

Design or Serendipity? : The Rise of India Software Industry

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1. Introduction

This paper the historical forces associated with the rise of the software industry, the crown jewel of post-independent Indian economy. After India attained its independence in 1947, the government led by the then Prime Minister Jawarhalal Nehru, and influenced by the ideals of Mahatma Gandhi, adopted a socialistic economic model. The intent of the economic model was to restrict the influence of domestic private industry which was primarily controlled by family owned business groups, and foreign multinational corporations. State owned enterprises and banks were seen as the engines of economic growth and development.

There is little dispute among economists and contemporary observers of India that in the subsequent half a century, India's economic performance has been relatively poor. However, a stunning exception to this general characterization of the Indian economy is the dramatic rise of the Indian software industry in the past two decades. During this period, it rose from nothing to a vibrant industry with several globally competitive firms with a global customer and investor base. Today, India has become the destination of the world's major software companies as a potential location for a significant portion of their own operations.

In this paper, we seek to understand why the software industry has been able to grow and thrive in India while the rest of the economy has been languishing. Our analysis examines the role of specialized intermediaries in furthering the growth of the Indian software industry. Some of these intermediaries arose in the market place

naturally in response to the business opportunity presented by the software industry. Most have, however, arose as a result of the unintended consequence of the flawed government policies. Finally, Indian business groups, also played an important role as de facto intermediaries filling the institutional voids in India.

Section 2 of the paper describes some of the key Indian economic policies and their macro and micro consequences. Section 3 describes the rise of the software industry in India. Section 4 analyzes the role of intermediaries, government policy, and domestic business groups in the development of the industry. Section 5 concludes.

2. Economic History of Post-Independent India

2.1 Policy Framework

The economic policies of India after it became independent in 1947 were dominated by a distrust of multinationals and global trade, and a faith in significant government role in the economy. Distrust of multinationals and global trade was a result of the long history of British colonial rule following the arrival of East India Company in the early 1600s. The Indian independence movement, led by Mahatma Gandhi, emphasized “Swadeshi” or self-sufficiency, as being critical to liberating India from the British colonial rule. The faith in government, rather than in markets, to be the primary force in shaping the country’s economy came from the beliefs and ideologies of Jawaharlal Nehru, the first Prime Minister of India.

Several specific policies were put in place to pursue the above vision.¹ The Industrial Policy Resolution of 1948 gave government monopoly to run infrastructure operations such as railways, airlines, and telecommunications. The Industrial

¹ The material in this section draws heavily from the discussion in Heeks (1996), and Viotor and Thomson (2003).

Development Act of 1951 stipulated that any company seeking to enter a new business, or to substantially expand the capacity in its existing business, must obtain a license from the government. The Industrial Policy Resolution of 1956 decreed that public sector would occupy the “commanding heights” of the economy, especially in heavy manufacturing industry. The Monopolies and Restrictive Trade Practices (MRTP) act of 1969 prohibited corporations exceeding a certain size from entering certain sectors of the economy which were reserved for either “small scale” sector or government owned companies.²

Government policies also significantly restricted imports and foreign investment. Policy instruments included restrictions on imports of many products and technologies, requirement of government permits and very high customs duties for these that are permitted to import, and control of foreign currency availability. Government also restricted technology license agreements in terms of length and royalty levels. Finally, there were significant restrictions on foreign direct investment and foreign portfolio investment was banned. The Foreign Exchange Regulation Act of 1973, for example, restricted foreign equity holdings to 40 percent except in special circumstances. It also specified policies for access to foreign exchange for imports, and the use of foreign exchange earned through exports.

Control of the financial institutions and markets was yet another important mechanism that facilitated government’s role in the economy. Indian government set up several key ‘developmental’ financial institutions: the Industrial Development Bank of India, the Industrial Financing Corporation of India, and the Industrial Credit and

² In 1990, companies restricted by the MRTP were defined as companies with greater than 70 percent market share or those having more than 1000 million rupees (or US\$57 million) in assets.

Investment Corporation of India. These institutions provided long-term debt to new industrial ventures, took significant equity positions in these new start-ups, and held on to their equity positions after companies went public. Almost all major banks were either owned by the government in the first place, or were “nationalized,” giving government a virtual monopoly in the credit markets.

Most of these policies were in place in one form or the other from 1947 till 1991, when India experienced a severe financial crisis. This crisis, along with the collapse of the Soviet Union, prompted the Indian government to begin rolling back many of its earlier economic policies in favor of markets and private sector. These changes include the removal of license requirements for entering entry and expansion, opening the economy to multinational companies and foreign institutional investors, relaxing import and foreign currency restrictions, a dramatic reduction in tariffs, subjecting public sector companies to competition by opening almost all sectors of the economy to private sector, and a gradual move towards privatization of government owned companies.

2.2 Macro and Micro Economic Consequences

At the macro level, India’s overall economic performance during the post-independence years can only be characterized as relatively poor.³ For example, the United Nation’s Human Development Report of 2002 ranks India 124 among the 173 countries. According to the statistics reported by the Planning Commission of the Government of India, the country’s GNP grew at annual average rate of approximately 4

³ Many of the statistics quoted here are drawn from statistics published by the Government of India, and compiled in Vietor and Thomson (2003).

percent between 1951 and 1990. This rate increased to approximately 6 percent in the post-reform years of 1990 to 2002.

India's population has grown significantly to 1.05 billion by 2002. While government spending on public education was more around 3 percent of GNP, a disproportionate amount of this went to supporting higher education. Government funded Universities and national Institutions produced large numbers of graduates with advanced degrees in sciences, engineering, management. Notable among these are the Indian Institutes of Technology and Management which were elite institutions with generous government funding and highly selective admissions rates. There were also hundreds of state-funded or subsidized science and engineering colleges that produced thousands of graduates every year. However, primary and secondary education was poorly funded and managed, leading to very high levels of illiteracy. According to the Indian government's 2001 Census of India, adult illiteracy rate stood at 34.6 percent in 2001. Agriculture still remained the dominant source of income for a very significant portion of the population, and there was significant levels of unemployment and underemployment. Per capita GNP in 2001 stood at approximately \$450 dollars.

India's economic policies also had important implications for corporate ownership patterns in the economy. Table 1 shows comparative statistics on the Indian state owned companies (SOEs) (or public sector companies) and exchange listed private sector companies, and multinational companies (MNCs) operating in India, as of 1993.⁴ The ratio of number of traded private sector companies to state owned companies was approximately 17 to 1. Thus, there were far more traded private sector companies than public sector companies. However, public sector companies were on average

⁴ Data drawn from Khanna and Melito (1997)

significantly larger than traded private sector companies. Revenues of all traded private sector companies was only 1.5 times the revenues of state owned companies; similarly, assets of traded private sector companies were only 1.2 times the assets held by the public sector companies. More strikingly, the total amount of equity capital in traded private sector companies was only 0.51 times the equity in public sector companies. Thus, private sector companies, while large in number, were more fragmented and relied on far less equity investment, relative to the public sector companies.

Table 1 also compares the traded Indian private sector companies with multinational companies operating in India as of 1993. For each MNC operating in India, there were approximately 17 exchange listed private sector companies. Domestic private companies were 4.3 times larger than MNCs in sales, and 9 times in terms of assets, 6.7 times in terms of equity. Thus MNCs played a relatively minor role in the Indian corporate sector as of 1993.

Private sector firms consisted of those affiliated with business groups and unaffiliated companies started by individual entrepreneurs. Business groups are typically family controlled business entities. The structure of business groups grew out of the “managing agency” system employed by the British in the 19th century. In this system, the managing agency controlled large numbers of companies across a range of industries, with limited liability to the agency. In 1970 the management agency system was abolished by the government, but family-owned or controlled companies nonetheless formed identifiable business groups over time. Group companies were often linked through a maze of cross-holdings and interlocking directorates, and usually emphasized a common identity.

While groups were ostensibly restricted by regulations, they tended to be run by politically savvy entrepreneurs. Studies have pointed that groups maintained “industrial embassies” in New Delhi, and that they secured licenses solely to prevent others from a particular activity.⁵ There was also wide-spread perception that groups enjoyed preferential access to capital from state-run financial institutions, and they were easily able to raise equity capital through contributions from group companies. Due to these factors, business groups that existed prior to India’s independence, such as the Tata and Birla group continued to grow in the post-independence era, and remained the two largest groups as of 2002. The Reliance Group, in contrast, is an example of a new business group that emerged in the 1960s and grew rapidly to go on to become one of the largest industrial enterprises in India. In 1993, there were a total of 1113 group companies that were publicly listed on one of India’s several stock exchanges.

Post-independent India also gave birth to a large number of new companies that went on to become publicly listed on the countries’ stock exchanges. In 1993, there were 1539 publicly listed non-group companies. These companies were in part a result of government’s policy of restricting existing companies from expanding capacity. Promoters of these companies were also able to launch these businesses with relatively small amount of own equity, thanks to the access to capital from state-owned financial institutions, and public capital markets.

Table 2 compares group and non-group companies listed on Bombay stock exchange (BSE) as of 1993.⁶ The sample consists of 567 group firms and 437 non-group firms for which the necessary data was available. The group affiliates are members of

⁵ See Encarnation (1989).

⁶ These data are from Khanna and Palepu (2000)

252 different groups. Ninety five percent of the groups have five or fewer affiliates traded on the BSE and the largest group (the Tata group) has twenty one affiliated companies traded on the BSE. The mean (median) sales of group affiliates is 1,411 (666) million Indian rupees. This is significantly larger than the mean (median) sales of unaffiliated firms, which is 366 (217) million rupees. The mean (median) age of group firms, which is 28.3 (22) years, is also significantly larger than mean (median) age of unaffiliated firms. The mean (median) Tobin's q for group firms was 1.39 (1.14), insignificantly different from the mean (median) value of 1.37 (1.06) for the non-group firms.

In terms of ownership, the total sample has the following mean (median) structure: foreign institutional ownership, 8.9 (1.6) percent; domestic institutional ownership, 13.9 (10.2) percent; insider ownership 27.1 percent (26.5 percent); directors' ownership, 9.4 percent (3.4 percent); top fifty owners excluding the above categories, 6.21 (4.0) percent. The remainder is held by dispersed shareholders. Relative to unaffiliated firms, group firms, on average, have significantly higher percentages of foreign and domestic institutional ownership, and higher insider ownership.

In summary, the Indian corporate sector as of early 1990s had the following profile. A little more than a hundred relatively large state owned enterprises and more than 2500 smaller publicly traded private sector companies, roughly equally split between group affiliated and non-group companies. Private sector activity remained relatively fragmented, in part due to the licensing and capacity expansion constraints imposed by government policy, and in part due to the relatively indiscriminate financing by the state owned financial institutions.

3. History of Indian Information Technology Industry

3.1 Origin

In contrast to the lackluster performance of the Indian economy as a whole, the performance of the Indian software industry has been impressive.⁷ The industry's total revenues in 2002 stood at \$10.2 billion, and it grew at more than 40% per year during the 1990s. The industry accounted for \$7.7 billion in exports in 2002, which was a significant portion of the approximately \$73.3 billion total exports of goods and services from India in that year.⁸ According to a report prepared by the international consulting firm McKinsey for the National Association of Software and Service Companies (NASSCOM), an industry trade association, the industry is expected to grow to \$77 billion by 2008, accounting for 7 percent of India's GDP, 33 percent of its foreign exchange inflows, and 4 million jobs. By all these measures, software industry is the crown jewel of India's post-independence economy.

Until the mid-1960s, there was virtually no software development going in India. Whatever software sold was bundled with computers sold by multinational companies like IBM. The early software development efforts focused on producing in-house applications for efficient use of these computers. Government policies attempted to encouraging the growth of a domestic hardware industry through high import tariffs on hardware. State owned hardware companies, such as the Electronic Corporation of India Limited, attempted to produce computers for domestic academic and commercial use,

⁷ This history relies on the following sources: Heeks (1996), Ghemawat (2002), NASSCOM-McKinsey Report (2002), NASSCOM Newslines (2002), Kennedy (2001), Nanda and DeLong (2002), and Kummerle (2003).

and these efforts included development of operating systems, compilers and application packages. Most of these efforts, however, were not very successful.

Commercial organizations interested in importing computers could do so if they committed to certain amount of software exports. According to Heeks (1996), The first firm that agreed to such an arrangement was Tata Consultancy Services (TCS) in 1974. TCS was set up in 1968 by the Tata Group, India's largest business group, to enable the group companies to use computers in their operations. The company formed an alliance with Burroughs Corporation. Under this alliance, Burroughs would help secure US clients for TCS; in return, TCS would act as an exclusive sales agent for Burroughs hardware in India. Based on this alliance, TCS secured its first U.S. client – the Detroit Police Department. TCS today is the largest software services company in India employing more than 19,000 software engineers. The company is privately held, fully owned by Tata Sons Limited, the apex of the Tata group companies.

Another important milestone in the history of the Indian software industry came when IBM decided to leave India in 1978. IBM took this step in response to the Foreign Exchange Regulation Act (FERA) of India, which limited multinational companies (MNCs) to a maximum of 40% ownership stake in their Indian subsidiaries. MNCs had to either choose between reducing their stake to this level by selling their shares to the Indian public, or leave the country. Several MNCs chose to dilute their stakes through public offerings on the Bombay stock exchange, but IBM and Coca Cola were two prominent exceptions. The decision of IBM to leave India meant that 1200 employees of the company had to look for other alternatives to exploit their skills. Many of these employees set up small software consulting companies which would offer software

development and maintenance services to former IBM customers, leading to the beginnings of the Indian software industry. The departure of IBM also allowed many smaller hardware companies to expand into India, exposing Indian software programmers to a variety of software platforms.

The domestic demand for software services in India was fairly limited for a number of reasons. First, fearing unemployment from automation, Indian government did not encourage the adoption of computerization in government and state-owned enterprises. Second, its interest in developing a domestic hardware industry led the government to impose extremely high tariffs (350 percent in much of the 1970s and early 1980s). Third, Indian private sector companies had little incentive to adopt information technology to improve operations and productivity, given the highly protected nature of the economy. As a result, Indian software firms found it difficult to generate much demand for their services in the domestic market. This lack of demand from the domestic market, and a pressure to generate export revenues if they wanted to import latest hardware for their operations, motivated Indian software industry to focus on exports from its early days. This is in significant contrast to the orientation of much of the Indian private sector, which was focused on the Indian domestic market rather than the export market.

There were no specific government policies that explicitly focused on the Indian software market, perhaps because the Indian government did not view software as a potentially important source of economic activity in India. There were, however, several indirect consequences of government policy. We already discussed two such indirect effects above. There were several other indirect effects as well. The capacity and

licensing restrictions discussed in the previous section did not apply to the software sector because the policies attempted to control manufacturing activity. Further, there were no restrictions on foreign investment in the software sector. This meant that multinational companies such as Citicorp and Texas Instruments could establish wholly owned software development centers in India.

Starting in late 1980s, the Indian government made several policy decisions that helped the growth of the Indian software industry. Two such important policies were relaxation of hardware imports by software firms, allowing software firms to set up private telecommunication networks to perform remote development. Many of the general economic reforms in the 1990s also significantly helped the software industry. Prominent among them are: the elimination of restrictions on accessing international capital markets, the granting of employee stock options, and more recently, the deregulation of international telecommunications services. The delicensing of hardware imports and the greatly falling hardware prices internationally meant that entry barriers into the Indian domestic software industry fell drastically.

The party currently in power (as a leader of a coalition), the Bharatiya Janata Party (BJP), was the first to explicitly support the software industry in its election manifesto. An interesting feature is that most of India's state governments have explicit information technology promotion policies and compete to attract firms to their states. The formation of the industry lobbying group, NASSCOM, provides an efficient means for dialogue between the private sector and the various state and central governments.

3. 2 The Indian Software Industry: Equilibrium in 2003

Supply side

Approximately 70% of the cost structure of a software company is accounted for by personnel related costs. India's initial entrée into the software business has to do with its access to cheap talent. India produces more engineers and scientists than every country in the world other than the U.S. The key feature of the talent is that it is much more globally mobile than labor in general. Indians (especially programmers), in particular, account for more than 40% of the H1B visas (temporary work visas) issued by the U.S. to foreign talent. Further, the Indian diaspora, long-established successfully in the U.S., has played a key role in facilitating the flow of talent back-and-forth between India and the U.S. (Kapur and Ramamurti, 2001).

Indian firms compete vigorously in the global software services market. Firms from countries like Russia, Ireland and the Philippines are prominently cited as direct competitors, for example. Software firms from advanced economies like the U.S. are also indirect competitors, in that clients may choose between generally more sophisticated services from these expensive advanced-economy firms and the less sophisticated but cheaper services from emerging economies.

Demand side

Three types of demand for software services existed that were relevant to India.⁹ At the low end was the demand by foreign firms for on-site services, also referred to in a

⁹ Indian industry has generally played only a very small role in other large parts of the global software industry, such as packaged software. We eschew discussion of these parts of the industry for brevity. Also, we focus on export markets, rather than on the domestic Indian software market, since our interest is in global competition in this paper.

derogatory sense as ‘bodyshopping.’ This practice involved Indian programmers relocating to the host country, typically for a short period of time and for significantly lower wages than local programmers in the host country. Clients generally received the services of the programmer ‘bodies’ with much less by way of organizational knowledge from the software firms. One reason why many Indian software companies started this way had to do with their lack of access to appropriate hardware in India, in turn caused by regulatory (typically foreign exchange) restrictions.

The other type of demand was by foreign, primarily U.S. companies, for Offshore Development Centers. These were physical locations in India that companies dedicated to the needs of a particular advanced-economy multinational, where teams of Indian programmers and some personnel from the foreign company worked together for long time periods and with more intensive knowledge exchange. The third type of demand was a mixture between bodyshopping and the offshore development centers.

Equilibrium

Several indicators of India’s success in the global software industry are worth reviewing.. Table 3 shows the time-series of the total activity of the Indian software industry from 1988 to 2002. Indian software industry in 1988 had a total revenue of 0.7 billion Indian rupees, and the proportion of exports to domestic sales was 41 percent. By 2002, the industry grew to a size of 365 billion rupees, with exports accounting for 76 percent.

There were altogether 2810 companies in the industry in 2002, a majority of them small private companies. Table 4 shows the distribution of these companies by revenues. Table 5 shows a list of top 20 companies and their revenues. The top five firms in the

industry, with sales greater than greater than 10 billion Indian rupees, account for 32 percent of the total revenues of the industry. These five firms are: Tata Consultancy Services (TCS), Infosys Technologies, Wipro Technologies, Satyam Computer Services, and HCL Technologies. TCS, Wipro, and Satyam are affiliated with family owned business groups, which entered the software industry as part of a diversification move by their parent groups. TCS is privately owned; Wipro is publicly traded, but approximately 84 percent of the shares are held by the founder; Satyam is publicly traded, with only 11 percent of the shares held by the founding family. Infosys and HCL were started by computer professionals, and are publicly listed companies. There are also several large Indian software companies which are affiliates of multinational companies. These include Indian arms of overseas software services firms such as IBM Global Services, and Price Waterhouse Coopers. Also, there are arms of multinational operating companies which use India as a base for their internal software development needs. Examples include Siemens Information Systems Limited and Motorola. Affiliates of multinational companies together account for 22 percent of the industry's total revenues.

There are 24 large software companies that are publicly traded on the Indian stock exchanges.¹⁰ Three of these – Infosys, Satyam, and Wipro- are also listed on the U.S. stock exchanges. Software industry market capitalization on Indian stock exchanges rose from \$4 bn in January 1999 to a high of \$90 bn and then, following the NASDAQ crash and its ripple effect in India, settled at \$55 bn by mid-2000.

Table 5 compares the largest Indian software companies with some of the largest U.S. software companies in terms of revenues, employees, profitability, and

¹⁰ There were also other software companies that are publicly listed, but these have very small amount of sales.

market capitalization, all as of 2002. Indian companies are clearly not as large as some of the largest US software firms such as CSC, Accenture, and EDS in terms of revenues or manpower. However, in terms of profitability, Indian firms are significantly better than their US counterparts. The stock market valuations of Indian companies, despite their smaller size, are often larger than the market capital of the US firms.

Given the cheap talent and the initial absence of reputation, Indian firms started out at the low end providing primarily bodyshopping services. They gradually built reputations for reliability and high quality of services and began to provide more value-added services (Banerjee and Duflo, 2000). By 2002, offshore services, the more value-added part of the Indian software firms' offerings, had risen to 51% of export revenues from 5% in 1991-92. The US accounted for 66% of the total exports of the industry and UK accounted for the second largest share of exports, at 14%. 185 of the Fortune 500 US companies were customers of the Indian software services industry.

Five of the nine software development centers in the world with CMM Level 5 ratings, the highest ratings on the predominant quality scale developed for software at Carnegie-Mellon University, were located in India. Companies like General Electric, Citicorp and IBM had their only CMM-certified operations in India rather than in the U.S.¹¹

The upgrading of the Indian software industry was expected to continue. Expected revenues by 2008 were set in the neighborhood of \$87 billion by a NASSCOMM-McKinsey study, as long as government continued to remove bottlenecks for the

¹¹ It may be that quality concerns are greater when a firm is located in an environment with a reputation for poor governance and poor quality products. Perhaps U.S. firms do not find it necessary to seek certification of this sort.

development of the software sector. Talent now increasingly captured a piece of the software pie, partly as a result of global pressure on domestic wages. A Jardine Fleming study suggested that the costs of an Indian programmer had risen to as much as \$3,000/month (though this was still 1/3 of the costs of a U.S. programmer).

The Indian software industry, on average, appears to follow better corporate governance practices relative to the rest of the Indian industry, consistent with the hypothesis that globalization puts pressure on companies to improve their governance to global standards. Some data from Credit Lyonnais Securities Analysis (CLSA) supports this assessment of the current state of Indian corporate governance. The data are from a set of questions regarding corporate governance administered to 482 companies in 24 emerging markets in 2001.¹² The companies are generally the ones of greater interest to foreign investors, typically characterized by some subset of the following characteristics – large size, greater equity float, and foreign listings. When we ranked countries by the mean corporate governance score constructed by CLSA, we found that India ranked in about the middle. Since most countries in these data have poor average corporate governance (with some exceptions like Hong Kong and Singapore), and since the selected companies are generally the better governed ones, this confirms the characterization offered above.

The same CLSA data, however, also point out that the corporate governance ratings of the software firms are higher than those of other Indian firms. The mean ratings for software firms (of which there are eight in the CLSA data) and for non-software firms (of which there are 72) are, respectively, 64.3 and 54.7 (minimum of 0 and maximum of 100), with the difference statistically significant with a p-value of 0.02. The medians

¹² Data from Khanna and Palepu (2003)

are, similarly, 62.9 and 53.8, with the difference statistically significant with a p-value of 0.2.

The data also confirm that software firms are, on average, more exposed to global competition than other Indian firms. To ratify this assertion, we supplemented CLSA data with a variety of indicators of global competition. Software firms are more likely to be traded on a U.S. stock exchange (p value 0.02) and on the London Stock Exchange (p-value 0.08) and more likely to be listed on the NYSE (p value 0.01). Software firms garner a higher percentage of their revenues through exports (p value 0.01), are more likely to employ foreign talent in senior managerial positions (p value 0.01) and are somewhat more likely to employ a Big 5 accounting firm (p value 0.12).¹³

In summary, the Indian software industry appears to be an exception to the generally mediocre performance of the Indian industry in terms of size, growth, and exports to advanced economies. The ownership structure of the industry is very diverse. Among the top firms in the industry are group affiliated firms, de novo start-ups, and multinational companies. There are many privately owned companies, including the largest company in the industry. There are also widely traded companies, some even on international stock exchanges.

4. Specialized Intermediaries and the Indian Software Industry

Our thesis is that the presence of specialized intermediaries facilitates *de novo* entry. Thus one would expect to see two categories of software firms in an emerging market like India. The first are de novo entrepreneurs who leverage access to available

¹³ However there is no statistically significant difference between software and non-software firms in the proportion of equity held by institutional investors.

specialized intermediation to launch viable business models. The second are incumbent firms (that is, firms with pre-existing businesses) that leverage access to their internal cash (and talent) flows to launch software businesses. Such incumbent firms might include business groups that are (largely) domestic entities, as well as multinationals building software businesses within the emerging market, either as a replication of, or a complement to, their existing businesses elsewhere.

The enormous froth in the software industry – with 2800 publicly traded firms – suggest a burgeoning entrepreneurial spirit. The first sub-section below considers the specialized intermediaries that might have facilitated the entry of these firms. The next consider the route actually taken by two of the largest firms – one indeed responding to the availability of ambient (domestic and global) intermediation capabilities, the other leveraging internal group-specific capabilities. The final sub-section reflects on where the specialized intermediaries come from in the first instance, revisiting our theme of serendipity versus design.

4.1 Specialized Intermediaries relevant to the Software Industry

The table below indicates the approximate decade in which various intermediaries relevant to the operation of the cross-border market for India's software industry came into existence. Unquestionably India's talent, nurtured by government-sponsored institutions like the Indian Institutes of Technology (IIT) and other selective engineering schools spread across the country, were a factor in rendering feasible the industry's existence. This had begun to happen by the 1970s, hastened by IBM's departure in 1977. During this time an incipient diaspora – a larger proportion of India's engineers have

settled overseas, notably in the U.S., over time – probably played a role in making firms aware of India’s software firms.¹⁴ A qualitative change occurs with India’s liberalization in 1991, when capital access becomes much easier, both in India and, later in the decade, in New York. A contemporaneous, though unrelated, emergence is that of a software programming standard, the Capability Maturity Model, at Pittsburgh’s Software Engineering Institute in the late 1980s, which Indian firms were able to leverage to burnish their reputations as providers of quality software services of unlikely, to western perceptions, provenance. The late 1990s and early years of the current decade saw the Indian diaspora playing a prominent role in facilitating cross-border activity in product, talent and capital markets, facilitated by organizations like The IndUS Entrepreneurs (TiE). Interestingly, the availability of all these intermediation capabilities, with the exception of TiE, are appropriately seen as exogenous to the software industry. The subsequent table, and the text that follows, provides a detailed analysis of some of these intermediaries.

Decade in which particular specialized intermediary first facilitates particular cross-border market for Indian software

Product	Diaspora		CMM	Diaspora
Talent	IIT			Diaspora
Capital			Bombay Stock Exchange; Global Capital Markets	Diaspora
Timeline	1970	1980	1990	2000

Some relevant details regarding particular specialized intermediaries

¹⁴ However, some industry leaders have decried the importance of the diaspora in early years (e.g. Azim Premji’s views as articulated in Ramamurti, 2001).

	Indian Institute of Technology (IIT)	Indian Institute of Management (IIM)	National Assoc. of Computing Machinery (NASSCOM)	The IndUS Entrepreneurs (TiE)	Capability Maturity Model (CMM)
Founded by	Government sponsored (1950s)	Government sponsored (1960s)	Private entrepreneur (Dewang Mehta). Not a software incumbent. 1986.	Incumbent software industry entrepreneurs	Carnegie Mellon University. Not a software incumbent. 1986.
Ownership	Government	Government	Industry Association (need info)	Non profit	Affiliated with CMU.
Explicit to Software industry	No	No	Yes	To a considerable degree, though ostensibly for entrepreneurs of all stripes.	Yes. Originated for application to military avionics software.

Of course, there are several other ‘institutions’ that would-be software entrepreneurs rely upon, other than those mentioned briefly above. Most obviously, there are laws and regulations in India and, to a lesser extent, laws that govern cross-border commerce, that are relevant. There are executive search firms that specialize in software – some web-based – that are too numerous to detail here. Then there are cross-border intermediaries that matter – like NYSE or NASDAQ – that facilitate entrepreneurial activity. The criteria used to pick the five institutions above, admittedly somewhat arbitrarily purely to bound the analysis, is that each is a free-standing legal entity domiciled in India.¹⁵ Further, the intermediaries selected in this table run the gamut from

¹⁵ We need to verify the legal status of TiE though. It has chapters all around the world, but the core organization might well be domiciled in the U.S.

being Indian-domiciled-owned to entirely unaffiliated with India, and being partly to completely associated with the software industry.

Consider the Indian Institutes of Technology (IIT). These are a set of five institutes founded in the late 1950s and early 1960s in response to the government's determination to invest in the scientific capabilities of a newly independent nation. (Later two other IITs were added to the initial set in 1995 and 2001.) Each institute is largely government funded, though set up typically with assistance from a diverse array of foreign institutions (e.g. U.S. universities played a role in setting up IIT Kanpur and foundations from the then-U.S.S.R. were key to setting up IIT Bombay). The appendix contains details.

These institutes are considered technical institutes par excellence, producing human capital on par with the world's leading engineering colleges, though their research reputation leaves much to be desired. There is room to debate the extent to which the high-quality engineers produced by the IITs are a result of training done by the institutes, versus a consequence of the incredible cream-skimming of talent from the Indian population that results in the annual matriculating class at the IITs. The appendix contains a more detailed analysis of possible causes of the IITs' success.

In our context, the IITs are intermediaries in the market for top-quality engineering talent. Both as a vehicle for imparting cutting-edge training, and as a certifier of quality, the IITs make it immeasurably easier for software entrepreneurs to locate and recruit talent. Our reasoning would predict that they should, therefore, play a role in facilitating entry by de novo entrepreneurs.

The IITs have long been criticized for contributing to India's brain drain. Critics question the need to subsidize the education of India's talent pool, the vast majority of which is subsequently lost to global talent markets, most notably to the United States in recent decades. Of late, this criticism has been muted, however, as the Indian diaspora has played a non-trivial intermediary role in fostering the return of talent – brain gain or brain circulation – as well as of capital from Silicon Valley to India (Saxenian, 200x; Desai et al 2002; Huang and Khanna, 2003). Indeed, the IITs fiftieth year worldwide anniversary celebrations were held very recently in Silicon Valley, a testimony to the importance of the U.S.-based Indian diaspora.

The IndUS Entrepreneurs, TiE for short, is a derivative intermediary, so to speak. It is the result of successful Indian entrepreneurs, often from the IITs and often in the software field writ large, voluntarily getting together. The stated purpose is to share their experiences as entrepreneurs and reduce the barriers for Indian, and other South Asian, entrepreneur 'wannabes.' It is also, undoubtedly, a networking vehicle for its members and a means by which they can spot good opportunities to which their hard-earned wealth can be put to use. TiE has been enormously successful, starting with five chapters in the United States, and now with chapters spread around the world. (We need to add details.)

The Capability Maturity Model, designed to measure sophistication of an organization at producing software, is at the other extreme from the IITs. It is a set of abstract ideas, rather than a physical entity. Further, it has nothing to do with India, having been created in Pittsburgh by the Software Engineering Institute, affiliated with Carnegie-Mellon University, building on work done over the decades in the field of

statistical control of quality. The appendix provides details, though it is short on providing an understanding of incentives to invest in the 'model' and, related to this, on the details of the organization that supports investment in, and maintenance of, the model.

For our purposes, the CMM is an impartial arbiter of quality that can be used by entrepreneurs to credibly signal their worth and, thereby, make the market in the buying and selling of software products. Banerjee and Duflo's earlier work on the Indian software industry provides evidence of the importance of reputation and reputational considerations are likely of greater importance for de novo entrepreneurs than for established business houses.

NASSCOM was founded as the industry association in 1986 and is widely credited as having been a constructive force in developing the Indian software industry. The person most credited with NASSCOM's success was Dewang Mehta, its president for most of its existence. Though not the founder, Mehta was the de-facto founder, and received an 'Entrepreneur of the Year' Award for his efforts at NASSCOM, traditionally awarded to founders of private sector enterprises. It is noteworthy that Mehta was not a software engineer, having aspired to be a doctor initially and meandered through political science and acting into his role at NASSCOM, purely by accident. Thus the software industry association was created, effectively, by an individual who was truly independent. His thespian interests, interestingly enough, were sometimes singled out as responsible for his success, since they allegedly affected his ability to bring people together, and deal with equal ease with non-commerce-minded politicians and bureaucrats, on the one hand, and commerce-minded entrepreneurs on the other.

NASSCOM serves many functions as an intermediary in the market for software services, and in clearing the market for software talent. First, it is important to note what it does not do. It does not act as a certifier of quality of its members. Any software firm can become a member by paying the annual dues. What it does do, as emphasized to us by its three senior-most executive officers, includes the following. First, it functions as an information clearinghouse by publishing detailed directories of its membership roles and relevant information regarding each of its members, updated annually, and available for purchase to anyone. Second, it represents the software industry domestically and abroad. Domestically, it primarily concerns itself with primary demand creation since the domestic industry, for reasons considered in this paper, is relatively under-developed. Abroad, it works to develop the 'India brand' in software. This has traditionally been in the United States and Western Europe, but increasingly is also in countries like China and Russia. It runs political interference for the software industry. For example, it did so when there was commercial fallout after India's nuclear test explosions recently, and is currently doing so in response to the backlash in the United States opposing the 'exporting of U.S jobs' to India. Finally, it aspires to play a role in thought leadership in the Indian software industry. This is through running seminars and colloquia and also through serving as a clearinghouse on research in relevant topics, e.g. recently in software privacy and software piracy. Here it serves a virtual function – matching researchers with consumers of research – rather than attempting to do the research itself.

Organizational aspects of NASSCOM are interesting. Membership is by annual fee with the fees being much larger for larger organizations. To reduce free-riding, which cannot entirely be eliminated given the public good nature of several of the assets

produced by NASSCOM, the organization charges separately for newsletters and occasional briefings over and above its basic services.

The president of NASSCOM is appointed by the Secretariat. Separately, there is an elected executive council of members which has important input to NASSCOM's actions. There are more than 800 members, representing over 90% of the Indian software industry's turnover, though 20 members account for half of NASSCOM's turnover. Votes are weighted by membership fees (though the maximal weight assigned to a vote is no more than 5x the minimal vote). While it may seem that this ensures that a large firm will always chair the executive council, in practice it has been so only in one case out of five elections. Large firms recognize the need to have smaller ones in the organization, so that the politicians and bureaucrats see the association as representative, and small firms recognize the need for large firms, without whom NASSCOM would not have much power.

4.2. Software Firms and Institutional Voids

Consider the founding of Tata Consultancy Services (TCS) in 1968, which, in retrospect, marks the birth of the first Indian domestic software firm at a time when IBM was riding herd in India.¹⁶ TCS was set up by India's oldest business group, the House of Tata, by pooling together management talent from existing Tata companies to create a new entity to act as an information technology bureau for various members of the Tata group.¹⁷ In two senses, it is the prototypical example of the filling of institutional voids

¹⁶ The data, though not the interpretation, for the few paragraphs on the founding of TCS are from Kennedy (2001).

¹⁷ The origins of the House of Tata go back to the founding of a textile mill in 1874. Major businesses in existence by the mid 1990s included, in the order in which they were founded, Indian Hotels (1902), Tisco (1907), Tata Sons (1917; the ultimate holding company of the group), Tata Power (1919), Tata Chemicals (1929), ACC (1936; cement company), Telco (1945), Tata Industries (1945; entity to help promote new ventures), and Tata Tea (1962). By 1970, under the dismantling of the British-era 'managing agency'

(Khanna and Palepu, 1997, 2000), that is, of the creation by diversified business groups of internal solutions to compensate for the absence of external specialized intermediaries (institutional voids). The voids in question here refer to the absence of intermediaries facilitating the pooling of talent to launch such a company and the absence of an entity to provide information technology services to service the corporate demands of the time.

Ex post, it transpired that even the extensive scope and scale of the Tata group companies did not provide sufficient scale for a viable business – so, under newly appointed CEO F. C. Kohli, TCS built up a credible list of major Indian customers between 1969 and 1973.

Armed with the reputation of the Tata Group, and its track record in India, TCS sought business overseas, turning successfully to secure an alliance with Burroughs Corporation in the U.S., whereby Burroughs would secure programming contacts and TCS would execute them.¹⁸ It is important to realize that India's distortionary foreign exchange regulations played a key role in prompting TCS to solicit business overseas. Foreign exchange was needed to pay for importing the hardware on which TCS performed its software programming services. It is also worth noting that such cross-border arrangements have been common in the history of the Tata group. For example, its ventures in the late 1990s included joint venture agreements with the likes of AT&T, NTT, Honeywell, Jardine Matheson, (the then) Daimler Benz, and numerous others. Elsewhere we have argued that the network of joint venture agreements represent credible commitments not to engage in short-term opportunistic behavior toward the

system, the Tata Group did not exist as a legal entity. However, 'a semblance of unity was maintained by a network of inter-corporate shareholdings, weekly cross-company directors' meetings, and J.R.D.'s [the then-CEO] dynamic personality and moral force' (Khanna, Palepu and Wu, 1998).

¹⁸ MIT-trained Kohli's own contacts in the U.S., as part of the IEEE association, no doubt played a facilitating role.

marginal joint venture partner, and that the network itself is facilitated by the diverse (cross-industry) scope of the Tata Group (Khanna and Palepu 1997).

Experience gained domestically and through Burroughs meant that TCS was well-positioned when another distortionary Indian regulation – the requirement of divesting sufficient equity to local partners – forced IBM (and several other multinationals) out of India in 1977. A separate entity – Tata Burroughs (later Tata Infotech) – was created to focus on business based on the Burroughs platform, while TCS decided to focus on the rising IBM platform in its outside-India work. A U.S. office was opened in 1979 to solicit business and, with successful projects for various banks, American Express, IBM and others under its proverbial belt, TCS had established the industry, and its position, by the mid 1980s.

In contrast to TCS, Infosys Technologies, another of India's software success stories, is the prototypical example of building a business by leveraging external (i.e. non-India specific) institutions to compensate for domestic (India-specific) institutional voids. Narayan Murthy, the individual most associated with Infosys today, mused that the biggest challenge facing Infosys was “running a first-world firm in a third world country” (Nanda and De Long, 2002, page 9). Infosys was founded in 1981 by seven entrepreneurs, all ex-employees of Patni Computer Systems (itself one of the entrants into the post-IBM-withdrawal vacuum). Its initial capital consisted of approximately \$1,000 of personal savings and no Tata-like reputation to leverage. However, at least one of the founders, Murthy, had his professional outlook sensitized to the importance of personal incentives by his own stint working outside India (Paris).

Infosys struggled, teetering on the precipice of bankruptcy in 1989, until a foreign exchange crisis forces India to ‘open up.’ Reasons cited for Infosys’ early difficulties can reasonably be traced to pre-1991 institutional voids in product markets (lack of availability of quality hardware), capital markets (limited availability of financing for de novo entrepreneurs) and labor markets (visa restrictions preventing cross-border talent mobility). A lot of these constraints were removed when barriers to the flow of people, capital and ideas were relaxed so that Infosys software engineers could be relocated relatively easily to their customer sites, Infosys management did not spend excessive time circumventing regulations in New Delhi, foreign knowhow regarding the industry was accessible, and equity capital could be accessed locally through listings (which Infosys did in 1993).

While the post-1991 liberalization eliminated some institutional voids, more fundamental ones remained. A Forbes article commented that there was a ‘perception that a smart, honest, reputable company could never come out of a country where cows still run in the street.’¹⁹ A 1999 NASDAQ listing was designed to ameliorate informational problems that hampered Infosys reaching blue-chip companies in the global market. Several executives at Infosys and its competitors, and several regulators at Securities and Exchange Board of India (SEBI; India’s SEC equivalent) commented to us, for example, that the NASDAQ listing was designed primarily to gain credibility with customers and to permit the issuance of dollar-denominated stock options to compete in global markets for talent. For a company that, by this time, was not liquidity constrained, as we have demonstrated elsewhere (Khanna and Palepu, 2001), raising capital was not the reason to

¹⁹ Eric Pfeiffer, ‘From India to America,’ Forbes ASAP, August 23, 1999, pp. 19-24. Quoted in Nanda and De Long (2002: pp. 13).

list overseas. SEBI member Jayanth Verma's comment to us regarding the spate of software listings overseas that followed is instructive. "The industry that probably needs capital the least, went after the international capital markets most aggressively.... In fact many of these companies don't know what to do with the capital they raised. .. The pressures that the capital markets can put on a company that doesn't need to raise capital are next to nothing."

A few final points are worth noting. First, TCS's moves arguably laid the foundation for the industry's development. Azim Premji, founder of Wipro, India's second largest software company and an NYSE-listed company, commented, 'The legacy of the early pioneers – Tata Consultancy Services – was a growing number of foreign companies favorably impressed about what Indian companies could do in software' (Ramamurti, 2001).

Second, the global listing and global track record, of all the software companies was predicated on a successful track record established domestically. Thus, Wipro did not sell overseas for the first 20 years of its existence, TCS went overseas after an initial successful run domestically. Indeed, Premji points out 'It is also important to remember that Indian companies built their expertise serving domestic customers before venturing abroad' (Ramamurti, 2001).²⁰ Even Infosys, global from the outset, listed overseas after it was an acknowledged leader in the cross-border software market.

Third, the TCS and Infosys caselets should not be misconstrued to imply that groups do not use the services of specialized intermediaries. For example, Athreye (2002)

²⁰ In related research on entrepreneurship in five emerging markets (Argentina, Brazil, Hong Kong, India, Mexico), we have found that domestic preeminence often precedes attempts at cross-border success (Khanna and Palepu, 2003).

shows that group affiliates use CMM ratings at least as much as do de novo firms.²¹ It may be that group affiliates, which are generally larger than non-groups, have the scale needed to make the use of intermediaries worthwhile, as argued elsewhere by us (Khanna and Palepu, 2003).

4.3 A Coda: The Endogeneity of Intermediaries

The above sub-sections take specialized intermediaries as exogenously determined. In the medium to long-term, this is clearly conceptually inadequate. Where do the specialized intermediaries come from? To what extent are they designed, rather than serendipitous outcomes? We consider this issue briefly here.

1. Some available intermediation capabilities are clearly serendipitous outcomes. For example, consider following accidental consequences of government policies. Lax regulations permitted several firms to go public. One consequence was that, from a market microstructure perspective, the Bombay Stock Exchange had to develop capabilities to handle large volumes of firms. Similarly FERA regulations led to the removal of a de facto monopolist, IBM, which in turn led to a more competitive product market, ultimately supplanted by a tiered market structure – with a handful of leading firms and a large competitive fringe of smaller mom-and-pop shops, as it were.²²

2. Consider the feedback from firms to intermediaries. In particular, what kinds of firms have an incentive to invest in intermediaries? We also expect that de novo

²¹ Note that that paper does not report the statistical significance of differences in mean use of CMM ratings, nor does it break out CMM ratings from the use of ISO ratings.

²² Our view is that these feedback loops are poorly understood. Consider an even more convoluted example. Wipro has spawned many startups (Arora and Athreye, 2001). This is partly because its very concentrated ownership structure – the founder owns 85% of the stock – has meant that ambitious, and well-trained employees, have left Wipro to found dozens of successful companies which, in turn, have gone public, contributing to the success of the industry and to the depth of intermediation capabilities that serve the industry.

entrepreneurs have a greater incentive to promote and invest in the specialized intermediaries than do the incumbents. While each category – de novo entrepreneurs and incumbents – faces a substitution effect by thus furthering additional possible entry, the incumbents have an ‘outside option’ represented by their internal markets and are less beholden to the services of the specialized intermediaries.

The clearest illustration of this is perhaps the role of Infosys. It has emerged as the poster-child of good corporate governance in India, indeed, in Asia. Further, it has contributed extensively to the furthering of good corporate governance in India in general, burnishing the image of, first, the software industry, second, other industries exposed to global competition in the product or factor markets, and, finally, all other firms. Consider the schematic from Khanna and Palepu (2001), reproduced here in Appendix C, which illustrates the role of Infosys in furthering corporate governance. Murthy, Infosys’ public persona, continues to play a public advocacy role in highlighting the role of good governance and in furthering other ‘public goods’ in the industry. Thus, he has a leading position at NASSCOM and is represented on the governing councils of the Indian Institute of Technology and the Indian Institute of Management.

Comparatively, spin-offs from business groups (Wipro and TCS) have not done nearly as much to develop corporate governance in India. Note that TCS is a wholly owned subsidiary of Tata Sons, the closest the Tata Group has to a holding company (Khanna, Palepu and Wu, 1998), Wipro is owned 87% by its founder, while Infosys is only 25% owned by insiders.

3. Finally consider the effect of multinationals on the availability of specialized intermediaries. To the extent that multinationals and groups leverage internal markets

rather than rely on outside intermediaries, one might reasonably posit some crowding-out effect from the presence of multinationals to the nurturing of arms-length intermediaries. On the other hand, it is widely believed in India that multinationals – especially Citibank, Texas Instruments, and, more recently, General Electric and a resurgent IBM and other computer industry majors from the west – have had a major effect on nurturing the industry. Their presence has highlighted India's arrival on the global software map, has further deepened India's markets for software talent, and has provided a competitive spur to India's domestic firms. Infosys' Murthy commented, 'I'm glad we took the route of becoming more competitive with foreign firms rather than of lobbying with government to keep foreign firms out .. We came out with a lot of innovations. The only way to survive and grow is by putting your own house in order' (Nanda and De Long, 2002, p. 5).

5. Conclusion

Post-independent India pursued a set of economic policies that generally curbed private sector activity, and made Indian industry fragmented and uncompetitive. The one exception to this has been the Indian software industry which began to grow in the 1980s. The industry today has more than 2500 firms, all in the private sector. The leading Indian software firms are globally competitive, highly profitable, and are growing very rapidly. They are listed on the world's major stock exchanges, and boast of a large fraction of the world's leading companies as their customers.

In this paper, we trace the history of the development of the Indian software development, and the role played by the private sector product, labor, and financial market intermediaries, and the domestic business groups.

Appendix A

Indian Institutes of Technology

History

The Viceroy's Executive Council set up the 22 member Sarkar Committee in 1946, just before India gained independence from Britain. The Sarkar Committee recommended the creation of four technical centers of excellence, one each in the east, west, north and south of India, to be engaged not just in the teaching of undergraduates, but in post-graduate teaching and research in a way comparable with the world's best institutions. MIT was occasionally mentioned as a model.

The first Indian Institute of Technology (IIT) was established in 1950 in Kharagpur in east India (though the name IIT was first adopted in 1951). The Parliament of India passed the 1956 IIT (Kharagpur) Act deeming this an institute of 'national importance' and allowing it to issue degrees. The other four (of the initial five) IITs were set up soon thereafter – IIT Bombay in 1958, IIT Madras in 1959, IIT Kanpur in 1960 and IIT Delhi in 1961. Each had a separate Act of Parliament to 'convert' it in a degree-issuing university soon after its establishment. In 1995, a sixth campus was added at Guwahati, and in 2001, a seventh campus was added at Roorkee by upgrading one of India's oldest existing engineering colleges.

After the five initial IITs were set up, Jawaharlal Nehru, India's first Prime Minister, realized that, to keep pace with science and technology worldwide, links with the outside were needed. (Note that the national goal was to achieve self-sufficiency, especially in technology, at the time.) The IITs received much such assistance. Thus UNESCO provided a lot of support to launch IIT Bombay between 1958 and 1973. The government of the USSR provided technical assistance, fellowships for faculty, and equipment. IIT Bombay received further assistance from Ecole Polytechnique in France in 1982-83 as well. IIT Madras was founded with assistance from the Federal Republic of Germany. And, under the Kanpur Indo-American Program, 1962-1972, IIT Kanpur received assistance from nine leading institutions in the U.S.

Scale

Some information on the scale – faculty, students, budgets – is worth keeping in mind. There are about 1875 faculty across the five original IITs. (This is an approximation based on information on the web for IIT Kharagpur which had 450 faculty and IIT Kanpur which had 300 faculty in 2001.) Approximately 2000 students are admitted each year to the flagship undergraduate program through the intensely competitive annual Joint Entrance Examination – national ranks in which are used to issue priority to students in choosing their specialized field and geography – for a four-year course of study. So in a given year, 400 students would be added to each campus, and the total undergraduate population would be 1600 students per campus or 7,000 across the five campuses. The total number of students in residence on the five campuses

is roughly 10,000, implying that 3,000 students are in various post-graduate courses of study. (This is an approximation based on information on the web for IIT Kharagpur which has 2700 students and IIT Kanpur which had 2300 students on campus in 2001.)

Cumulative investment over four decades is estimated to be approximately \$1 billion. This is a very crude estimate, based on extrapolating (multiplying by the five IITs that have been in existence for the bulk of these forty years) numbers provided by the IIT-Madras website, which claim that cumulative investment in IIT Madras in 2001 Rupees is Rs 10 billion, approximately \$200 MM.

We do not have estimates of operating budgets. However, we know that a representative IIT received approximately \$2 million/year in sponsorship money for research from the government and from consultancy done for industry. This is a trivial sum in comparison with the budgets of major U.S. universities, and in comparison with any reasonable assessment of the value of human capital that emanates from the IITs. Note that, for the most part, students pay very little tuition.

Why have the IITs been spectacular successes?

This is an intriguing question, especially viewed against the backdrop of generally poorly performing government-run and government-sponsored organizations in India, including educational institutions. Consider several categories of answers

Good Governance

Prima facie, it is hard to believe that being responsible to the Government of India, and being funded on an operating basis by the Government, is consistent with good governance. However, it is intriguing that there are several individuals with demonstrated track record of commercial success who have lent their names to a Pan-IIT organization charged with overseeing the institutes. There is a 14 member board (including six academics), chaired by Infosys Chairman Narayan Murthy and ex-McKinsey Managing Director Rajat Gupta. There is an Advisory Council made up of luminaries from the business world – including several successful entrepreneurs based both in India and in Silicon Valley (some in software, others in telecommunications and related areas), venture capitalists (based in India and in Silicon Valley), and at least one successful professional (whose career spans activity in a multinational - Unilever's India subsidiary – and the Tata Group).

Why do these successful individuals devote time to this organization? A sense of obligation to their alma mater is the probable likely cause. Prestige with being associated with the institute is probably also a factor. One could try to tell an economic story to justify their involvement but it is not self-evident what this might be. Of course, many of the individuals are parts of organizations that are now the recipients of talent-outflows from the IITs and therefore have a stake in the success of the organization, but the vast

number of similar recipients of such largesse imply that there is too much of a free-rider problem to make this a compelling explanation.

Competition

For most of the four decades under consideration, it is difficult to take seriously the prospect that the IITs did well because the hot breath of competition spurred them on to competition. Quite simply, there was no compelling competition – no place for talent to gravitate to other than the IITs.

As an aside, consider why talent did not go overseas. For most of the four decades since their existence, it has been exceedingly difficult for talent to leave a poor country to study in technical institutes of comparable acclaim overseas. For example, until the mid 1990s, for all but an exceedingly small number, it was very difficult to obtain loans from financial institutions to study in the west. This situation has been somewhat amended with some convertibility of the India rupee and the emergence of a (somewhat more) global market for talent.

It is, however, true that there was some intra-IIT competition with reputations for particular branches of engineering being excellent on one or the other of the campuses at a point in time. For example, IIT-Kanpur was considered the center of excellence for computer science in the mid 1980s.

It is also true that competition for talent has heated up since the mid 1990s. Consistent with this is the far greater emphasis on strategic planning on the campuses. The IIT Madras website provides a wonderful detailed example of a strategic planning process launched in 1996, the results of which were available in 2001.

Poor Organization offset by Other Contemporaneous Factors

This alternative says that the premise of the assertion in this sub-section is wrong. That is, the IITs are not that successful in the sense of being efficient organizations. It is just that the factor inputs off which they feed – notably talent – are so compelling that the output cannot but be successful in the global arena. Vigorous competition among large numbers of students for a very small subset will inevitably cream-skim. Such concentration of talent will do well even if surrounded by an organization operating quite below the relevant technical frontier.

Consistent with the idea that the success of IIT is mostly due to superb quality of student raw material, note that one is hard-pressed to point to major research discoveries from the IITs. The IITs' success as a teaching institution – especially an undergraduate teaching institution – is the basis of its repute.

Further, in recent years, successful alumni have been contributing to the institutes and may further obscure any shortcomings in the organizational structure and governance of the institutes.

Summary

The IITs appear to be an example of successful government intervention. We believe, however, that it is not government-intervention per se that is the cause of success, but other contemporaneous factors that condition the effect of government intervention. First, India's emphasis on autarky in the four decades following Independence, and the capacity constraint on available spots meant that talent had nowhere else to go. Second, the installed base of exceedingly successful alumni, especially in the United States, and their continued loyalty to their alma mater, has provided a feedback loop that reinforces the IIT's ability to attract talent.

Note that a government intent on maximizing (or at least raising) economic surplus would no doubt have expanded capacity in this success story. The contours of the success story, after all, were well known to all by at least the 1970s. Nonetheless, the government should be credited, if credit is the right term, with not interfering in ways too numerous and distressing to contemplate (e.g. tampering with admission decisions).

It also appears that this is an organization in which, to a first approximation, the private sector has not had much of a say. Individuals from the private sector contribute some time to the ongoing governance of the IITs, but it is in their individual rather than in their 'corporate' capacities. It is difficult to make the case that individual companies, from the software sector or elsewhere, have invested in the maintenance of the IITs.

Appendix B

The Capability Maturity Model

Capability Maturity Model (CMM), as the name suggests, seeks to identify the evolving capability of an organization at developing software. It was created in 1986 by the Software Engineering Institute (SEI), an entity affiliated with Carnegie-Mellon University (Pittsburgh), initially for use in software used in military avionics. The intellectual origins of the model are in statistical quality control dating back to the 1930s. These were popularized in the business world by Deming and Juran, and adapted to software by Crosby (1997). Subsequent development occurred by scientists at IBM, before the action shifting to the SEI.

Five levels of capabilities are attainable by an organization – these are labeled, from the lowest to the highest level of capability, Initial, Repeatable, Defined, Managed and Optimizing. The first level corresponds to ad hoc and chaotic processes, and it is only the fifth level that is associated with continuous and measurable improvement in an organization's ability to develop software.

Progressing to a higher CMM rating is non-trivial. Studies show that such progression requires a serious commitment from senior levels of management of the candidate organization, and usually took considerably more time than expected at the outset. Attaining the highest level requires, approximately, a ten-year commitment of gradual improvement. A 1997 assessment of 628 users of the CMM model suggested the following distribution of software capability: 62% at level 1, 23% at level 2, 13% at level 3, 2% at levels 4 or 5. This distribution is 'right shifted' relative to an assessment of 218 users undertaken in 1992, indicating improvements in attained CMM levels in the population at large.

Some descriptive evidence seems to suggest that the CMM criteria are perceived as being more relevant to large organizations than to smaller ones (Herbsleb et al. 1997, Table 5). There is some controversy in the literature regarding whether attaining a higher CMM rating does, in fact, reduce costs or improve quality. (For example, a controversy that has not been adequately resolved, to our mind, is whether or not the correlation between higher CMM rating and lower cost is not driven by other underlying unobservables.)

Appendix C

Key Events in Infosys' voluntary adoption of international corporate governance standards

From Founding (1981) to 1986:

Company founded on a shoestring budget of \$1000 contributed by seven founders who left another software startup, PCS.

First project in New York. Global product company from the outset.

From 1986-1992:

Four loans totaling \$725,000. General reluctance to use debt. Financing mostly through profit retention. Founders continued to contribute through acceptance of lower-than-market salaries.

1989:

90% of Infosys revenues came from work done at client sites outside of India
Uncompromising exposure to global product markets

1993:

Among first-market priced IPOs in India (following removal of controls on IPO prices that existed prior to 1991)

Year ?:

Reporting per U.S. GAAP caused by the need to present a clear picture to customers in the U.S.

1996:

Move toward having independent directors. Such directors do not hold stock in the company.

1997:

Development of an audit committee modeled on Blue Ribbon Committee's charter.
Subsequently forms the standard for SEBI's recommendations of what audit committee should look like.

1997:

Webcast annual shareholder meeting
Post presentations made by CFO and CEO to analysts on the website

1997:

Quarterly reporting initiated

Late 1997:

Formed compensation committee comprised entirely of independent directors. Committee determined senior management compensation. This committee was set up because both NYSE and NASDAQ listings required this.

Early 1998:

Disseminated all press releases on web site.

1998

Changed designations of senior management to suit global requirements to prepare for NASDAQ listing.
Developed voluntary 10K form which included an additional risk factor section. In India, risks were traditionally described but not evaluated. In India, there was not the same absolute liability associated with not analyzing risks as there was in the U.S.

March 1999

NASDAQ listing. Infosys voluntarily opted to behave like a U.S. domestic issuer, rather than subjecting itself to the less stringent standards of a foreign issuer.

2000

Infosys was the first company worldwide to comply with new 20F regulations. Companies can file 10Qs and 20Fs within 90 days of end of quarter and 190 days of end of year. Infosys typically files within 8-9 days. Infosys also distributes quarterly reports to U.S. shareholders though it is not required to.

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Table 1

Comparison of Indian Public Sector, Private Sector, and Multinational Corps., 1993

Expressed in ratio	Private sector compared to public sector^a	Indian private sector compared to all foreign companies^b
# of Co.	16.92	17.18
Sales	1.53	4.32
Profits	2.22	3.87
Assets	1.21	9.07
Equity	0.51	6.71

Source: Author's calculations from a database maintained by the Center for Monitoring the Indian Economy (CMIE), Bombay, India. Found in Tarun Khanna, "Modern India," HBS Case No. 979-108 (Boston: Harvard Business School Publishing, 1997, p. 7.

^a The private sector is comprised of Indian group-affiliated firms (IG) and Indian non-group affiliated firms (IN). The public sector is comprised of central and state government owned firms (P). This column depicts, for each category, the ratio $(IG+IN) / P$. (i.e. there are 16.92 times as many companies in the private sector as there are in the public sector, but total sector sales are only 1.53 times greater than total public sector sales.)

^b This column depicts the Indian private sector relative to foreign firms (F), i.e., the ratio: $(IG+IN) / F$.

Table 2
Comparison of Group and Non-Group Firms Listed on the Bombay Stock Exchange in 1993.

Variables	Group Firms		Nongroup Firms	
	Mean	Median	Mean	Median
Sales (million of rupees)	1,411	666	366	217
Age (years)	28.3	22	19.8	14
Tobin's q	1.39	1.14	1.37	1.06
Ownership by foreign institutional investors (%)	10.1	2.3	7.4	0.9
Ownership by Indian institutional investors (%)	15.6	13.3	11.3	6.5
Ownership by insiders (%)	31.9	31.3	20.8	17.1
Directors' ownership (%)	5.7	1.1	14.2	10.7
Top fifty owners excluding the above categories (%)	4.9	3.2	7.6	5
Number of firms	567	567	437	437

Source: Tarun Khanna and Krishna Palepu, "Emerging Market Business Groups, Foreign Intermediaries, and Corporate Governance," in *Concentrated Corporate Ownership*, ed. Randall K. Morck (Chicago: The University of Chicago Press, 2000), P. 276. Data obtained from CMIE for 567 affiliates of 252 different groups and for 437 unaffiliated firms traded on the BSE.

Note: The summary statistics in this table are based on 1993 values. Tobin's q is defined as (market value of equity + book value of preferred stock + book value of debt)/(book value of assets). Sales are measured in millions of rupees, with an approximate exchange rate at this time of U.S. \$1.00 = Rs 30.00. Age measures number of years since incorporation. Foreign institutional ownership aggregates ownership of foreign corporations as well as that of foreign financial intermediaries. Domestic institutional ownership aggregates ownership in the hands of all state-run financial intermediaries. Insider ownership includes the stakes held by group family members and by other group firms and measures stakes held by insiders for nongroup firms. Directors' ownership captures the ownership of nonfamily directors. Top fifty ownership captures the largest shareholders not included in the aforementioned categories. Group membership is based on definitions of groups from CMIE and is described in the text. The mean and median values for all the variables except for the mean value of Tobin's q and change in Tobin's q are significantly different between the group and nongroup firms at the 5 percent significance level.

Table 3
India's Software Exports, Domestic Sales, and Imports (Rs. Billion/\$ Million)

Year	Exports Rs.	US\$	Domestic Sales	Exports/ Total Sales (%)
1987-88	Rs. 0.70	\$52	Rs. 1.00	41
1990-91	Rs. 2.50	\$128	Rs. 2.25	52
1991-1992	Rs. 4.30	\$164	Rs. 3.20	57
1992-93	Rs. 6.70	\$225	Rs. 4.90	57
1993-94	Rs. 10.20	\$330	Rs. 6.95	59
1994-95	Rs. 15.30	\$485	Rs. 10.70	59
1995-96	Rs. 25.20	\$735	Rs. 16.70	60
1996-97	Rs. 39.00	\$1,110	Rs. 25.00	61
1997-98	Rs. 65.30	\$1,790	Rs. 35.80	64
1998-99	Rs. 109.00	\$2,650	Rs. 49.50	68
1999-00	Rs. 171.50	\$4,000	Rs. 94.10	70
2000-01	Rs. 283.50	\$6,230	Rs. 98.90	74
2001-02	Rs. 365.00	\$7,680	Rs. 115.00	76

Note: The figures for the domestic software activity do not include in-house development of software by end users, which is presumed to be a considerable amount.

Source: Adapted from Pankaj Ghemawat, "The Indian Software Industry in 2002," HBS Case No. 700-036 (Boston: Harvard Business School Publishing, 2002), p. 20. Data from NASSCOM; Heeks, R. *India's Software Industry: State Policy, Liberalisation and Development*, (New Delhi: Sage Publications, 1996).

Table 4
Structure of Indian Software Exports Industry

Annual turnover	No. of Companies	
	2000-01	2001-02
Above Rs. 1,000 crore	5	5
Rs. 500 crore – Rs. 1,000 crore	7	5
Rs. 250 crore – Rs. 500 crore	14	15
Rs. 100 crore – Rs. 250 crore	28	27
Rs. 50 crore – Rs. 100 crore	25	55
Rs. 10 crore – Rs. 50 crore	193	220
Below Rs. 10 crore	544	2,483

Note: In 2001-02, companies under Rs. 10 crore revenues included non-NASSCOM member companies.

Source: Adapted from “NASSCOM: Strategic Review 2003: The IT Industry in India” (New Delhi, 2003). Available from the National Association of Software and Service Companies.

Table 5**Top 20 IT Software and Services Exporters from India**

Rank	Company	Rs. core	US\$ million
1	Tata Consultancy Services	3,882	813
2	Infosys Technologies Limited	2,553	535
3	Wipro Technologies	2,256	481
4	Satyam Computer Services Limited	1,703	357
5	HCL Technologies. Ltd.	1,319	277
6	IBM Global Services India Pvt. Ltd.	764	160
7	Patni Computer Services	732	153
8	Silverline Technologies	603	126
9	Mahindra-British Telecom Limited	541	113
10	Pentasoftware Technologies Ltd.	459	96
11	HCL Perot Systems Ltd.	449	94
12	Pentamedia Graphics Ltd.	431	90
13	NIIT Limited	400	84
14	Mascot Systems Ltd.	399	84
15	i-Flex Solutions Ltd.	392	82
16	Digital Globalsoft Ltd.	331	69
17	Mphasis BFL Group (Consolidated)	313	66
18	Mascon Global Limited	307	64
19	Orbitech	264	55
20	Mastek Limited	259	54

Source: Adapted from “NASSCOM: Strategic Review 2003: The IT Industry in India” (New Delhi, 2003). Available from the National Association of Software and Service Companies.

Table 6
A Comparison of the large US and Indian Software Companies

	Revenues June 2002, \$ million ttm	Operating Margin June 2002, Per cent ttm	No. of Employees June 2002	Market Capitalization October 2002, \$ million
U.S.				
Companies				
Accenture	11,600	3.9	75,000	12,400
CSC	11,500	4.7	67,000	4,800
EDS	22,300	10.3	143,000	6,370
KPMG				
Consulting	2,368	5.6	9,300	1,240
Sapient	217	N/A	2,427	123
Indian				
Companies				
HCL Tech	340	28.1	5,587	1,209
Infosys	571	32.1	10,470	7,140
Satyam	421	26.7	9,532	1,370
TCS	810	25	19,000	8,100
Wipro	734	24.5	13,800	6,340

Source: Adapted from "NASSCOM Newslines, November 2002" (2002). Available from the National Association of Software and Service Companies. <<http://www.nasscom.org>>