Contents

1

The Indian Software Industry in the Global Division of Labour

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1. Introduction

At the dawn of the twenty-first century India's traditional image as an impoverished nation is undergoing considerable change. While India continues to suffer from rampant poverty, persistent inequalities and internal political uncertainties, there has been a quiet revolution underway in India's high-technology industry. India, known for its tea, jewellery and garment exports, has now become a significant exporter of software. Consequently, the industry, the government and scholars are banking on the continued expansion of the sector. Considerable hope has been pinned on the sector's ability to address India's chronic developmental problems of low growth, unemployment, balance of payments deficits and technological backwardness.

In this volume we attempt to take a deeper look at India's software industry. Rather than assume that the rapid growth of software exports is a sure sign of the sector's strength or that exports will necessarily solve India's development problems, we critically examine the Indian software industry. This was prompted by three observable features of the Indian software industry: first, for all the hype of rapid sectoral expansion, the Indian industry has occupied a marginal position in the world market; second, notwithstanding high growth rates, India's exports have been largely low value output; and third, the size of the domestic market is less than a third of India's export market. These characteristics demand a closer examination of the industry to identify the sources of growth, the particular barriers facing it, and the possible strategic and policy responses that could raise the Indian industry to a higher trajectory. To accomplish this the industry must sustain its high growth rate for the foreseeable future and, relatedly, must move up the value chain to obtain such high growth. Consequently, much of the optimism regarding the sector's transformative capability on the Indian economy hinges on the industry's ability to innovate and cope with new competitors in a rapidly changing global information and communications technology environment.

This chapter lays out some of the basic features of the Indian industry in the context of the global sector. I argue that the Indian industry faces considerable

structural barriers to innovation because of its overt dependence on exports of software services to the US. Relatedly, the industry's growth is constrained by India's very small domestic market, limiting the diffusion of information and communications technologies (ICT) and information technology (IT) services. If this interpretation is correct, then the Indian industry must pursue a coherent set of strategies to break out of low value software and diversify export markets. There are also public policy issues which the Indian state must execute to facilitate the industry's transition from a low end trajectory to a high end one.

This collaborative project assesses the preparedness of Indian industry to meet the global challenges. It discusses how India fits into the international division of labour, the industry's trajectory, and how the industry and the government might harness the potential economic benefits of a dynamic Indian software industry. The project as a whole draws on the experiences of a number of firms and explicitly addresses the state of the Indian industry, its strengths and weaknesses, firm strategies, and the opportunities offered by the world economy. Each contributor identifies some of the challenges facing the industry, the strategic responses of firms to overcome barriers to innovation, and offers policy options for the government to make sustained growth a reality.

In the discussion that follows, I begin by briefly delineating some of the global structural barriers that prevent most developing countries from actively participating in the world economy. Second, I extend this exclusionary tendency to the Indian software industry by bringing out three forms of decoupling of the industry, which I argue place it on a low end trajectory. These are: (a) decoupling the software industry from the larger hardware sector; (b) disconnecting the industry from the domestic market; and (c) the specialized division of software into services and products.

Consequently, I show that Indian industry is neither large by global standards nor innovative. India's specialization thus far in a few niche markets, while consistent with contemporary economic globalization, is not consonant with the tremendous opportunities which the global information and communications technology (ICT) goods and services markets offer. The third section briefly explores how the principal challenges facing the Indian sector, namely the three kinds of decoupling, could be addressed. Anticipating competition from China and other countries, I refer to comparative data whenever possible throughout the discussion. The chapter ends with strategic implications for the industry as a whole, which the individual chapters in this volume take up in greater detail.

2. Structural dependence of developing countries

Historically, colonies suffered from a narrow specialization in primary exports. Export dependence locked in the local economy to a low accumulation

path. Declining terms of trade and low income elasticities for primary commodities generated the 'export pessimism' and subsequent import substitution industrialization (ISI) strategy of early post-Second World War development thinking. However, by the 1970s even ISI was exhausted, due to narrow domestic markets, high costs and technological backwardness. For necessary economic transformation, as witnessed in East Asia, economic strategy for international competitiveness was switched in favour of export substitution. Exports facilitated learning through economies of scale and increasing returns, while foreign markets became a source for knowledge acquisition. The rise of East Asia demonstrated the importance of a market-augmenting role for the state and the significance of local learning anchored in export competition.

Today, the global economy is characterized by hyper-competition among mostly multinational corporations (MNCs) from the triad nations of the US, European Union and Japan. A handful of countries, such as South Korea, Taiwan, Singapore, India, China and Brazil, are attempting to upgrade their industrial activities. The rest of the developing world compete either vigorously in labour-intensive exports or are considered 'structurally irrelevant' (Hoogvelt, 2001: 189). Of the $12.4 trillion of global trade, the advanced capitalist countries had a share of 65 per cent, while the least developed countries, most of which are from Africa, had a mere 0.64 per cent (UNCTAD, 2002).[2] During 1999–2000, the triad economies accounted for 75 per cent of global foreign direct investment (FDI) inflows and 85 per cent of FDI outflows (UNCTAD, 2001: 9–11).

Home to nearly 50 000 MNCs and host to nearly 100 000 foreign affiliates, the triad's dominance of the world economy is virtually absolute. For example, US MNC affiliates in five IT industries had global sales of $202 billion, while total US exports of IT goods and services was only $113 billion in 1998 (US Department of Commerce, 2002: 54). The structural inequality is also evident from the size of firms (Table 1.1), suggesting the enormous difficulties in breaking into the world market. There are a few examples of East Asian countries capturing global market shares in manufacturing. The question is, can India do it in the software industry? Not only are the largest

Table 1.1. Size of firms and the structure of the world economy (averages of top 10)

Top 10 manufacturing MNCs (global) (1999)	$134 billion
Top 10 manufacturing MNCs (developing countries) (1999)	$24 billion
Top 10 ICT firms (global) (2000)	$63.4 billion
Top 10 software firms (global) (2000)	$5.9 billion
Top 10 Indian IT firms (2000)*	$278 million

Note: *Four were MNC subsidiaries.

Source: UNCTAD (2001:) for top manufacturing firms; OECD (2002: 63, 67) for top ICT and software firms; *Dataquest* (www.dqindia.com/top/20/) for top Indian IT firms.

MNCs from the industrialized countries but even the top developing country firms are about a sixth the size of such MNCs' gross sales. Similarly, on average, the top global ICT and software firms had sales revenues of $63.4 and $5.9 billion respectively, whereas the average for the top ten Indian IT firms was only $278 million.

Global competition suggests that not all firms can pursue all activities. Rather, outsourcing, joint-ventures, subcontracting, technical collaborations and alliances are institutional arrangements by which firms will try to specialize (Okhi, 2001: 85). Lacking core competence of a high technological order, most small firms are adjuncts to larger enterprises. For example, in Internet software development, smaller firms adjust to the standards set by giant telecommunications companies, while applications software developers are further down the industry hierarchy (Casper and Glimstedt, 2001). Large MNCs can be flexible if they outsource or subcontract some of their production and service needs. In practice, this means farming out non-critical, labour-intensive, low value activities to other suppliers as these activities are out of synchronization with MNC core competence (see US Department of Commerce, 2002: 54–7). This is both an opportunity and a constraint to growth for developing country firms. It permits breaking into markets hitherto closed to most but also condemns new suppliers to only those market niches the buyer is willing to forgo.

The Indian software industry is just such a case, facing both opportunities to move into new markets but at the same time locked into providing low wage services to rich clients abroad. The fact that many Indian firms provide software services to Fortune 500 companies is a cause for both celebration and sombre introspection as Indian exporters are very small in comparison to their renowned clients. However, just as many East Asian economies with considerable accumulation of technology have successfully upgraded their industrial capability, Indian firms are also at the juncture of strategically moving up the software value chain. To accomplish this, two concerted efforts will be critical: an emphasis on technological and commercial learning and a supportive institutional environment to encourage dynamic expansion. The constraints, in the form of industrial decoupling, which limit dynamic learning, are presented below. From this discussion some strategic responses are identified to make the Indian industry a global force as well as a contributor to India's developmental needs.

3. The decoupling of the Indian software industry

From hardware manufacturing

In the era of mainframe computers, most software was produced or subcontracted by computer manufacturers. With the diffusion of micro- and personal computers, the structure of the software industry changed dramatically. In addition to the in-house development of software by firms and by

mainframe producers, there emerged independent software developers for external buyers as a distinct category, with many catering to the lucrative consumer-oriented applications market (Mowery, 1996: 4–6). As the installed base of PCs and other hardware such as telecommunications equipment increased, the production of software became delinked from hardware production. Increasingly, the independent developers of software are becoming more prominent as technological and organizational innovations permit greater flexibility in outsourcing customized software services to distant producers. In the area of software applications, whose production is less dependent on hardware production, there has been a proliferation of independent packaged software developers. Microsoft is the leading player in packaged software, separate from hardware manufacturing. However, its Windows operating system, acting as a dominant design, compels other hardware-independent application software producers to develop Windows-based applications.

Software, however, is complementary to hardware. Given the technological trajectory based on microelectronics, there is clear evidence of convergence of digital technologies (Dicken, 1998: 150). Consequently, the production and use of software are integrally linked to hardware, broadly classified as ICT goods. These include electronic data processing equipment (computers), office equipment, controls and instruments, communications equipment (radio, mobile systems, radar), telecommunications, consumer electronics, and components that go into these hardware.

India's position in the global ICT market is low, suggesting a disconnection between software development and a domestic hardware base. Recent data on global production of ICT goods (Table 1.2) reflect several characteristics of the international division of labour, the considerable asymmetry in this division, and India's poor standing. The OECD clearly dominates global production of ICT goods, with 77.5 per cent of the world total. Two OECD members – the US and Japan – together have 50 per cent of the global output and they dominate the production of various ICT goods. However, there is a distinct global division of labour in consumer ICT goods and components production, in which other economies actively participate.

Countries from East and South East Asia (including Japan) dominate these two segments, with Japan and China producing 44 per cent of consumer electronics, while Japan, Korea, China, Malaysia, Singapore and Taiwan control 55 per cent of components. As Japan consolidates its grip over high end consumer goods and components, China is making inroads into the low end. Korea, Taiwan and Singapore have specialized in memory chips, hard disks and other related segments (Okhi, 2001: 71). In this global division, India ranked 26th among 33 countries. Indian software producers in the early 1990s were confident that by the end of the decade India's hardware industry would be comparable to Taiwan's (Lakha, 1999: 148). In 1999, Taiwan's ICT goods production was ten times that of India's. Smaller countries

Table 1.2 World production of ICT goods (selected countries and OECD)

	1999 total ICT ($ m)	*Share of world total (%)*	*1990–99 (CAGR %)*	*1995–99 (CAGR %)*	*1997–99 (% change)*
US	320 840	29.5	5.8	4.4	20.3
Japan	220 728	20.3	2.3	4.0	1.3
Korea	57 597	5.3	10.8	4.2	19.2
Germany	47 545	4.4	0.5	4.4	37.9
Ireland	16 481	1.5	12.8	17.0	54.9
UK	47 734	4.4	6.2	6.9	28.4
OECD-21	843 121	77.5	4.2	1.4	16.5
China	59 738	5.5	19.8	20.1	NA
Malaysia	38 956	3.5	20.1	9.0	32.8
Singapore	40 755	3.7	11.9	0.7	−4.7
Taiwan	40 979	3.8	12.7	9.0	30.6
India	4 841	0.4	0.4	−0.3	5.5
Brazil	13 484	1.2	1.3	−5.0	−30.4
Israel	6311	0.6	14.6	11.2	35.5
Total	1088 539	100.0	5.6	1.4	22.3

Note: CAGR = compounded annual growth rate.

Source: Adapted from OECD, 2002, 2000.

such as Ireland, the Philippines and Israel had greater production in these segments than India.

On the growth front, the ICT industry exhibits some consistent trends. During 1990–9, the decade of considerable technology-led expansion of the world economy, some smaller countries like Ireland and Israel have grown quite rapidly: 12.8 per cent and 14.6 per cent annually, respectively. It was also the Asian group (excluding Japan) that had some of the best rates of growth, varying from 10.8 per cent for Korea to 20.1 per cent for Malaysia. These were also economies that leveraged the global market during its expansionary phase, while India withdrew from it with its autarkic policies. India's growth rate in ICT goods in the 1990s lagged behind considerably with a paltry 0.4 per cent. In the second half of the 1990s, Ireland and East and South East Asia, excluding Japan and Singapore, grew the fastest. While Japan was reeling under the recession set in motion in 1990, Singapore was still recovering from the 1997 Asian financial crisis. India's growth rate fell before rising modestly in the 1995–9 period to 5.5 per cent in 1997–9.

The disconnection with the domestic market

The specialization of ICT goods production by Asia has been integral to upgrading manufacturing capabilities. Relatively early entry with multinational investments in combination with state promotion and aggressive learning strategies by business have contributed to this global specialization. India

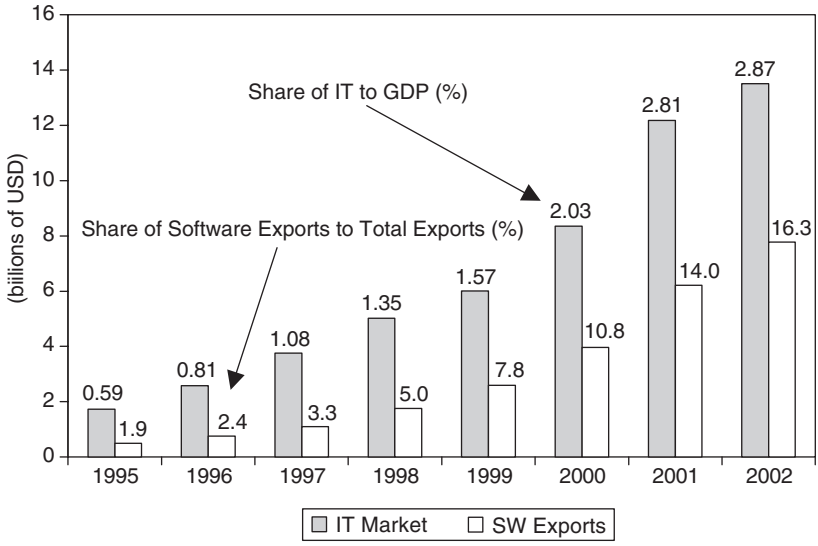

Figure 1.1 The recent growth of the Indian IT industry (1995–2003)

Notes: IT = hardware, peripherals, networking, domestic and export market for software and services.

Source: NASSCOM, 2002: 21, 28.

has essentially missed this manufacturing bus. Only now is the Indian IT segment showing some signs of growth, being led by overall economic growth (Figure 1.1). This growth rate of IT has, however, been spearheaded by the rapid expansion of the software segment, especially for the export market.

The Indian IT market has clearly expanded in nominal terms. In 1995 the industry had under $2 billion in output. In 2002–3 it had reached $16.5 billion, representing 3.15 per cent of India's GDP. This share was over five times that of 1994–5. China's IT industry reported $27.4 billion value added in 2001, representing 4.2 per cent of GDP (US & Foreign Commercial Service, 2002a). During 1994–2002, India's exports of software and software services increased from less than half a billion dollars to $9.9 billion. This was a twentyfold increase, representing over 20 per cent of India's total exports in 2002–3. What is remarkable is the steady decoupling of India's hardware output from software production, evident from a rising ratio of software exports in relation to hardware output (Figure 1.2). Economic liberalization in the 1980s effectively forced Indian hardware firms to move into software specialization, thus reversing the earlier strategy of creating a national hardware industry (Sridharan, 1996).

Not coincidentally, this decoupling was not witnessed in the heavily guarded, nationally oriented supercomputer development. Past US restrictions on the export of American-made supercomputers compelled Indian

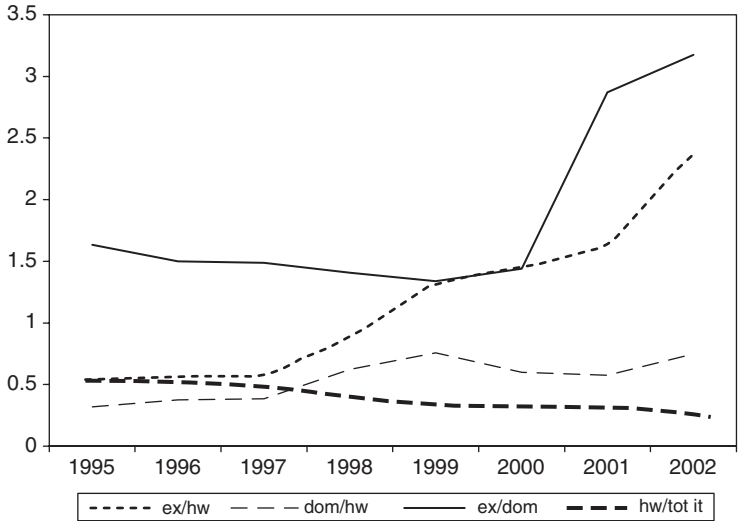

Figure 1.2 Decoupling of the Indian software industry (various ratios)
Notes: ex = exports of software; hw = hardware; dom = domestic software market; tot it = total
Source: Adapted from NASSCOM 2002: 21, 28.

organizations to develop their own. Though less powerful than American and Japanese machines (13–36 teraflops compared to India's one teraflop), these are considered by the industry to be the state-of-the-art. Built inexpensively by the Centre for Development of Advanced Computing (C-DAC) and the Indian Institute of Science (IISc), they have already sold seven units to Russia, Canada, Germany and Singapore (India Abroad News Service, 2002). This is illustrative of India's hardware capability and its wherewithal to overcome global structural dependence.

Decoupling is also reflected in the declining share of hardware in relation to total information technology output. However, there appears to be a stable relationship between domestic output of hardware and software. This can be interpreted as a slow-growing domestic market for IT in general, which is not inconsistent with a demand-constrained economy. Finally, there is a decoupling of software export markets from the domestic market (Kattuman and Iyer, 2001: 216). Domestic projects are assumed to be more complex, such as Mumbai's stock exchange and Indian railways' reservation systems, both designed and implemented by the Computer Maintenance Corporation (OECD, 2000: 135). This suggests limited spillovers from the wide range of project experience obtained from the domestic software market. The exogenously driven Indian software industry is captured by an increasing ratio of software exports relative to the domestic software market

(Figure 1.2). India also has an unusually high share of software production in relation to the total IT market in India, ranging from nearly 50 per cent in 1995 to over 75 per cent in 2003. This contrasts very sharply with the 1997 OECD norm of 13.4 per cent (OECD, 2000: 62). The corresponding ratio for China in 2001 was 18.5 per cent (US & Foreign Commercial Service, 2002a).[3]

The software services and products divide

The third form of decoupling is India's specialization in software services, an activity quite distinct from developing software packages. The spectacular growth of Indian exports, averaging over 50 per cent in most years, has been through software services. Exports accounted for 60 per cent of the total Indian IT market in 2002–3. Of the total software market, $9.88 billion or nearly 80 per cent was exported (NASSCOM, 2003: 21, 45). What is missing from the basket of software exports is software products or packages. This is in sharp contrast to Ireland's software export profile. In 2000, Ireland's packaged software exports amounted to $3.82 billion. However, as foreign companies for tax purposes book their revenues in Ireland, Irish software production has been artificially inflated (Arora et al., 2001: 1270). There is no comparable figure for India, suggesting negligible presence in this market niche. The closest India comes to software products is installing and integrating 'packaged software' created by multinational firms. The value of such exports from India was estimated to be only about $300 million (NASSCOM, 2003: 36).

In and of itself, exports of software services are a market strength. They are also a source of employment. The ability to mobilize large numbers of technical professionals has made Indian firms adept at quickly providing low cost software and IT services to foreign clients, many of them MNCs. However, specialization is also a result of India's inability to penetrate other market niches, such as software packages. There are several reasons for this. First, product development requires a dynamic domestic market in general. Second, without a large installed base of hardware the benefits of network externalities cannot be captured, thus limiting the market size. Third, packaged software development demands intensive interfacing between users and producers, which neither small markets nor geographically distant producers can support. Fourth, software products demand heavy marketing outlays, exacerbated by first-comer advantages. The latter places most small firms at a disadvantage; developing country firms are further disadvantaged.

According to NASSCOM's 2002 *Strategic Review*, the bulk of India's service exports fell under two categories: first, legacy application management, maintenance services and migration, comprising 27 per cent of exports; and second, customized services comprising 30 per cent of total exports. Both these categories of services (though not necessarily all their sub-categories) are generally considered to be low value additions (NASSCOM, 2002: 29). In the 2003 *Review*, the first category was not listed, while the second category

was estimated to account for 35 per cent of exports. A third category, IT-Enabled Services (ITES), comprising 20 per cent of exports, also consists of low value services such as customer interaction centres and business process outsourcing (BPO). In 2001–2 their combined contribution was 65 per cent of ITES exports, which is likely to increase as ITES as a whole expand. There was a 60 per cent growth in ITES exports over the 2001–2 and 2002–3 periods (NASSCOM, 2003: 58). It might be pointed out that the growth in ITES exports is good for employment. Capturing a sizeable share of this market, with global spending estimated at $1.2 trillion in 2006 (NASSCOM, 2003: 57), would reduce India's chronic unemployment of non-technical graduates. However, the larger issue has to do with the general problem of low value service exports. According to NASSCOM's earlier report (2002: 24), the global demand for IT services, which includes customized services and ITES, will be $700.4 billion in 2005. India's current strength is in customized services, which is expected to be sustained in the future. However, this segment of the global IT services market has been estimated to be only 4.4 per cent of the global market in 2001 and is expected to fall to a mere 3.6 per cent by 2005 (see Table 1.3).

If the market segment in which India excels is small to begin with, and it is likely to witness a relative decline in a few years, then it is clear that India needs to diversify its markets away from this segment. This may mean moving into high value software services for which there are considerable opportunities, such as systems integration, packaged software support and installation, and processing services. This does not, however, mean that India should give up all low end services. For example, low wage ITES is a growth sector with significant absorptive capacity for India's large pool of educated, non-technical personnel. Much would depend on the supply of skills in India and their global demand (Desai, 2001). What is incontrovertible, however, is that India must develop not only higher order skills in general but also widen experience in complex project design and execution so as to cope with the rapidly changing global ICT market. This demands an innovative strategy that takes into account India's current endowments but also foresees future competitive strengths in creative ways.

4. Strategic responses to exploit global opportunities

The characteristics of the Indian ICT sector as a whole suggest that Indian producers will have an uphill battle protecting their current position in software exports, let alone becoming a global IT powerhouse, unless there is some radical rethinking on competitive strategies. As it is neither practical nor intellectually productive to present an exhaustive list of 'to do' items (many are elaborated in the individual chapters), I present a discussion centred around the three forms of decoupling and relate them to innovation strategies for the software sector.

Table 1.3 Forecast of global IT services and India's opportunities

	Global market (2001)		*Global market (2005)*		*India's exports*	*India's global*	*Potential for*
	US $ b	*% share*	*US $ b*	*% share*	*(2001, US $ b)*	*share (%, 2001)*	*exports*
Professional services	142.9	32.5	238.7	34.1	5.3	3.7	
IT consulting	21.3	4.8	31.5	4.5	0.1	0.3	Low–Medium
Systems integration	81.1	18.4	142.1	20.3	0.1	0.1	Low–Medium
Custom applications	19.3	4.4	25.3	3.6	4.5	23.1	High
Network consulting & integration	21.2	4.8	39.8	5.7	0.7	3.3	Low
Product services	117.9	26.8	176.9	25.3	0.4	0.3	
IT training & education	25.5	5.8	40.9	5.8			High
H/W support & installation	44.4	10.1	49.4	7.1			Low
Packaged software support services	48.0	10.9	86.6	12.4	0.4	0.7	Medium–High
Outsourcing services	179.2	40.7	284.8	40.7	0.1	0.0	
Processing services	78.4	17.8	103.8	14.8			High
IS outsourcing	64.0	14.5	100.2	14.3			High
Application outsourcing	13.4	3.0	39.0	5.6			Low–Medium
Network infrastructure management	23.4	5.3	41.8	6.0	0.1	0.3	Medium–High
Total	440.0	100.0	700.4	100.0	5.7	1.3	

Notes: IT = information technology; IS = information services; H/W = hardware.

Source: Calculated from NASSCOM, 2002: 24, 46.

First, a strong link between production of ICT goods or hardware and the Indian software industry is necessary to foster learning and thus inter-industry synergy in ways that are currently not possible. Second, a strong home market engendered by a dynamic ICT sector can also foster software opportunities, which could provide an alternative to the customized software services India currently exports. As this niche is limited by the extent of the global market, and as India's current strengths lie in this particular segment, it is of the utmost importance consciously to reduce this excessive dependence. It is here that development of software packages with business and government promotion becomes critical. Entrepreneurship and its explicit institutional support through venture capital are likely to be key ingredients in this market-diversifying strategy.

Third, India's innovative capability can be enhanced by intensifying the interfaces between users and producers of software, a possibility made difficult with distant export markets. Subsequently, a greater domestic orientation could induce strong linkages among firms (foreign and domestic), universities and governments. Fourth, the deepening of the domestic market can be leveraged to attract overseas Indians (non-resident Indians or NRIs). Much has been reported about the successes of Indian engineers in Silicon Valley and much is expected from such talent if they were to return to India with their technical knowledge, market contacts, entrepreneurial energy and business savvy. An integral understanding of these cumulative causal mechanisms helps us understand the ways by which the decoupling of the industry might be resolved. If followed through by appropriate strategic responses by firms, the industry and the government, the Indian industry could be well positioned in the global economy for sustained growth.

Hardware production to build technological capability

East and South East Asian economies are not strong in software but they have large domestic ICT markets. For example, Japan, South Korea, Taiwan, Singapore and Malaysia have successfully created a viable high-technology manufacturing base. The basic mechanism has been to establish dynamic linkages with the world economy that rest on strong domestic capabilities for manufacturing hardware (Dedrik and Kraemer, 1998: 23). Even Brazil, plagued with macroeconomic instability, external indebtedness and high costs of protectionism, has been able to foster a viable hardware sector (Evans, 1995; Sridharan, 1996). Even more remarkable is Ireland's global presence in both the hardware and software industries. In 2000, Ireland, with less than four million people, exported and imported nearly $25 and $16 billion respectively of ICT equipment (OECD, 2002: 273). In 2001, Ireland had nearly a $4 billion market in packaged and IT services software, suggesting a link between the hardware and software sectors (OECD, 2002: 320).

Many would argue against the establishment right now of an investment-intensive fully-fledged hardware sector in the small Indian market. Others

will point to the severe competition afflicting the sectors in Asian economies (Dedrik and Kraemer, 1998: 312). Yet others are likely to point to the economic robustness of 'specialization' and India's premier position in global software outsourcing. These are all reasonable arguments, but only from a static point of view. In a dynamic context, factor prices, costs, markets and industry structures do not remain fixed. Instead, increasing returns from increasing economies of scale and industrial agglomeration could have substantial spillover effects. The synergy between expanding hardware and software sectors can be a significant source for learning in the overall ICT industry.

Consider the case of Singapore, where software development capability lags behind India's. However, Singapore provides a window not only to what can be done to promote hardware manufacturing but also how hardware manufacturing capability could be leveraged to induce learning in the ICT sector in general. The convergence of American business interests and the strategic intervention by the Singaporean government to create a high technology industry demonstrates the possibility of creating world class manufacturing capability even in a tiny city state (McKendrick, Doner and Haggard, 2000). From low-wage based assembly operations, Singapore now specializes in design and manufacturing of hard disk drives. While this suggests the advantages of (manufacturing) specialization rather than diversification, it is evident that ultimately it is the diffused learning process that matters most in industrial competitiveness. Wong's (1995) 'dynamic interaction' model demonstrates why this is so. His model (see Figure 1.3) shows this interaction among three factors: entrepreneurial innovation, state intervention and agglomeration of competitive advantage (Dedrik and Kraemer, 1998: 249). The learning process entailed a virtuous cycle of sector-specific targeting, spillover effects into related industries, skill building in the electromechanical and electronics industries, a deepening supplier base, and the clustering of industries that contributed to competitive advantage.

Singapore's broad manufacturing capability can now be leveraged to move into other ICT development activities. We see some evidence that this is occurring. For example, while Singapore has not specialized in software development, it has been able to attract numerous software professionals as well as entrepreneurs from India. One important case has been the relocation of Vedika Software from Kolkata (formerly Calcutta) to Singapore. The company started in Kolkata in 1987 and produced a successful accounting package called FACT (personal interview with Vedika staff, Kolkata, April 1998). The software is now used by over 9000 companies in nearly twenty-five countries. The IT-friendly Singaporean environment, in which ICT goods production is a critical ingredient, facilitated Vedika's international presence, suggesting that hardware manufacturing can be a centrepiece of national competitiveness and can act as a catalyst for software development.

China provides another example where strength in hardware manufacturing could be a springboard for software growth. In 2000, China's software

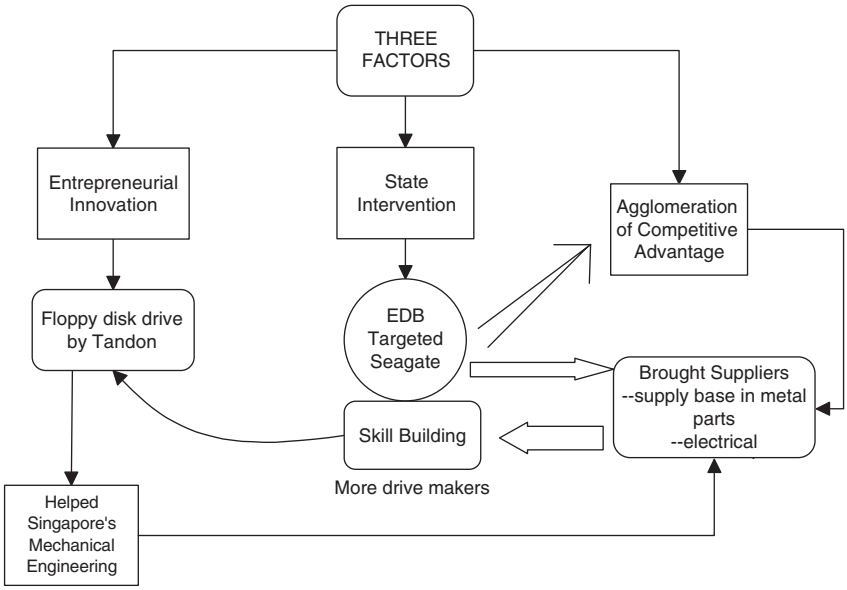

Figure 1.3 Learning through dynamic interaction in hardware manufacturing

Note: EDB = Economic Development Board of Singapore.

Source: Adapted from Pom-Kam Wong (1995) in Dedrik and Kraemer (1998: 249).

exports totalled a mere $220 million (Wong and Wong, 2002: 6).[4] This represented 8 per cent of China's total software market, which translates roughly to a domestic market of $2.5 billion. This is virtually identical in size to India's $2.45 billion domestic software and services market (NASSCOM, 2002: 46). Where China excels is in the manufacture of ICT goods. In 2001 it ranked as the world's sixth largest ICT market (OECD, 2002: 58). Between 1992 and 2001, China had the highest annual growth rate (over 50 per cent), increasing from under $10 billion to nearly $70 billion. India's ICT market grew at a respectable rate of 40 per cent per year during the same period, expanding from less than $5 billion to about $20 billion. However, China's lead in hardware production, rising cross-border foreign direct investment from Taiwan, steady increases in skilled personnel, and the continued promotion of China's science and technology establishment places it in a very advantageous position (Saxenian, Chapter 7, and Sridharan, Chapter 2). Recently, *Current Science* highlighted India's decline in scientific publications from the eighth position in 1973 to now fifteenth in the world (in Jayaraman, 2002a: 100). Between 1980 and 2000, India's science-related publications fell from 14 983 to 12 127, while China's rose from 924 to 22 061. Over the long haul, the absence of strategic business and government policy

could render temporary India's current lead over China's software competitiveness.

There are other competitors in the fray. The former Eastern bloc and the former Soviet Union are well-endowed with high technical skills to exploit emerging IT opportunities. Between October 1999 and February 2000, Russia received 1.7 per cent of H1B visas (OECD 2002: 168).[5] While this is a very small share in relation to India's, Russia's ratio of 55 engineers for every 10 000 people places its skill profile far ahead of India's (Kozlov, 2001). Russia's IT market has been estimated at $3.9 billion in 2002 (Lakaeva, 2002). It is entering both low value and high end development work. For example, just like India it is getting into business process operations and IT-enabled services but also complex projects such as application-specific integrated circuit (ASIC) chips for Nortel (Kozlov, 2002). With its own overseas technical diaspora, Russia is being advised to lure back its emigrant engineers (see Goyal, 2001). The Eastern European countries (the Czech Republic, Hungary, Poland and Slovakia) are still behind India's software output, but their IT markets (both packaged software and IT services) are on the upswing (OECD, 2002: 320). In 2000, Hungary exported $5.24 billion of ICT goods, with nearly an equal volume of imports, suggesting considerable activity in the IT industry (OECD, 2002: 273). These are also markets with significant technical talent and low disposable incomes, suggesting future competitive pressures on the Indian industry.

Diversifying software development

As we have seen, India specializes in the export of customized software. Nearly 60 per cent of India's export revenues comprise legacy applications and customized services (NASSCOM, 2002: 29). Software export revenues for India, while on the rise, have not been particularly high when compared to other software exporting economies such as Ireland and Israel. For example, India's revenue per employee has been between $20–30 000 compared to Ireland's $60–80 000 (Arora et al., 2001: 1269–70; Heeks, 1996). The very nature of customized software for specific clients restricts wide applicability to other sectors and thus constrains economy-wide learning (Kumar, 2001). Relatedly, the focus on ITES as a driver of software exports, while perfectly logical from a resource allocation view, reinforces the low wage segment of the value chain. This sentiment is echoed by industry representatives when they say that Indian software firms 'take up projects after people conceptualize something' or that the Indian industry must get into products (Sircar, 2002).

Higher skills add higher value. Skill development is a product of formal training as well as accumulated learning experience. As this chapter has suggested, a strong hardware sector and a large installed computer base can facilitate learning, neither of which is prominent in India. It is therefore not surprising to find that in the area of *high* value customized software services

requiring high skills, India has not been able to capture much of the global market. These services include systems integration, packaged software integration, network infrastructure management, consulting, turnkey projects, product development and design, embedded software, and R&D services. India's combined exports in these areas in 2001–2 totalled $2.67 billion or 35 per cent of total software exports (NASSCOM, 2003: 36). Curiously, the 2002 *Report* for the same information for the same year showed an export of $1.5 billion or less than 20 per cent of total software exports (NASSCOM, 2002: 29). The most visible change in the new export data was for R&D services of $1.21 billion or a 110 per cent increase in the new estimate. Two other categories that did not exist in the previous report are product development and design ($300 million) and embedded software ($910 million). These are encouraging signs as they all entail higher order services (Sridharan, this volume). However, India's global shares in other high value service areas such as systems integration, packaged software integration, network infrastructure management, and consulting were a mere 0.1, 0.7, 0.3 and 0.3 per cent respectively, while India's total exports amounted to only 1.3 per cent of the global market (NASSCOM, 2002: 24, 29). If Indian firms had the necessary skills and project experience, India's exports in these areas and as a whole would have been much higher.

The principal drawback to developing products is a weak domestic market. However, there are other non-technical factors that influence product development (Krishnan and Prabhu, Chapter 6). Most products and applications are off-the-shelf software programmes, such as word-processing, financial programmes, statistical packages and the like. The question as to why India is not good at making products has to do with the size of the domestic market (Desai, 2001), which is influenced by the installed base of hardware in the economy and its associated network externalities. Product development is also stunted by the lucrative services export market, while geographical distance dissuades firms from taking up product development for export markets (D'Costa, Chapter 3). Others have emphasized the importance of effective copyright protection and an established intellectual property rights regime, which are still evolving in India. The huge costs in development, short marketing span, and follow-up support services, which are all integral to the product development chain, can deter firm entry. At the same time, applications software have a more stable environment with low entry barriers as they are based on standard hardware and operating system platforms (Casper and Glimstedt, 2001: 273). However, application software is also dependent on user community feedback. Hence, domestic market development is likely to have a favourable impact on software product development.

To successfully develop software products, firms must be able to accumulate domain expertise in areas such as banking and finance, retail trade, engineering and design, industry, education, entertainment, health and the

like. Expertise is developed through high R&D investment and from firm-specific knowledge in the context of an expanding, dynamic market. Thus far the Indian software industry has not demonstrated much proclivity towards R&D (Parthasarathi and Joseph, Chapter 4). The small, albeit growing, domestic market continues to constrain deep interaction that is possible with a large user base and thus limits software product development. India's presence in the packaged software or products market is negligible. A few companies, large and small, have attempted software products but found the market difficult (Desai, 2002). A handful of firms have viable products. Of the large ones, for example, Infosys, Tata Infotech and Ramco have financial and enterprise resource planning products, while Vedika Software, a small firm, has an accounting package. The presence of this limited number of software products concentrated in the area of financial and banking-related services illustrates the importance for product development of the large Indian market for these services.

The question is whether other markets can be developed for various applications software. While it would be difficult to overcome the technical challenges associated with creating products for distant users (in export markets), firms can diversify their software portfolio to capture the huge benefits from product development by focusing on longer product cycles and intermediate product niches, such as middleware that bridge telecommunications architectures with applications software (Casper and Glimstedt, 2001: 268–72). Targeting the home market, as the installed base and Internet connectivity increase, would be a significant redirection of the Indian industry. Products will also spread the risks of limited export market growth in standard customized services. However, to translate ideas into new products, firms must be innovative in conceptualizing novel applications with complex functionalities. They must also be commercially savvy enough to bring new products to the market quickly and effectively. One promising avenue is open source software development, which permits distributed innovation (Kogut and Metiu, 2001). Here too, the user-driven feedback is critical for fitness of products and reducing the time to bring them to market. More importantly, because of the distributed nature of software development, large numbers of Indian engineers could be mobilized to develop software to serve the domestic market. A recent open source Linux operating system has been applied to the 'Simputer', a low cost machine developed by the Indian Institute of Science in Bangalore (Jayaraman 2002b: 359).

The high risks associated with products, resulting from high development and marketing costs, software piracy, and weak intellectual property rights, demand a multi-pronged institutional approach to reduce market risks. Open source development is one way of overcoming the rigidities of copyright laws and fostering new product development. The development of a venture capital (VC) market is another institutional arrangement which could underwrite some of the risks of product development.

An innovation of Silicon Valley (SV) that accompanied and led the high technology boom, VC market development has been quintessentially a US phenomenon. With particular forms of social networks at the core of the technology industry (Saxenian, 1994), transferring the SV model *in toto* to the Indian institutional context would be problematic (Dossani and Kenney, 2002: 227–8; Casper and Glimstedt, 2001). However, the evolutionary nature of VC formation in the US and the changing business and macro-economic environment in India suggest that VC development is possible in India, albeit adapted to India's particular conditions. The Taiwanese and Israeli experiences, approximating an SV model (Dossani and Kenney, 2002; also Saxenian, Chapter 7; Avnimelech and Teubal, Chapter 5) illustrate the significance of VC to new start-ups and product development. For example, given Israel's small market, it has been relatively successful in particular product niches. The development of a VC market in India will be critical to launching start-up companies and altering the institutional environment to support greater entrepreneurial activities such as product development (Kumar and Jain, 2002). Thus far the VC market is small and immature by US standards, but it has been growing consistently, except for the 2001–2 financial year. The Indian VC market expanded from $20 million in 1996–7 to $1.2 billion in 2002–3 (NASSCOM, 2003: 152). A nearly ninefold increase ($10 billion) in VC disbursements is predicted in 2007–8. As non-resident Indians (NRIs), especially from Silicon Valley, get more involved with the Indian IT industry, they are also likely to emerge as supporters of a fledgling VC market and a source for entrepreneurial initiatives (Saxenian, Chapter 7; Krishna and Ojha, Chapter 9).

Developing the domestic market

What is perhaps most disconcerting is the assumption that somehow India's current lead in the export services market will be maintained. Already India's low wage advantage is eroding, certainly in the higher-order skill levels. This is evident, though not conclusively, from the recent interest shown by a few Indian firms such as Satyam Computer Services to set up a development centre in China.[6] China offers tremendous market opportunities as its economy continues to grow at high rates. The internationalization of Indian software firms means that they will also behave like other MNCs seeking cost reductions and new markets elsewhere.

China is the only other country where both cost and market objectives could be met. There is a large supply of IT professionals, wage costs are low, and the Chinese economy is displaying robust growth. With a large hardware industry, a strong science and technology establishment, and a growing number of Internet users, China is well poised to challenge India in the software industry (Trivedi, 2002). China's heavy investment in Internet infrastructure despite a later start than India has placed it well ahead of

India (Press et al., 2002). According to the CIA estimate, in 2002 China had 47.8 million Internet users compared to India's 16.6 million (Press et al., 2002: 21).[7] China's international bandwidth is roughly twice that of India with 3297.8 megabytes per second and the gap in the installed base of PCs is widening in China's favour (Press et al., 2002: 6, 11). According to the *Computer Industry Almanac*, China has 34 million PCs compared to India's 5.2 million (compared to 3.7 million versus 1.1 million in 1996). China's ICT spending is also surging ahead of India's, with considerable investment in chip-making facilities to meet the demand of the domestic electronics industry (Einhorn, 2002a). It is estimated that by 2005 China's chip output will exceed $8 billion. With nearly $60 billion in 2001, China was well ahead of India's ICT spending of $20 billion. Comparable figures for 1997 were roughly $30 and $10 billion respectively. Even India's English language advantage could be eroded as China aggressively introduces English language training for their software engineers (Einhorn, 2002b).

The significance of leveraging the domestic market for export competitiveness is well illustrated by the Chinese ICT trajectory. One industry official squarely attributed India's great disadvantage to the 'soft demand from local customers' compared to China's booming domestic market (Gordon Brooks, in Einhorn, 2002b). India's surge in software exports, which is decoupled from an ICT base and a dynamic domestic market, means that the industry must innovate up the value chain. Otherwise, the Indian industry will face increasing competition due to the erosion of its labour cost arbitrage. Rising wage costs would automatically dampen the industry's propensity to serve the domestic market and reinforce the sector's penchant for exporting customized software services in a path-dependent fashion (D'Costa, Chapter 3). This would also mean excessive demand on the supply of Indian talent, exacerbated by the global shortages of IT workers. A redirection of emphasis towards the domestic market is expected to alleviate some of the shortcomings of an overly export-dependent, software services sector. While leapfrogging with ICT production is difficult, the enclave nature of software production in India must be reoriented to spread the benefits of the digital economy (Mansell, 2001: 285–8).

The global shortage of IT skills, especially in the US, Germany, the UK and Japan suggests widespread poaching of Indian talent for multinational operations. This puts further pressure on the wage level in India. An ageing society combined with shortages of researchers in science and engineering has created a massive demand for non-immigrant labour in the US (Larson and Brahmakulam, 2002: 41). This by itself is not an unfavourable outcome as Indian firms will be compelled to move up the innovation chain. Currently, about 500 000 Indians are employed by the Indian technology sector. However, with global demand outpacing supply even India is likely to face shortages of critical skills. For 2004–5 these shortages are estimated to be 64 000 'knowledge' professionals assuming 'minimum' industry

growth, and 533 500 under an 'optimistic' scenario (NASSCOM, 2002: 65). Even if only 20 per cent of these are likely to be ITES workers, who are not part of the high skill group, there will be shortages of skills.[8]

In the absence of a dynamic domestic market, Indian skilled professionals will continue to be lured away to foreign firms and markets. The US has relied on H1B visas to secure a large number of Indian technical workers: nearly 50 per cent of the total number of visas in 1999, while China obtained less than 5 per cent (OECD 2002: 179). Even Indian firms in the US such as Syntel, Wipro and TCS relied on the H1B visa system to recruit Indians. Under this scenario, considerable effort must be expended to retain highly skilled IT professionals in India as well as persuade NRIs to conduct higher order IT activities. To guarantee that these professionals will 'circulate' back to India, as is currently being observed (Kripalani, 2002), the Indian domestic economy itself has to be raised to a higher level and the quality of life vastly improved.

To extricate the Indian industry from narrow specialization of customized software service exports a comprehensive and multi-pronged approach to domestic market development will be critical. This is not expected to be at the expense of the export market. Rather, it is aimed at generating the necessary intersectoral linkages in high technology manufacturing, fostering the accumulation of technological know-how, and providing a domestic foundation for high value added software exports. Admittedly, late entry in manufacturing is not easy. The global economy today is highly competitive, prices of commodity components are declining, and several ICT industries are saddled with excess capacity. However, with inter-firm arrangements, developing domestic capability becomes feasible (Basant and Chandra, Chapter 8). As alliances among firms with different competencies become routine, Indian firms need to actively seek out and team up with those that can offer relevant technologies, markets and exposure. Both less risky and more pragmatic, partnerships among firms and between firms, universities and research labs are viable ways of promoting local learning and engendering technological spillovers in the wider economy.

Recent efforts by Indian firms such as Encore Software and the Indian Institute of Science (IISc) have led to the development of an indigenous and inexpensive computer called Simputer. Similarly, HCL Infosystems has launched unicode compatible PCs to support seven Indian languages. Both are examples of serving the domestic market with hardware and software, and not at the expense of the export market. Already the affordable Simputer is being targeted to other developing countries in Asia and Africa. Nor should India's solid achievements in creating indigenous supercomputers be ignored. What is needed is a more institutionally driven, large-scale concerted thrust towards raising the technical and commercial profile of the Indian software industry, which would in the end meet India's developmental needs.

5. Conclusion

It is evident that the massive growth rate of the Indian software industry has caught the world's attention. One of the poorest countries in the world, better known internationally for its uncompetitive industries, India has come a long way with its high-growth software industry. However, by examining India's particular position in the larger global division of labour, this chapter demonstrates that there are still many hurdles to overcome. First, Indian firms are small by global standards, suggesting considerable fragmentation of the Indian industry. To be global players it is important for Indian firms to consolidate their operations and focus, where applicable, on particular core competencies (Kattuman and Iyer, 2001: 217). This will necessarily require strengthening technical, commercial and organizational innovative capabilities of firms (Bhatnagar and Dixit, Chapter 10). India already boasts a few 'world class' companies such as Wipro, NIIT, C-DOT and Infosys (Ghoshal, Piramal and Budhiraja, 2001). The challenge for the country and the industry is to diffuse them throughout the economy.

Second, the Indian industry faces several structural barriers, as revealed by the three kinds of decoupling displayed by the Indian software industry. These are the disconnections between ICT manufacturing and software development, between export markets for software and domestic markets, and between software products and services. The net result has been narrow specialization at the lower end of the value chain, erosion of the wage advantage, emerging new competition from other countries such as China, the growing scarcity of skills, and forgoing of huge opportunities by not leveraging the ICT and IT industries for domestic development. While India's share is globally quite high in the customized software services market, this segment is expected to have less than 4 per cent of the global software market. India's predicted presence is also expected to be low in high-growth niches such as systems integration and packaged services. This makes it all the more urgent to extricate the industry from its low end trajectory.

To counter these challenges both the industry and the government must respond strategically. Linkages for innovation must be promoted systemically (Freeman, 1997) among software-related institutions. The precise details of these broad strategies are discussed in the individual chapters. However, two areas for concerted action deserve mention here. The first is to deepen India's innovative capability so as to capture more lucrative software niches; and the second is to nurture the domestic market so as to generate spillovers through dynamic interaction. Some of the interrelated sector-specific initiatives, in no particular order, would include the following:

- large-scale investments in ICT manufacturing
- diffusion of IT-related applications throughout the economy

- emphasis on learning and accumulation of technological capability, including staying abreast of the technological frontier, such as embedded software (ubiquitous computing), Linux and wireless technologies
- superior quality of physical and ICT infrastructure
- expansion in the quality and quantity of education infrastructures for skill building
- greater engagement with science and engineering and associated R&D
- a risk-reducing environment for entrepreneurial initiatives, such as venture capital
- identification of strategic partners, between MNCs and domestic firms; between business, university and government; *and* among domestic firms.

Many of these areas, such as infrastructure provision, VC market development, skill enhancement, and some types of institutional partnerships are being addressed. Regarding the domestic market, a number of ad hoc developments have taken place. Recently there have been small investments from East Asian firms for the manufacture of some hardware and components. There are also state-owned enterprises manufacturing ICT goods, such as C-DOT and Indian Telephone Industries. Even as many Indian firms undertake chip design work (a high value activity), there does not appear to be any discussion on establishing chip manufacturing units such as those set up in China. IT diffusion has been sporadic, covering the modern corporate sector (Miller, 2001), citizen services in Andhra Pradesh, preventive health care programmes, and delivery of agricultural information (World Bank Group, 2002), to name a few. What is not self-evident is that these Internet-based services require ICT goods, many of which make use of advanced wireless technologies. Outside the prosperous parts of the urban economy, IT diffusion is not widespread. It cannot be, given India's large illiterate population and very low per capita incomes. This suggests the importance of strategic intervention with investment in software-related industries and infrastructure within the broader imperatives of raising the overall level of Indian economic development.

The external sector has played a very important role in the recent evolution of the software industry. The principal benefit has been sourcing foreign technologies and capturing markets. With dominant designs and industry standards set by MNCs, it is evident that Indian firms will have to be followers. However, this need not come in the way of learning and innovative capability so long as firms are willing to undertake more complex projects by investing in skill development and R&D, and exploiting new opportunities such as open source software. Many of the software development centres of MNCs in India have begun high level work for their in-house needs. Texas Instruments has successfully designed a chip, yielding considerable global revenues; while Oracle has developed a substantial part of its operating system in India. This certainly points to the salubrious

effects of MNC activity, resulting from the availability of human capital (Patibandla and Peterson, 2002; Ghemawat and Patibandla, 1997). The question, however, is to what extent in-house projects for distant users result in the synergy often associated with local users or, to put it in another way, what kind of learning takes place when the entire industry interacts nominally with the domestic economy? While this remains an empirical question, it is suggestive of specialization in low value services and various forms of economy-wide distortions (D'Costa, 2003). What matters now is the resolution of the three disconnections by leveraging the domestic economy for export competitiveness and balanced home development. Only then will the industry begin to 'walk on two legs' (Schware, 1992).

Notes

1. I thank E. Sridharan and Janette Rawlings for their editorial comments. Errors and omissions are mine alone.
2. http://www.unctad.org/Templates, accessed 11/27/2002 3:30 p.m.
3. Cross-national data are not strictly comparable. China's ratio was obtained by dividing $2.9 billion of software (IT services and packages) by the sum of IT services and packages ($2.9 billion) and hardware ($15.7 billion) (US & FCS, 2002b).
4. I am grateful to Pete Suttmeier for bringing this source to my attention.
5. These are work visas given by the US government to foreign skilled, non-immigrant workers, which are valid for six years but must be renewed after three years.
6. Information obtained from http://custom.marketwatch.com, retrieved on 11 Nov. 2002.
7. I thank Pete Suttmeier for bringing this publication to my attention.
8. This 20 per cent was arrived at using the current norm of ITES workers in relation to total software professionals (NASSCOM, 2002: 63). This ratio could be higher as India continues to promote ITES and the industry is unable to penetrate the high value segments of the customized services area.

References

Arora, A. et al. (2001) 'The Indian Software Services Industry', *Research Policy*, 30 (8): 1267–87.

Casper, S. and H. Glimstedt (2001) 'Economic Organization, Innovation Systems, and the Internet', *Oxford Review of Economic Policy*, 17 (2): 265–81.

D'Costa, A. P. (2003) 'Uneven and Combined Development: Understanding India's Software Exports', *World Development*, 31 (1): 211–26.

Dedrik, J. and K. L. Kraemer (1998) *Asia's Computer Challenge: Threat or Opportunity for the United States and the World?* (New York: Oxford University Press).

Desai, A. V. (2001) 'The Peril and the Promise: Broader Implications of the Indian Presence in Information Technologies', Workshop on the Indian Software Industry in a Global Context, Indian Institute of Management, Ahmedabad, India.

——(2002) 'The Dynamics of the Indian Information Technology Industry', Centre for New and Emerging Markets', London Business School, unpublished.

Dicken, P. (1998) *Global Shift: Transforming the World Economy* (New York: Guilford Press).
Dossani, R. and M. Kenney (2002) 'Creating an Environment for Venture Capital in India', *World Development*, 30 (2): 227–53.
Einhorn, B. (2002a) 'High Tech in China: Is it a Threat to Silicon Valley?', *BusinessWeek/online*, 2002.
——(2002b) 'Shenzhen: the New Bangalore?', *BusinessWeek/online*, http://www.businessweek.com/technology, accessed 12/17/2002 9:47 a.m.
Evans, P. B. (1995) *Embedded Autonomy: States and Industrial Transformation* (Princeton: Princeton University Press).
Freeman, C. (1997) 'The "National System of Innovation" in Historical Perspective', in D. Archibugi and J. Michie, *Technology, Globalisation and Economic Performance* (Cambridge: Cambridge University Press), pp. 24–49.
Ghemawat, P. and M. Patibandla (1997) 'India's Exports Since the Reforms', in J. Sachs, A. Varshney and N. Bajpai, *India in the Era of Economic Reforms* (Delhi: Oxford University Press).
Ghoshal, S., G. Piramal and S. Budhiraja (2002) *World Class in India: a Casebook of Companies in Transformation* (New Delhi: Penguin Books India (P) Ltd).
Goyal, A. (2001) 'Intellectual Capital: IT or Not to IT, That is Not a Question', *The Russia Journal*, http://www.outsourcing-russia.com, accessed on 12/19/2002 2:07 p.m.
Heeks, R. (1996) *India's Software Industry: State Policy, Liberalisation and Industrial Development* (New Delhi: Sage Publications).
Hoogvelt, A. (2001) *Globalization and the Postcolonial World: the New Political Economy of Development* (Baltimore, MD: Johns Hopkins University Press).
India Abroad News Service (2002) 'India Beats US Curbs to Produce Supercomputer', http://www.siliconindia.com, accessed 12/17/2002 9:50 a.m.
Jayaraman, K. S. (2002a) 'India's Scientists Agonize Over Fall in Publication Rate', *Nature*, 419: 100.
——(2002b) 'India Online', *Nature*, 415: 358–9.
Kattuman, P. and K. Iyer (2001) 'Human Capital in the Move Up the Value Chain: the Case of the Indian Software and Services Industry', in M. Kagami and M. Tsuji, *The 'IT' Revolution and Developing Countries: Latecomer Advantage?* (Tokyo: Institute of Developing Economies, Japan External Trade Organization), pp. 208–27.
Kogut, B. and A. Metiu (2001) 'Open-Source Software Development and Distributed Innovation', *Oxford Review of Economic Policy*, 17 (2): 248–64.
Kozlov, V. (2001) 'Report Wary on Future of Russia's IT Sector', http://www.outsourcing-russia.com, accessed on 12/19/2002 2:06 p.m.
——(2002): 'Russian Firms See ITES & BPO as Competitive Advantage', http://www.outsourcing-russia.com, accessed on 12/19/2002 2:00 p.m.
Kripalani, M. (2002) 'Calling Bangalore: Multinationals are Making IT a Hub for High-Tech Research', *Businesseek/online*.
Kumar, N. (2001) 'Developing Countries in International Division of Labour in Software and Service Industry: Lessons from Indian Experience', Workshop on the Indian Software Industry in a Global Context, Indian Institute of Management, Ahmedabad, India.
Kumar, V. and P. K. Jain (2002) 'Commercializing New Technologies in India: a Perspective on Policy Initiatives', *Technology in Society*, 24 (3): 285–98.
Lakaeva, I. (2002) 'Trends in the Russian IT Market', US & Foreign Commercial Service, US Embassy, Moscow.
Lakha, S. (1999) 'The New International Division of Labour and the Indian Computer Software Industry', in J. Bryson et al., *The Economic Geography Reader: Producing and Consuming Global Capitalism* (Chichester: John Wiley & Sons Ltd), pp. 148–55.

Larson, E. V. and I. T. Brahmakulam (2002) *Building a New Foundation for Innovation: Results of a Workshop for the National Science Foundation* (Santa Monica, CA: Science and Technology Policy Institute, RAND).
Mansell, R. (2001) 'Digital Opportunities and the Missing Link for Developing Countries', *Oxford Review of Economic Policy*, 17 (2): 282–95.
McKendrick, D. G., R. F. Doner and S. Haggard (2000) *From Silicon Valley to Singapore* (Stanford: Stanford University Press).
Miller, R. R. (2001) *Leapfrogging? India's Information Technology Industry and the Internet* (Washington, DC: International Finance Corporation).
Mowery, D. C. (1996) 'Introduction', in D. C. Mowery (ed.), *The International Computer Software Industry: a Comparative Study of Industry Evolution and Structure* (New York: Oxford University Press), pp. 3–14.
NASSCOM (2002) *The IT Industry in India: Strategic Review 2002* (New Delhi: National Association of Software and Service Companies).
——(2003) *The IT Industry in India: Strategic Review 2003* (New Delhi: National Association of Software and Service Companies).
OECD (2000) *OECD Information Technology Outlook: ICTs, E-Commerce and the Information Economy* (Paris: OECD).
——(2002) *OECD Information Technology Outlook: ICTs and the Information Economy* (Paris: OECD).
Okhi, H. (2001) 'International Division of Labor in East Asia's IT Industry', in M. Kagami, and M. Tsuji, *The 'IT' Revolution and Developing Countries: Late-Comer Advantage?* (Tokyo: Institute of Developing Economies, Japan External Trade Organization), pp. 63–91.
Patibandla, M. and B. Petersen (2002) 'Role of Transnational Corporations in the Evolution of a High-Tech Industry: the Case of India's Software Industry', *World Development*, 30 (9): 1561–77.
Press, L. et al. (2002) 'The Internet in India and China', *First Monday*, 2002.
Saxenian, A. L. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, MA: Harvard University Press).
Schware, R. (1992) 'Software Industry Entry Strategies for Developing Countries: a "Walking on Two Legs" Proposition', *World Development*, 20 (2): 143–64.
Sircar, A. (2002) 'The Issue: What If We Don't Move Up the Value Chain?', *Dataquest*, 2002.
Sridharan, E. (1996) *The Political Economy of Industrial Promotion: Indian, Brazilian, and Korean Electronics in Comparative Perspective, 1969–1994* (Westport, CT: Praeger Publishers).
Trivedi, A. (2002) 'India's Software Supremacy and the Chinese Threat', siliconindia.com, 2002.
UNCTAD (2001) *World Investment Report 2001: Promoting Linkages* (New York: United Nations).
——(2002) 'Statistics: Value of Exports and Imports of Goods in 2001 (millions of dollars)', (UNCTAD Secretariat, New York).
US & Foreign Commercial Service (2002a) 'IT Product Distribution', US & Foreign Commercial Service.
——(2002b) 'Computers/Peripherals and Growth of Internet (Users, Computers, Handheld Devices)'.
US Department of Commerce (2002) *Digital Economy 2002*, US Department of Commerce, Economics and Statistics Administration (Feb.).
Wong, J., and C. K. Wong (2002) 'China's Software Industry (I): On the Fast-Track', East Asia Institute, Singapore.

Wong, P. K. (1995) 'Competing in the Global Electronics Industry: a Comparative Analysis of the Strategy of Taiwan and Singapore', International Conference on the Experience of Industrial Development in Taiwan, National Central University, Taiwan.
World Bank Group (2002) *Information and Communication Technologies: a World Bank Group Strategy* (Washington, DC: World Bank Group).

Index