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IT and regional development: lessons from the growth of the software industry in India, Ireland, Israel, Brazil and China

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Abstract:

During the 1990s the software industry grew at spectacular rates in some emerging economies, generating much interest in the question of how countries behind the technology frontier had been able to achieve substantial growth in a technology intensive industry. In this paper, we explore the factors that explain the rise of the software industry in Brazil, China, India, Ireland and Israel, highlighting both what is common and what is different across the five countries. We find that Brazil and China have relied upon the domestic market, while India, Ireland and Israel, have grown through exports. Although all countries were marked by substantial investments in human capital, the I countries have seen a more limited role of sector specific public policies and a greater role for private entrepreneurship. Moreover, many traditional explanations of success in technology intensive industries, namely clusters and knowledge spillovers in clusters, R&D subsidies, and venture capital appear to have played a modest role at best. Instead, MNCs, openness, and entrepreneurship have been far more important.

Non Technical Summary

The Indian software industry is widely admired for its rapid growth over the last two decades. How did India do it and what can we learn from this? To answer this question it is useful and important to place the Indian experience in context. Other countries, comparable to India in some respects, also developed substantial software industries. Their experiences, compared and contrasted, provide insights that are important for policies for regional development. There are two groups of countries. Brazil and China have managed develop large and sophisticated software sectors based on domestic demand, whereas India, Ireland and Israel have export oriented sectors. Belying the hopes of many, Brazilian and Chinese software firms have not as yet succeeded in converting what they have accomplished in their domestic markets into export success. In principle, there is no reason why they cannot succeed in this endeavor, merely that when firms enjoy privileged access to domestic markets, they focus their energies there rather than on exports.

The export oriented industries in the I countries had different routes to export success. Israeli firms built on the peerless Israeli science and engineering infrastructure and the unique opportunities offered by Israel defence infrastructure. Ireland benefited from policies intended to attract MNCs to locate manufacturing plants but which enticed software firms to localize software in Ireland and sell it in the EU and elsewhere. Indian firms focused on exports of services to leverage its large pool of engineers.

Despite the different paths, there are important commonalities. First and foremost, all of these countries made sizeable investments in human capital, relative to their internal needs. The importance of human capital -- skilled and creative workers -- to a "high-tech" industry is routinely acknowledged but often public policy discussions tend to focus on more trendy

prescriptions such technology parks, venture capital, incubators and university industry centers. Not only did these investments create the necessary workforce, they also created a diaspora of engineers in the United States (and to a lesser extent in Great Britain), which proved to be of great importance in linking software firms with their customers, and for Israel, with their venture capitalists as well. At least as important has been the role of the ethnic diaspora as entrepreneurs, leveraging the comparative advantage of the mother country in the export markets of the adopted ones.

The standard recipe for the promotion of technology intensive sectors, namely universities, R&D subsidies, clusters, and venture capital, appear to have been of marginal importance. To be sure, such policies do little harm and may even do some good. But there is no evidence that these policies are behind the export successes in software that we have studied. Rather, the principal policies have been more general, those that have promoted investments (public and private) in human capital, capital markets where entrepreneurial firms can raise capital, labor markets where entrepreneurial firms can find the human capital they require, and general support for world class science and technology. Policymakers must not, moreover, make a fetish of technological sophistication. Even in technology-based industries, technology may not be the only means of entering the industry value chain, as the Indian case makes very clear.

Despite being technically not very sophisticated, the Indian software industry has grown even as wages have increased year on year. For the most part, developing new products or undertaking high level design has not been the principal means of offsetting the wage advantage. Rather, Indian firms upgraded their ability to take on and manage larger projects. Instead of moving aggressively into product design, they focused on taking on lower end functions such as maintenance and support. This focus leveraged the capabilities Indian firms had developed,

which was to manage projects with large teams of skilled people. In other words, moving up the value chain, as policy makers frequently wish to do, can be accomplished in a variety of ways; moving up the technology chain is not the only way, nor always the best.

During the 1990s the software industry grew at spectacular rates in some emerging economies: In India, the software industry went from being practically non-existent 1980 to employing nearly half a million and accounting for nearly 3% of national GDP by the turn of the century (Arora et al, 2001; Arora and Athreye, 2002). In Ireland, according to government statistics, software is said to account for nearly 10% of the GDP. The software industry in Israel has also grown at very high rates, and India, Ireland and Israel are among the leading exporters of software worldwide. During the same period software grew in some other non-G7 economies as well. For instance, both Brazil and China recorded double digit growth rates, mostly by servicing domestic demand. In the past decade, growth has slowed down but the emerging economies of India, Brazil, China, Israel, and Ireland boast of substantial software sectors.

Since software is commonly viewed as a high tech industry, it is intriguing that such spectacular growth has occurred at least in some economies that are behind the technological frontier. This raises several questions. What accounts for the spectacular growth of software in these emerging economies? Does this phenomenon suggest a new model of economic development? How crucial are exports for this process and can Brazil and China, with their domestic market oriented software industry forge a new path for growing a high tech industry in an emerging economy? Can the success achieved by countries such as India, Ireland and Israel be replicated, or at the very least, are there lessons other emerging economies can learn from their experience? What do we learn from their experience about the role of human capital in economic growth, about firm formation and capabilities, about business and managerial models, about industry structure?

In this paper, we distill the findings from a a study of the software industry in five countries – Brazil, China, India, Ireland and Israel. This paper is organized as follows. Section 2 briefly describes the international software industry.

Section 2: Size and growth:

Getting accurate measures of the size of the software industry in different countries is bedeviled by problems of definition and data availability. The various sources are not directly comparable. However, table 1 gives the relative sizes of the software industry in different countries at the turn of the century.

Table 1 shows that in 2002, the Indian and Chinese industries were of comparable size (respectively $12.5 and $13.3 billions), while the 2001 sales of Brazil and Israel were $7.7 and $4.1 billions. The Irish industry reached $13.9 billion in total sales in 2002, of which $12.3 billion is attributed to the multinational companies and $1.6 billion to the indigenous sector.[1]

The employment differences among our five countries are more marked than those in sales. In March 2003 the Indian software industry employed about 250,000 people.[2] The 2000 figures for China and Brazil are respectively about 160,000 and 190,000. Tthe 2002 employment in the Irish software industry was about 28,000 (15,300 and 12,600 respectively for MNCs and indigenous firms), while the 2001 employment of the Israeli industry was about 15,000. To put these figures in perspective, employment in the U.S. software industry was slightly above 1 million, with sales of around $200 billion, while the comparable figures for

[1] The Irish MNC sales are most likely inflated by accounting devices guided by the substantial tax concessions offered by the country. Indeed, the MNCs in Ireland have employment levels comparable to that of the indigenous firms (15,300 and 12,600 respectively in 2002), while their sales are over 8 times as much. Since they mostly localize their products in Ireland not design them, this gap must arise mainly from accounting reasons, not superior value added.

[2] This excludes what NASSCOM calls IT enabled services, such as call centers and help desk operations, which employ 160,000. Another 260,000 software professionals are estimated to work in what NASSCOM calls user organizations.

Japan were 534,000 and $85 billion.[3] The sales and employment figures produces notable differences in the sales per employee, with Israel having the highest sales per employee. The revenue per employee of the Indian industry in 2002 was about $50,000, and comparable to figures for China and Brazil.

The picture that emerges from these figures is consistent with the stylized facts. The Israeli software industry is largely product- and-R&D oriented. The software industry in Brazil, China and India is of lower value added, and in Indian in particular, is heavily service oriented. Ireland is in between, with a handful of product oriented firms, and a number of small consultancies and niche firms.

Table 1. The Software Industry in Brazil, China, the 3Is, and in the US, Japan and Germany – 2002 or latest available figures

Countries	Sales ($ billion)	Empl (000)	Sales/ Empl (000)	Software Sales/GDP (%)	Software Development Index
Brazil *	7.7	160 **	45.5 **	1.5	0.22
China	13.3	190 **	37.6 **	1.1	0.23
India	12.5	250	50.0	2.5	0.96
Ireland (MNE)	12.3	15.3	803.9	10.1	0.34
Ireland (Domestic)	1.6	12.6	127.0	1.3	0.04
Israel *	4.1	15	273.3	3.7	0.17
US	200	1024	195.3	2.0	0.05
Japan **	85	534	159.2	2.0	0.08
Germany *	39.8	300	132.7	2.2	0.09

Various sources. * = 2001; ** = 2000;
The Software Development Index is the ratio between Software Sales over GDP (in %) and the GDP per capita of the country (in 000 US $) (See also Botelho *et al*, 2005)

[3] Note, however, about two thirds of all software occupations are not in the IT sectors. Thus, the true number of software workers in the U.S. is probably closer to 3 million (see also IT Workforce Update, 2003).

Table 1 also shows that in Brazil and China software sales are between 1and 1.5% of GDP, only slightly smaller than the corresponding figures for richer countries such as the U.S., Japan and Germany.[4] The software share of GDP is higher in Israel (3.7%) and India (2.5%). The shares for India and China have also increased substantially in recent years, while they have remained more stable for the other countries. In 2001 the GDP share of software was only 0.6% in China and 1.7% in India. Thus, in these two economies software has continued to grow faster than GDP in 2001-2002, despite the general slowdown in the IT sector worldwide. Table 2 below (taken from figures compiled by the Chinese Software Association) suggests that the software industry in India and China have grown faster than those in the United States, Japan and Western Europe. Note that the figures in Table 2 are from a different source than table 1, and though similar, are not identical.

Table 2: Software Revenues, selected countries, 2002-2004, in $ Billion

	2002	2003	2004
China	13.3	19.3	27.8
Korea	16.8	20.1	20.7
India	12.2	16	20
USA	280	297	311
Japan	71	79	83
Western Europe	216	225	238

Source: Chinese Software Association, converted from local currency by authors.

Moreover, in all five countries, the ratio between the software share of GDP and the GDP per capita (Botelho *et al*, 2005) is higher than in the U.S., Germany, and Japan, suggesting a specialization in software, particularly for India. But the most impressive figures about the software industry in these emerging economies are their growth rates, which have ranged as high

[4] The GDP shares of Brazil, China, and the domestic Irish software industry are indeed higher than other G7 countries, like the UK (1%) or Italy (0.8%), and they are comparable to the figure for the G7 countries as a whole.

as 40% per year in the Indian case (table 3, column 2). The number of firms has grown as well. In India, the membership of NASSCOM increased from around 100 in 1990 to 797 in 2000 (Athreye, 2005). Similarly, the number of new Irish software firms increased from less than 300 in 1991 to 760 in 2000 (Sands, 2005). Botelho *et al* (2005) report that of a sample of 685 Brazilian software firms in existence in 2001, a little less than a third (210) were founded between 1996 and 2000, and a slightly larger fraction, 221, were founded between 1991 and 1995.[5]

Table 3. Brazil, China and the 3Is: Software Industry Growth & Export Shares

Countries	Average Growth in the 1990s (%)	Exports as % of sales (2002 or latest available year)
Brazil	20	1 - 2
China	30-35	11
India	40	80
Ireland	20	85
Israel	20	70

Arora and Gambardella, 2005

Section 3 Understanding the Success Stories

As a first approximation, all the successful software exporters, India, Ireland and Israel, have a comparative advantage in human capital intensive activities, due to their relative abundance in human capital. Table 4, taken from Arora and Gambardella (2005), shows that the stock of scientists and engineers in Israel, Ireland and China grew by about 30% between 1981 and 1990, and in Brazil, it was more than twice that, growing by nearly 60%. We lack comparable figures for India but data on the engineering baccalaureate capacity in Indian colleges and universities suggest that the stock must have grown at least as much.

[5] There are no specific figures for the creation of new software firms in China or Israel. However, the existing scattered accounts support the idea of high rates of entry into the software industry in both countries.

Table 4. Stocks of Scientists and Engineers in Selected Countries, 1981 and 1990, in '000s.

	S&E 1981	S&E 1990	Increase (%)
Brazil	2951	4667	58%
China*	26457	34420	30%
India	7094	n.a.	
Ireland	155	200	29%
Israel	290	371	28%

* = 1982
n.a = not available
source: Arora and Gambardella, (2005: table 3)

To say that these countries are abundant in human capital only pushes the enquiry one step further: How did, for instance, a poor country like India become so well endowed with human capital? India is not well endowed with human capital by most measures. Barely 50% of the population is literate, and normalized by population, the stocks of scientific and technical personnel are modest, well below countries in East Asia. It is merely that during the 1970s and 1980s, India found itself with more engineers than its stagnant domestic economy could employ on attractive terms. Many migrated to America, where they rose to middle management positions in large firms.[6] When the big surge in IT demand came in the early 1990s, these emigrants were well positioned to broker the small initial contracts with Indian software firms, or as Kapur (2002) dubs it, act as "reputational intermediaries". Similar explanations, mutatis mutandis, may be applied to Ireland and Israel.

Simply put, the 3Is became abundant in human capital because they have produced more engineers than their hitherto lackluster industrial sector could absorb.[7] This is particularly relevant from about the mid 1970s up until the late 1980s. During this time, these countries grew

[6] US Census data analyzed by Kapur and McHale (2005) indicate that 77% of the Indian born population in America in 2000 had college degrees, and 37% had a masters degree or higher!
[7] In the Israeli case, the economic crisis in early 1980s and with the growing military alliance with the U.S. after the 1973 war led to a significant downsizing in the defense industry, the most notable instance of it being decision to stop the development of the latest fighter-jet ("The Lavi"). The result was that thousands of highly trained and experienced engineers became available. Breznitz (2005) also notes that generous redundancy packages became seed capital for many of these would be entrepreneurs.

only modestly, while continuing to invest in science and engineering. Indeed, the average growth rate of GDP per capita for India between 1970 and 1990 was barely 2% per annum, while both Israel and Ireland managed to grow at 2.4% and 2.9% respectively. In all three cases, however, this performance is lower than the performance of peer countries. Moreover, it masks the large decadal variation. In India, the 1970s were a period of very low growth, while the 1980s could be called the lost decade for both Israel and Ireland, a feature is which also reflected in the migration patterns to the United States, as discussed below.

In the more advanced countries and the rapidly growing Asian countries such as South Korea, Taiwan and Singapore, the science and engineering graduates faced a high opportunity cost of working in the software sector. Plentiful job opportunities in industry, in well established firms with good opportunities, mean that there would be fewer entrepreneurs setting up software firms, and nascent software firms would find it difficult to attract talented engineers.

However, the sustained growth of software exports required an expansion in engineering education capacity as well. This was accomplished through a mix of private and public investments, with the mix varying across countries.

In India, this growth was due to private sector investments, made possible by the decentralized nature of tertiary education in India, as also discussed in greater detail in Arora and Bagde (2006). Table 5 below shows that in 1985, roughly the time when software exports begin, Indian colleges graduated about 45,000 engineers of all types. By 2004, the capacity had increased to nearly ten fold to 440,000. Arora and Bagde (2006) estimate that 160,000-180,000 engineers were graduated in 2004 (Arora and Bagde, 2006).[8] Figure 1 shows that the vast bulk of this increase took place in private colleges that did not receive public subsidies (called "non-

[8] These figures do not reflect the large number of non-engineers who acquire computer training and skills in using relevant tools at non-degree granting institutes such as NIIT and Aptech.

granted colleges in India).

Table 5: Sanctioned engineering baccalaureate capacity in India, 1951-2004

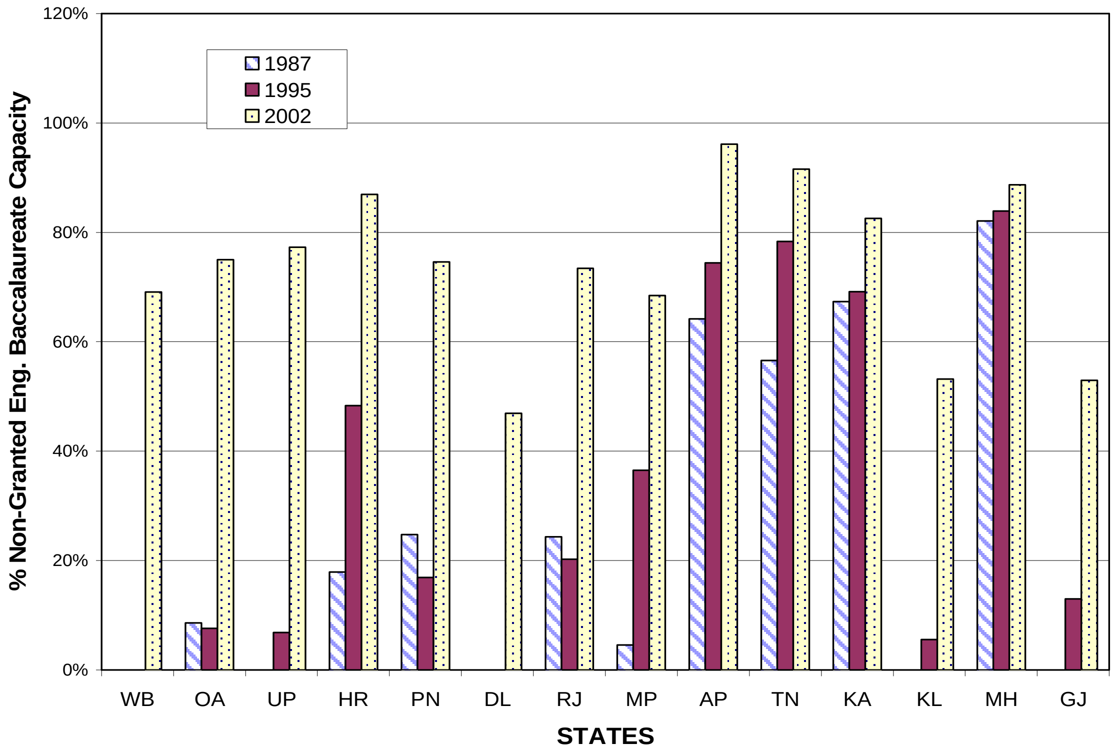
Year	Population in millions	Engineering college capacity	Engineering college capacity per million of population
1951	361	4788	13
1985	765	45136	59
1995	928	105000	113
2004	1086	439689	405

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

On the other hand, in Ireland, public investments were central in expanding educational capacity. Table 6 below shows the distribution of EU structural funds in the 1990s. The table shows clearly that Ireland spent a greater fraction of the EU funds it received on human capital rather than on roads and bridges. The results were quite dramatic. OECD figures show that in 2001 the share of Irish population between 25-64 with academic degrees was 14%, up from 11% in 1999 (OECD, 2002 and 2001). For people between 25-34 this percentage was 20% in 2001 *vs* 16% in 1999. This compares to more modest increases in the share of population between 25-64 with academic degrees in the top 4 European countries. The UK moved from 17% in 1999 to 18% in 2001, Germany remained stable at 13%, Italy moved from 9 to 11%, and France from 11 to 12%. For the population between 25-34, the UK moved from 19 to 21%, Germany from 13 to 14%, France from 15 to 18%, and Italy from 10 to 12%.

FIGURE 1

STATE SHARE OF PRIVATE NON-GRANTED COLLEGE IN SANCTIONED ENGINEERING BACCALAUREATE CAPABILITY IN INDIA, BY MAJOR STATES, VARIOUS YEARS



Legend*: WB = West Bengal, OA= Orissa, UP = Uttar Pradesh (incl Uttaranchal), HR = Haryana, PN = Punjab, DL = Delhi, RJ = Rajasthan, MP = Madhya Pradesh (inc. Chattisgarh), AP = Andhra Pradesh, TN = Tamil Nadu, KA = Karnataka, KL = Kerela, MH = Maharashtra, GJ = Gujrat.*
Notes: Data on Bihar and Jharkkandh are not available. Data for north eastern states, Jammu and Kashmir, and Himachal Pradesh, are omitted.

Table 6: Distributions of EU Structural Funds 1989-1993 and 1994-1999 (%)

Country	Human Resources		Infrastructure	
	1989-1993	1994-1999	1989-1993	1994-1999
Greece	25.6	24.6	40.9	45.9
Spain	24.2	28.4	54.0	40.4
Ireland	38.0	43.9	27.7	19.7
Portugal	26.1	29.4	29.2	29.7
Italy	21.6	21.4	38.7	29.8
Average EU11	29.6	29.8	35.2	29.5

Source: First Report on Economic & Social Cohesion 1996 DG XVI EC Brussels (From Sands, 2005)

Although undoubtedly correct, comparative advantage by itself seems insufficient to explain the success of the 3Is. After all, many other countries are abundant in human capital but have failed to develop into software exporters. Additional factors are needed to explain the successes observed.

Some traditional-explanations

Domestic demand and learning from the domestic market.

As Table 3, column 3 shows, the export shares of the 3Is are far higher than for China and Brazil.[9] However, the export share in China has grown substantially from about 5% in 1999-2000 (Tschang and Xue, 2005) to 11% in 2002. In China, and perhaps in Brazil as well, exports are based on competencies nurtured and developed by serving the domestic market (cf. Botelho *et al*, 2005).

Even among the 3Is there are differences in the extent to which the underlying growth model is export-led *vs.* development-led. Indian software growth was started and sustained by exports. Similarly, Irish software growth was due to MNCs. In Israel, the situation was different. Breznitz (2005) claims that the Israeli industry was catalyzed by domestic demand and became an international player only subsequently.

The Indian software industry is perhaps the clearest example of export led growth. Th initial growth of the Indian industry took the form of the Indian firms (and many U.S. based firms as well) literally renting out software programmers to work at the client's site and under the client's management. With booming demand, Indian software engineers had the opportunity to learn how to manage relatively large projects. Euro conversion projects and Y2K projects

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[9] As shown in Sands (2005), the software MNCs in Ireland exported 95% of their sales in 2002, and this percentage has been largely above 90% since 1991.

were well suited for the kind of competences and skills that the Indian software industry had by then developed.

The domestic Irish industry shows a less pronounced initial dependence on exports. MNCs were an early source of demand for domestic software firms, and as also discussed in Arora, Gambardella, and Torrisi (2004), many successful Irish software firms started as programming houses for the subsidiaries of the MNCs in the information technology (IT) sector, or as software application developers for other non-IT firms.

Of the three, Israel relied the least on the export market at the outset of its software industry. Breznitz (2005) argues that “the rapid expansion of defense R&D and the fast accumulation of IT skills by both university graduates and graduates of the military technological units created both local demand for IT usage, the knowledge base to supply it, and a positive attitude toward this nascent industry.” In addition, the Israeli software industry sits on the shoulders of a giant. It is linked to the sizable Israeli IT hardware industry (55,000 employees in 2002), a source of both demand and expertise.

In all the other countries except India, the software industry grew out of links with related sectors that were the sources of competencies and provided the underlying demand as well. For example, banking and telecommunications, along with customer electronics and retail automation, have been the principal sources of domestic demand in China. The government has been another big player, with national and regional governments often favoring domestic vendors for a variety of PC based software, from the operating system to application software.[10] Domestic demand also explains why Brazil, rather than for example some of its neighboring

[10] For example, Saxenian (2003) reports that the Beijing municipal government and the Guangdong provincial government recently required that all their departments used a Chinese language office software package, WPS2000, rather Microsoft Office2000, in spite of its lower technical quality.

regions, has become an important software producer. Brazil has an uncommonly high share of IT expenditures on GDP. World Bank data cited by Botelho *et al* (2005) indicate that in 2000 Brazil spent 8.3% of its GDP on IT. This compares to 7.9% in the U.S., 7.4% for Israel, 5.7% for China, and only 3.9% for India. The Brazil figure stands out when compared to its neighbors Mexico (3.2%) and Argentina (4.0%). Lead users such as banks have been central to the growth of the Brazilian software industry. Similarly, the telecom industry pushed the demand for communication software (e.g. the growth in the demand for cell phones). Public sector demand, exemplified by the installation of an electronic voting system, also helped (Botelho *et al*, 2005).

Insofar as Brazil provides the best test case for a domestic market based growth, the promise has been unfulfilled. Brazilian software firms are as yet small, diversified in terms of activities but largely oriented only towards the Brazilian market. Export successes, which would measure the success of domestic demand based model, are few and far between (Boetelho et al., 2005). China, with its much larger and faster growing domestic market, yields similar conclusions (cf. Tschang and Xue 2005). Domestic Chinese firms appear to be small and diversified, producing software products, software services, consulting and systems integration. By contrast, Indian firms tend to focus on software and IT services. Moreover, the number of software firms in both Brazil and China are thought to be more than that in the India, despite roughly similar sized software markets.

The overall impression one gets is as predicted by economic theory. When firms enjoy de jure or de facto protection in their domestic market, they will attempt to maximize the returns to their principal asset, in this case, privileged access to the local market. In some cases, this will imply providing a diverse range of products and services to their local customers, which is reflected in the high diversification of Brazilian and Chinese software firms.

All of this is not to imply that Brazil and China are failures. Given China's size and its economic performance, and in particular, its spectacular success in manufacturing, it would be foolish to bet against its success, and there are many promising signs from Brazil as well. These two countries represent an interesting alternative path to software success, albeit one whose contours are still under construction and whose ultimate fate is as yet unknown.

Public Policy

There are many types of public policies that have benefited software exports in the 3Is, not the least of which are the side effects of policies which led to slow economic growth, and the public policies which contributed to the growth of engineering education capacity. However, what is typically lumped under this heading is affirmative, sector specific policies such as preferential capital, R&D subsidies, tax benefits or other forms of encouragement for the sector. Although claims abound about the importance of public policies, not the least from state agencies tasked with taking care of software in these countries, the supporting evidence is limited.

China represents one extreme with targeted industry specific policies, as for instance in the 10th Five Year Plan. Perhaps even more important are the unwritten policies. The Chinese government helps the formation of the companies either directly or through some institutions like the Chinese Academy of Science; it employs procurement as a means to support them even when this means sustaining national alternatives to well defined international products. All of this is overlaid on a personal network of ties between the industry and the government bureaucracy – the *guanxi* as Saxenian calls it – that are very important for commercial success. That said, given the large role of government enterprises in the Chinese economy, it is natural to expect the domestic market oriented Chinese software industry to depend upon government sector demand.

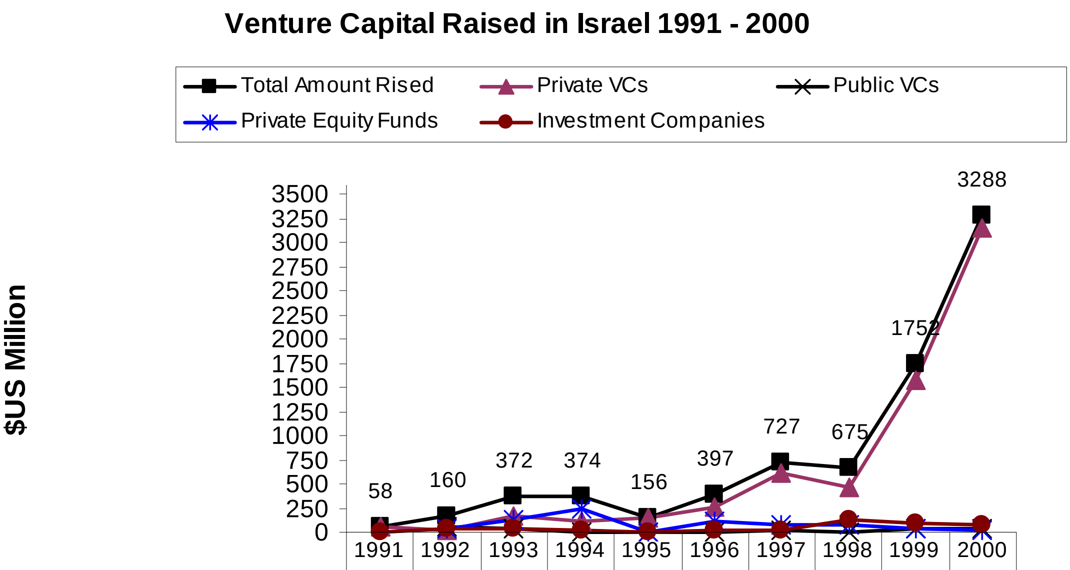
Further, just as defence sector demand has driven a great deal of IT (and software) development in the United States, it is reasonable to expect that the Chinese concerns about national security would lead to substantial support for software sectors such as operating systems, embedded software and network security products. The government in Brazil has had its biggest impact on the software industry through procurement and incentives for R&D. Government procurement has contributed to the high share of IT expenditures in the country. Apart from representative projects like electronic voting, an accomplishment not yet achieved even in more advanced countries, procurement contracts have helped the growth of the domestic firms, and have attracted some foreign software companies as well.

In Ireland, Enterprise Ireland is credited with a variety of initiatives aimed at promoting Irish SW exports. However, the two most important policies for Ireland relate to investments in education and encouragement of MNCs. Neither of these policies was specifically targeted at software, although once software exports began to grow, it was only natural that the needs of the software sector would loom prominently in policy discussions. Nonetheless, the historical record is quite clear: Promotion of MNCs and investments in education were general economic policies, aimed at promoting economic growth. Indeed, the early MNC investments were in semiconductors and hardware, seen at that time as more important, and were the source of some important indigenous Irish spinoffs, as Sands (2005) has documented.

In India, Athreye (2005a) argues that during the crucial years of its development, the software industry flew “under the radar” of the policy-makers. The domestic market was small and therefore there was little to be gained from protection. As a service industry, software was naturally exempt from many of the laws and regulations that have stifled the growth of Indian manufacturing. Neither were the large investments in the 1960s and 1970s in science and

engineering in India directed at software. Instead, the objective was to supply the manufacturing sector, whose slower-than-hoped-for growth resulted in the excess supply of engineers, described earlier. In more recent years, of course, the software industry and its industry association, NASSCOM, have come to exercise substantial political influence and helped craft favourable public policies. But that is the consequence of its success, not its cause.

Israel is probably the most successful instance where public policies were important in creating a comparative advantage in software. Israel made large public investments in science and technology, created funds for public investments in R&D and even created a public venture capital scheme to promote technology based ventures (Breznitz, 2005). Yet even in Israel, the target was all science and technology, rather than Information Technology, let alone software. The venture capital scheme, Yozma, appears to have been successful. Yet, as figure 2 below shows, public venture capital was a very small fraction of total private equity flows, including a substantial amount of private equity and venture capital flow from outside. As early as 1993, private venture capital and private equity investments total $300, eight fold larger than public venture capital investment of $42 million, and their importance steadily increases over the decade. By the year 2000, private venture capital is nearly one hundred fold larger than public venture capital investment! Even in India, in 1997, there were three American venture capital funds operating, with a corpus in excess of $300 million, in addition to several domestic venture capital funds.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Amount Rised	58	160	372	374	156	397	727	675	1752	3288
Private VCs	49	27	162	112	145	264	609	468	1575	3155
Public VCs		54	42	0	0	0	27	8	44	35
Private Equity Funds		45	128	242	6	110	66	74	40	26
Investment Companies	9	34	40	20	5	23	25	125	93	72

Figure 2: Venture capital raised in Israel, 1991-2000.
source: based on data provided by Dan Breznitz to authors.

An unexpected role of the public sector, highlighted by Arora, Gambardella and Klepper (2005), is as a source of firm formation. For example, university startups have been more important in China and Ireland. But the most significant example of the public sector as a source of firm formation is Israel’s military sector. As Breznits (2005) points out, the State in Israel was on many occasions the origin of the entrepreneurs, the first and main custmer, or the source of the technology itself, and the highly technical skills of some of its departments – especially the military – are responsible for the origins of some important software firms. Most interestingly, data from 200 leading Israeli software managers discussed in Arora, Gambardella

and Klepper show that the Israeli Defense Force (IDF) is the largest former employer of the Israeli software company managers (12.5%), and approximately 20% of Israeli software managers in the sample have been employees of the State working in “high tech” in the past.

However, the public sector can incubate capabilities, these capabilities will reflect the needs of policy, which may not always find favor in the international markets. The Chinese software industry may suffer in part from this problem. Chinese government procurement policies (including regional governments) and other interventions tend to encourage the formation of competencies in areas, like for example operating systems, where there are valid international alternatives (Saxenian, 2003). The peculiarities of the Chinese language or the size of the domestic market may justify this policy. Yet, one has to take into account the opportunity cost of not specializing in alternative areas wherein the Chinese software industry could complement international software production, rather than compete with it.

Discussions of technology based industries commonly tend to emphasize clusters, and the inter-firm learning in clusters, typically inspired by that most famous cluster of all, the Silicon Valley. As Arora, Gambardell and Torrissi (200X) discuss in greater detail, there is little evidence that cluster formation has been an important explanation in India or Ireland. Ireland is a small country where finding evidence for or against clustering based on location is difficult. Therefore, managers in both MNCs and domestic Irish firms were asked directly about the factors that were important in conditioning their location decisions. The answers, summarized in table 7 below, show clearly that learning effects in clusters are less important than access to human capital.

Table 7: Importance of factors driving the location of domestic Irish SW firms and SW MNCs in Ireland, Scale 1 = unimportant, 5 = very important.

Domestic Firms

	Near Customers	Near Partners	Business services	Phys. infrastruc	Communicat. Infrast	Skills	Universities
Mean	2.68	2.32	2.96	3.54	3.74	4.54	2.93
Mode	1	2	3	4	4	5	3
SD	1.33	1.16	1.14	0.92	1.21	0.69	1.12

Foreign Firms

	Competitors	Partners	Busin. Serv.	Phys. Infrastru	Comm. Infrastru	Skills	Labour cost	Subsid & Tax
Avg	2.54	2.54	2.54	3.54	3.77	4.54	3.33	3.67
Mode	3	3	3	5	5	5	3	5
SD	1.13	1.20	1.33	1.61	1.54	1.13	1.37	1.30

Source: Arora, Gambardella and Torrisi, 2004.

India is a large country and Bangalore is an important software cluster, lending some credence, at least at first glance, to the importance of clusters. Nonetheless, Bangalore is only one of the software clusters in India: there are five software clusters, roughly equal in size. Table 8 presents data on software exports for the 14 major Indian states over time.[11] It shows quite clearly that Mumbai was where most of the initial software activities were located (indeed, Infosys was started in Mumbai and later moved to Bangalore). Furthermore, if one aggregates Delhi, UP and Haryana, which together make up the Delhi-Gurgaon-Noida cluster, it produced exports comparable to Karnataka (Bangalore) between 1994 and 2000. Karnataka pulls away from the other clusters only after 2000, by which time the Indian software exports were already very sizable (over $8 billion by 2001).

Complementary evidence is provided by Table QQQ, which lists the location of NASSCOM member firms based on headquarters until 2001, reasonable proxy for how attractive a location is for software activity since most firms tend to be single-location at birth. Table QQQ paints the same picture as Table QQ: until 2000 or so, Bangalore was not markedly more

[11] The data for 1996 and later come from STPI figures. For earlier years, the data are based on location of corporate headquarters and revenues for firms, gathered from NASSCOM and Dataquest. For TCS, which had software development activities in multiple regions, revenues were allocated to different locations based on company-provided estimates of employment by location.

attractive a location than Mumbai or the Delhi cluster.

TABLE 8: INDIAN SOFTWARE EXPORTS, BY STATE, 1990–2003, FOR 14 MAJOR INDIAN STATES (in millions of rupees at constant prices of 1993–1994)

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

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

TABLE 9: ENTRY DATES AND THE REGIONAL LOCATION OF INDIAN SOFTWARE FIRMS, 1980-2001

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

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

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

incentives and presence of other firms were also ranked very low among the factors that influenced the location decisions of firms (Athreye, 2006).

On balance, it appears that public policy can help, albeit to a limited extent. However, the major types of beneficial policies, such as investments in human capital, or liberal market and trade regimes, are hardly specific to the software sector. More targeted policies, such as public venture capital, R&D subsidies, and procurement support for the local software industry surely do not hurt, but also have limited success in creating an industry that can compete in the world market. Having sophisticated users located in the home market is undoubtedly useful, particularly for developing innovations. However, there is little evidence that governments can do much about it, and further, that even when such sophisticated users exist, leveraging that learning to succeed in the world markets is by no means a given, as the Brazilian example shows.

The X Factors: Entrepreneurship and Openness

In an insightful article, Hausmann and Rodrik (2002) note that such market experiments appear to lie at the very heart of export successes from developing countries. They argue that, in an uncertain world, figuring out where and how to exploit a certain type of resource abundance is not straightforward. For instance, Bangladesh's abundant supplies of cheap labour give it a comparative advantage in labour-intensive products as opposed to high tech machinery. But labour-intensive manufactures range from a variety of textiles to diamond polishing. Even in textiles, where Bangladesh has focused, Bangladesh's exports to the United States are narrowly concentrated in men's cotton shirts and trousers and knitted hats. By contrast, Pakistan, with a similar resource endowment, exports bedsheets to the United States but few hats. This is not an isolated example. Hausmann and Rodrik show that, of the top 25 exports of each country, there

are only 6 items in common. They find the same pattern for other pairs of comparable countries, such as Honduras and the Dominican Republic, and Taiwan and South Korea. They conclude that, in most developing economies, “industrial success entails concentration in a relatively narrow range of activities”.

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

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

takes place.

Information from outside the country, particularly from potential export markets, may be very important for export success. This is reflected in the sources of firm formation in the software industry in Ireland, Israel and India. Of the 38 Irish software companies for which Sands (2005) presents data, 28 had one or more founders who worked abroad, and 38 of the 58 founders had worked abroad. Similarly, Arora, Gambardella and Klepper (2005) present evidence that 40 percent of a sample of 200 top managers of the leading Israeli software firms had earlier worked for an American company and a third had their highest degree from a U.S. university. These percentages are markedly higher for managers in charge of finance or marketing. This is consistent with the idea that, although Israeli entrepreneurs were technically proficient, they needed marketing and financial expertise from American managers to turn this into commercial success.

MNCs have been a sizable presence in the software industries of our countries. At the risk of some exaggeration, one can say that MNCs came to Israel to do R&D, to India for inexpensive skilled workers, and to Ireland to leverage tax incentives and access the European market (Giarratana et al., 2005).[12] Giarratana *et al* (2005) find that while in Ireland the MNCs have contributed to the initial push of the industry, it is in Israel that today one observes a more active set of alliances and similar linkages between MNCs and domestic software companies, in marked contrast to India. Giarratana *et al* also find that two-thirds of the existing ICT Irish patents assigned to local MNCs were granted before 1994, against 37% for Israel and 32% for India, which suggests that the MNCs have begun to invest in R&D more recently in Ireland and

[12] In time, they also established software development and R&D facilities in Ireland. Of course, India is too large a market to ignore for software products and so firms like Oracle and Microsoft also came to sell in India.

India as compared to Israel.[13] This is consistent with the view that in Ireland the MNCs played an important role in nurturing the rise of the domestic firms when the industry started. By contrast, in Israel and in India there seems to be a co-evolution of the entry of MNCs while the industry grew in the 1990s.

The available evidence also suggests that the MNCs, especially Siemens and Ericsson, are contributing to the formation of domestic competencies in Brazil (Botelho *et al*, 2005). As in Brazil, the list of the top 10-15 software companies in China include MNCs like IBM, Microsoft, Oracle and SAP. These firms play a major role in the national industry especially as suppliers of their packaged products, but their role in developing local competencies is less well understood.

MNCs are of course, most prominently featured in Ireland, where they account for half the employment in the software industry, but over eighty percent of the exports. The quantum of value added by MNCs in Ireland is partly an artifact of creative accounting and low taxes on corporate profits, but there is no denying that MNCs have been vital to the Irish success in software. In addition to their direct contribution, MNCs have been the training grounds for managers and budding entrepreneurs have acquired not so much technical skills as general managerial capability.

The importance of the "foreign connection" is evident in the Indian software industry as well. A number of successful software entrepreneurs in India had substantial overseas experience. For a sample of 530 firms that were members of NASSCOM in the year 2000, Athreye (2005a) finds that 95 (18 percent) were created by existing Indian firms diversifying into software, 96 (18 percent) were multinationals, and 44 (8 percent) were founded by expatriate

[13] Giarratana *et al* (2005) confirm the stronger linkages between domestic and multinational ICT firms in Israel by using patent citation data. There are more cross-cites among the two types of firms in Israel than in the other two countries.

Indians overseas, almost all located in the United States. There are 212 (40 percent) *de novo* start-ups, which 160 were founded by those who had worked for other software or hardware firms. It is likely that a very substantial fraction of these had worked overseas on software export projects.

Table 10: Origins of the leading Indian SW exporters

Name of firm	Year Est.	Origin/type of firm	Notes
TCS	1968	Business house	
Wipro	1980	Business house	
Infosys	1981	Entrepreneur	Spin-off (Patni)
Satyam	1987	Business house	
HCL	1991	Entrepreneur	
Patni	1978	Entrepreneur	Diaspora
I-flex	1989	Spawn (Citibank)	MNC spawned
Tech Mahindra	1988	MNC- Business House	JV between BT and Mahindra
Perot Systems	1996	MNC-Business House	(earlier JV with HCL)
L&T Infotech	1996	Business House	
Polaris	1993	Entrepreneurial	
Hexaware	1989	Entrepreneurial	(Venture funded)
Mastek	1982	Entrepreneurial	
Mphasis BFL	1992	Spin-off (Citibank)	Diaspora
Siemens		MNC	
Genpact	1997	Spinoff (GE)	MNC - Diaspora
IGate	1993	Entrepreneur	Diaspora
Flextronics	1991	MNC	(Hughes Software) - Diaspora
NIIT	1981	Entrepreneur	HCL spinoff
Covansys India	1985	Entrepreneur	Diaspora

List of leading exporters is for the year 2006 by NASSCOM. It excludes IBM, Accenture, HP, Syntell, Inteligroup, Cognizant and Kanbay, which are headquartered in the United States, and all of which are estimated to be significant exporters.

The foreign hand is even more visible if one restricts the attention to the leading exporters, as shown in table 10 below. Of the twenty leading exporters identified by NASSCOM,

five were started by Indians living in United States; another four are multinationals. Of the remaining, the founders in virtually every case were educated or worked abroad. Since the NASSCOM list excludes leading exporters such as IBM, Accenture, HP and Intelligroup on the one hand, and Kanbay, Cognizant and Syntel on the other, the share of multinational corporations and firms started by the Indian diaspora overseas is even higher. Indeed, at a rough estimate, about half of Indian software exports are due either to MNCs or firms started by the Diaspora.

Summary and conclusions

First and foremost, the experience of the successful software exporters had underscored the importance of openness. This is more than simply a prescription for "Free Trade". American and British multinationals have been important exporters in Ireland and India, and increasingly, Japanese multinationals are doing the same in China. Openness has costs as well, as domestic firms may be denied opportunities to learn or scale up, and experienced managers and engineers may lured away to jobs in the developed countries, as in India or Israel. Such mobility of people, sometimes described as "brain drain", has been very important for software exports from India, Ireland and Israel, because the diaspora have provided the vital links between exporters and customers. At least as important has been the role of the ethnic diaspora as entrepreneurs, leveraging the comparative advantage of the mother country in the export markets of the adopted ones.

The implications for government policy are more modest. Multinationals can be attracted by favourable policies but it is unlikely that favourable policies are the most important ingredient (although hostile policies may be enough to turn them away). The standard recipe for the

promotion of technology intensive sectors, namely universities, R&D subsidies, clusters, and venture capital, appear to have been of marginal importance. To be sure, such policies do little harm and may even do some good. But there is no evidence that these policies are behind the export successes in software that we have studied. Rather, the principal policies have been more general, those that have promoted investments (public and private) in human capital, capital markets where entrepreneurial firms can raise capital, labor markets where entrepreneurial firms can find the human capital they require, and general support for world class science and technology.

Policymakers must not, however, make a fetish of technological sophistication. Even in technology-based industries, technology may not be the only means of entering the industry value chain, as the Indian case makes very clear. Moreover, this is not a prescription for long term decline. Many observers of the Indian software industry had predicted the decline of Indian software firms unless these firms invested in R&D to undertake sophisticated product development, moving away from "mere programming" (e.g., Heeks, 1996; DaCosta , 1998). Such recommendations are often part of a broader mindset wherein progress in technology intensive industries must necessarily take the form of moving up the technology ladder.

The lessons from the Indian experience are the opposite. The Indian software industry and Indian software firms have gone from strength to strength, even as wages have increased year on year. For the most part, developing new products or undertaking high level design has not been the principal means of offsetting the wage advantage. Rather, Indian firms upgraded their ability to take on and manage larger projects. Instead of moving aggressively into product design, they focused on taking on lower end functions such as maintenance and support. Although not as lucrative, such activities involve a steady and predictable stream of revenues

since maintenance contracts are typically three to five years in duration. Moreover, this focus leveraged the capabilities Indian firms had developed, which was to manage projects with large teams of skilled people. These capabilities are further evidenced by their more recent move into business process outsourcing, such as customer support. These activities are even less technology intensive and require lower skilled workers. They do, however, build on the capabilities these firms have developed on the one hand, and take advantage of the abundant supply of English speaking graduates required for such tasks.

Finally, our case studies highlight the importance of entrepreneurship. Although economic policymaking is frequently pessimistic about entrepreneurial possibilities, in this instance, there are grounds for optimism. For India and Ireland, and to a lesser extent for Israel, the entrepreneurship in high tech industries had hitherto been the exception, not the norm. Financial institutions and capital markets were not set up to promote entrepreneurship, and there were few role models to follow. Though in hindsight, the software exporters had a clear comparative advantage, discovering this, and discovering how precisely to leverage this advantage was an entrepreneurial accomplishment. In India, in particular, it required considerable experimentation and the continued growth of exports owes as much to the growth in firm capabilities as to the initial comparative advantage.

Arora, A., and Bagde, S., 2006., Human capital and Indian software exports" (with Surendra Bagde) *working paper*, Heinz School, Carnegie Mellon University, Pittsburgh.

Arora, A., and Gambardella, A., 2005, "The Globalization of the Software Industry: Perspectives and Opportunities for Developed and Developing Countries", in Jaffe, A., Lerner, J., and Stern, S., (eds.) Innovation Policy and the Economy, Vol 5, MIT Press, 2005. (revised version of NBER WP 10538).

Arora, A., Gambardella, A., and Klepper, S. 2005. Organizational Capabilities and the Rise of the Software Industry in the Emerging Economies: Lessons from the History of some US Industries. In From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel (eds.) Ashish Arora and Alfonso Gambardella, pp 171-207, Oxford: Oxford University Press.

Arora, A., Gambardella, A. and Torrisi, S., 2004. "In the footsteps of the Silicon Valley? Indian and Irish software in the international division of labor", in Building High-Tech Clusters, Tim Bresnahan and Alfonso Gambardella (eds), Cambridge University Press, 2004.

Arora, A. and Suma Athreye, 2002, "The Software Industry And India's Economic Development", Information Economics and Policy**,** Vol. 14(2): 253-273.

Arora, A., V. S. Arunachalam, Jai Asundi and Ronald Fernandes, 2001, "The Indian Software Services Industry: Structure and Prospects", 2001, Research Policy, 30(8), 1267-1288.

Athreye, Suma. 2005a. The Indian Software Industry. In From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel (eds.) Ashish Arora and Alfonso Gambardella, p. 7-40, Oxford: Oxford University Press.

Athreye, Suma. 2005b. The Indian Software industry and its evolving service capability. Industrial and Corporate Change, Vol. 14(3), 2005: 393-418.

Botelho, A. J., Stefanuto, G., and Francisco Veloso, 2005, "The Brazilian Software Industry", in *The Rise and Growth of the Software Industry in Some Emerging Economies*, Arora, A. and Gambardella, A. (eds.) Oxford University Press, Oxford UK.

Bresnahan, T. and Gambardella, A. (eds.) Building High Tech Clusters: Silicon Valley and Beyond, Cambridge University Press, Cambridge UK.

Breznitz, D. 2005. "The Israeli Software Industry." In *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland and Israel.* Arora, A. and A. Gambardella (eds). Oxford University Press,.

Hausman, J. and Rodrik, D. (2002) "Economic Development as Self-Discovery", NBER Working Paper #8952, Cambridge MA.

Heeks, R. (1996) India's Software Industry: State Policy, Liberalization and Industrial Development, Sage Publications.

Kapur, Devesh. 2002. The Causes and Consequences of India's IT Boom. *India Review* **1**(2)

Saxenian, A. (2002) Local and Global Networks of Immigrant Professionals in Silicon Valley, Public Policy Institute of California, San Francisco.

Saxenian, A. (2003) "Government and Guanxi: The Chinese Software Industry in Transition", paper presented at the Conference Global Software from Emerging Markets: An Engine for Growth?, London Business School, May 12.