms in India and from the entry of imitative domestic firms in the 1990s. The large stock of engineers was utilized and by the mid-1990s there were many signs of a tightness in the labour market. In 1998–1999, in response to the growing

[9]A notable example of this type of firm is Sasken, previously Silicon Automation Systems—an embedded telecom solutions company, which writes software across the telecom value chain.

scarcity of engineers, the government declared a state of 'educational emergency'. The three Indian Institutes of Information Technology were set up and private training institutions flourished. In interviews, firms confessed to pooling labour to alleviate temporary scarcities. Thus, if Firm A had a shortage of a particular type of skill (say a Java programmer) and knew that Firm B had employees who could do the job, they would 'rent' the employee from Firm B rather than leave a job uncompleted.

Wages in the software industry grew at over 30% per annum through the 1990s. Dollar rates were much lower, at about 7% per annum, as Table 8 shows. Even so, these rates were almost double those faced by other countries. Attrition rates of 20–22% were also well above the international average of 15%. Across a range of industrial sectors, software accounted for the highest wage bills at a time when competitive pressure was pushing billing rates downwards.

The vulnerability to employee attrition and upward pressure on wages created two different sorts of problems for domestic firms in the software sector. Rising wages increased the pressure on firm profitability due to growing competition in the product market. Firms were forced to restore profitability by increasing productivity. This increase in productivity was achieved in various ways: use of more efficient practices and the use of non-qualified labour whose engineering skills were acquired through firm-specific training. The manager of a foreign firm commented on the changing human resources profile thus:

Table 8 International differences in the salaries paid to software professionals (US$ per annum): 1995 & 1999

Year and position	USA	UK	Ireland	India
1995				
Project leader	54 000	39 000	43 000	23 000
Systems designer	55 000	34 000	31 000	11 000
Development programmer	41 000	29 000	21 000	8000
Quality assurance specialist	50 000	33 000	29 000	14 000
1999				
Project leader	65 600 (21.5)	47 400 (21.5)	52 300 (21.6)	33 700 (46.5)
Systems designer	66 900 (21.6)	41 300 (21.4)	37 700 (21.6)	16 100 (46.4)
Development programmer	49 800 (21.4)	35 300 (21.7)	25 600 (21.9)	11 700 (46.3)
Quality assurance specialist	60 800 (21.6)	40 100 (21.5)	35 300 (21.7)	20 500 (46.4)

Figures in parentheses indicate percentage change in salaries on 1995.

Source: www.man.ac.uk/idpm/for 1995 data, World Employment Report, 2001 for 1999 data.

> Yeah, the profile of the people who are joining the company has changed. Every body has started . . . accepting these as some part of their [labour] resource pool. They would be people with undergraduate degrees, people with postgraduate degrees in pure sciences, people with the different background who had some exposure to programming etc. Sometimes it doesn't matter whether you have exposure to programming or not, we will train you and make you. (Author's interview in a US-based firm)

Attrition meant the loss of employee-specific knowledge and the possibility that some of the organization's knowledge was passing to competitors. Attrition at senior levels also caused firms to lose portions of their customer base to the competition. Firms responded in some measure by adopting procedural norms that would make their software development immune to such attrition. One of these was to rely heavily on documentation and another was to start using proprietary tools wherever possible. New organizational structures evolved in order to maintain a mix of new and old employees through an informal deputising system. Skills gaps were identified and firms developed training programmes that would help maintain and upgrade their skill set. In time, firms were also able to use these procedures to institute better process control and to combine superior with lower quality workers (author's interviews).

Employee attrition and wage increases also prompted software firms to explicitly introduce human capital management strategies comparable to those exploited by their international rivals who were after all competing for the same labour. These included organizational practices designed to retain the interest and loyalty of employees, such as Employee Stock Options (ESOPs) and attention to charting a management career path for technical personnel in firms—perhaps the first signs of a technocracy.

The expanding demand for software services had encouraged increased scale of even medium-sized firms, as can be seen from Table 6. In turn, the growing scale facilitated a precise splitting of tasks. Thus in many offshore projects process control allowed something akin to a 'Babbage effect' in the growing specialization of the industry in outsourced services.[10] The best-quality programmers could be used for the tasks they were best suited to performing, while less able/less experienced programmers could be assigned to lower-level tasks and each could be paid according to their productivity. This splitting-up of tasks needed a general management capability—it required learning about how to split up the tasks involved in delivering the product and also required judgement to be exercised about how to recombine the results. Firms that had this capability were able to achieve huge increases in productivity.

[10]Babbage added a fourth source of increase in productivity within a firm resulting from the division of labour, in addition to the three proposed by Adam Smith. He argued that specialization of tasks within the firm allowed the firm to employ fully and pay each type of worker according to their ability.

The fast-growing export demand for software services also forced firms to develop the ability to scale up their operations and deploy them globally. By the late 1990s many Indian firms were operating several offshore 'sales' offices and the ability to ramp up operations was seen by them to be the key quality that differentiated them from their competitors.

6. Some implications of the case study

Dynamic capabilities are central to understanding the evolution of the Indian software industry. Export success, initially as a result of comparative advantage due to favourable factor endowments (availability of cheap, skilled software programmers), became a 'created' comparative advantage in outsourcing resting on the organizational capabilities of a few large software services firms.

Sections 4 and 5 of the paper described how Indian firms developed dynamic capabilities in accordance with the triad of processes, assets and paths outlined by Teece *et al.* (1997). In particular, the choice of the service market niche (the 'path' in the triad of factors identified in Section 2) was conditioned on several internal and external factors that influenced a firm's access to resources and its development of an internal organizational process. The evolution to complete offshoring was slow and incremental—moving from a predominantly on-site service model to a mostly offshore one over a period of 15 years.

The software case study also highlights two external factors that influenced the direction of growth taken by Indian software firms. First, the combination of low wage costs *vis-à-vis* the rest of the world with rising wage costs relative to rest of Indian industry (as the competition for Indian software programmers became global) induced Indian firms to move away from wage arbitrage to a new kind of competition based on the organizational ability to manage the writing of software codes.

Second, entrepreneurial experimentation in the early period of the industry's growth was extremely important in revealing the market niche of software services. Certainly it is hard to imagine that government direction would have uncovered this niche, and freedom from production licensing in software probably favoured such entrepreneurial experimentation. For all firms this experimentation was a source of inter-organizational learning. Growing export demand also absorbed some of the risks of entrepreneurial failure in the subsequent period. Firms that lost out in products turned their fortunes around by making service exports.

State policies benefited industry through a benign neglect in the early stages, but were proactive in creating innovative solutions to infrastructure problems in the later stages of the industry's evolution. Though beyond the scope of this paper, analysis would likely show that successful lobbying by the industry association NASSCOM probably played an important role in directing government effort towards the policies best suited to the needs of the industry.

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Address for correspondence

Suma S. Athreye, Open University, UK. e-mail: s.s.athreye@open.ac.uk

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Appendix

Tables

The National Association of Software and Service Companies (NASSCOM) was established in the late 1980s as the industry association and its membership has grown steadily since. NASSCOM publishes yearly registers, which contain information about its member companies. The data reported are not the company's balance sheet data, but are based on the answers to a questionnaire that members of NASSCOM are obliged to complete. The register gives details about sales revenues (export and domestic), certification, employment and years of establishment of various firms. These data are signed by the auditors of each company and thus represent the most reliable data with broad coverage for the industry as a whole. Tables 1–4 and Table 6 in the main text are based on computations from various NASSCOM registers.

We added to the data in the NASSCOM register in two ways: first, we visited the websites of firms to classify them as software product or service producers or IT Enabled Service (ITES) providers and excluded ITES firms. Second, we added an entrant type classification (reported in Table A1), which was verified by visiting the web sites of different firms in the 2001 register.

Table 8, on the size of recent outsourcing contracts, was collated from information in the following national newspapers: *Business Line, Business Standard* and the *Economic Times*.

Qualitative information

There is considerable use of qualitative information especially in Sections 4 and 5. This was obtained through interviews I conducted in firms and also draws upon data from interviews in software firms conducted by other researchers. This includes the published case study of Infosys in Palepu and Khanna (2001). It also includes unpublished interview notes made available to me by Ashish Arora from his interviews with Indian software firms undertaken as part of the Sloan project in 1997–1998. In the text I refer to these as the CMU interview notes.

Table A1 Types of entrant firms

Entrant type	Description
Missing	If the origin of the firm could not be determined
Professional entrepreneur	If a firm was started by professionals with prior experience in IT or IT management
Entrepreneur	If a firm was started by an existing individual entrepreneur in fields other than IT
Multinational enterprises	If a firm was started as a multinational subsidiary
US–Indian	If a firm was started by people of Indian origin and incorporated in the USA
Public sector enterprises	If a firm was started as a public sector unit/enterprise
Business house subsidiaries	If a firm was started as an arm of an existing business house
Joint ventures	If a firm was started as a joint venture