8 Building capabilities in the software service industry in India: Skill formation and learning of domestic enterprises in value chains*

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8.1 Introduction

It is widely believed that the spread of information and communication technologies (ICTs), particularly segments, such as software, that rely heavily on human capital investments, offers low-income countries (LICs) an opportunity to leapfrog (ILO, 2001). Indeed, a few low-income countries have emerged as relatively successful players in the global market for ICTs. India is definitely one of them. India's growth and presence in the global production of and trade in ICT-related sectors has been remarkable. The *Information Economy Report 2012* states that in the countries outside the Organisation for Economic Co-operation and Development (OECD), India has emerged as a very significant player in this sector (UNCTAD, 2012). The software sector in India has shown an ability to not only sustain but also upgrade into more value adding segments of the value chain to an extent.

The phenomenon of upgrading within high technology global value chains by developing economy firms needs to be understood and explained. This chapter seeks to understand how various institutional mechanisms have enabled accumulation of capabilities to upgrade at the national, chain and firm level. The analysis is framed by the capability and catching-up concept presented by Nübler in this volume. This framework explains the dynamics of catching up as interrelated processes of collective learning and productive transformation, and discusses the role of policies, institutions, networks and standards in driving both processes.

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Capabilities are reflected in the ability to innovate, to proactively expand the range of options for diversification and technological upgrading and to enhance the competences of firms and the economy to exploit those options. For example, technological capability enables firms to generate and manage technical change (Bell and Pavitt, 1993). Therefore, technological capability involves the ability of firms to learn to "upgrade" continuously.

Economic upgrading in value chains refers to the process through which firms and workers move from low value added segments to higher value added segments of a value chain (Gereffi and Kaplinsky, 2001). Upgrading may take many forms, from improving processes to produce the same output at lower costs (process upgrading), to improving the quality of existing products or moving into more value added products (product upgrading), backward or forward integration of processes (functional upgrading), to an ability to use the learning in value chain to enter into other global value chains (lateral upgrading).

The conventional value chain approach has been critiqued for its inability to explain the role of the State in influencing the mode of participation of clusters/ firms in the value chain (Parthasarathy, 2004). While it enables us to understand the dynamics of a firm/region once it is incorporated into a specific node in the value chain, it offers little towards understanding the process of incorporation. It is this limitation that Kaplinsky (2000) and Kaplinsky and Morris (2001) seek to overcome by incorporating the concept of "governance" by agents external to the value chain. The ability to upgrade, Kaplinsky (2000) points out, hinges crucially upon "governance", i.e. the non-market coordination of economic activities. Non-market forms of coordination can be exercised by firms or networks of firms as well as by public institutions such as government policy frameworks and regulatory and support institutions (Gereffi and Kaplinsky, 2001; Gibbon, 2000).

Drawing upon literature on civil society governance, Kaplinsky (2000) distinguishes three forms of governance that can be exercised within a sector or a value chain. "Legislative governance" refers to formulation of standards or rules for action either by lead firms in the value chain or by state institutions. "Judicial governance" mechanisms monitor behaviour and ensure that such rules or standards are complied with. Finally, firms need resources such as credit, infrastructure, new technologies or market information to meet the norms and standards mandated by institutions of legislative governance. Therefore, governance also can take on an "executive" role. Together, these forms of governance are said to condition the mode of upgrading. Along with actors within a value chain such as suppliers or client firms or labour, agents external to the value chain can exercise governance – for example, public and/or public–private institutions that govern labour markets, skill formation, credit access and sectoral development. Such governance interventions by external actors are particularly important in enabling the insertion of the sector into global value chains (Humphrey, 2004; Kaplinsky, 2000). The above framework allows us to understand how regional and national governance mechanisms can interact with forms of governance undertaken by actors within a value chain to facilitate learning by firms and labour for upgrading.

The following section (section 8.2) provides an overview of the growth of the software services sector in India, emphasizing the gradual process of its upgrading. In section 8.3 we identify the changing capability requirements wrought by upgrading. Next, we link the process of upgrading to the changing capability requirements. In subsequent sections we map the set of public governance measures and institutions that enabled the creation of a specific knowledge structure within the labour force that in turn provided the opportunity for movement of the sector into the global value chain for software services. Then, we map the state, sectoral and firm-level responses (or collective competences) to emerging market opportunities and to upgrading requirements and the governance mechanisms that facilitated the process. We emphasize (i) the role of public policy in education and skill formation that created the facilitating knowledge structure or mix of knowledge in the labour force; (ii) the role of networks in building up individual and firm capabilities; and (iii) the role of standards in building firm-level and sectoral capabilities. Government procedures, networks and standards, when they are "smart institutions", are carriers of competences to drive learning and the evolution of capabilities within firms and the labour force within the sector and, in the process of upgrading, to create high-performing firm-level procedures. This chapter draws heavily from secondary literature, supplemented with interviews of key informants in selected information technology (IT) firms to obtain insights into firm-level routines and processes for training, codifying knowledge and coordinating.

8.2 The Indian software industry: Trajectories of growth and upgrading in global value chains

According to the National Association of Software and Services Companies (NASSCOM), India's share in global IT sourcing has increased from 51 per cent in 2009 to about 58 per cent of the roughly US$55 billion global market for IT services in 2011.[1] NASSCOM estimates that the Indian IT sector accounted for approximately 7.5 per cent of the country's GDP in 2012, up from 1.2 per cent in

[1] www.nasscom.in/indian-itbpo-industry (accessed on 12 March, 2013).

1998. The main contention of this section is that the impressive growth registered in recent times is not merely due to lower costs but is also an outcome of a gradual build-up of technological capabilities and the progress of the sector up the global value chain for outsourced IT services.

The global software value chain can broadly be divided into two categories – value chains for services and for products. "Services" refers to software development for a specific client, whereas products are generic and meant for sale to multiple customers. To be sure, while, globally, software products account for bulk of revenues in the software sector, it is in the services segment that the Indian software sector has emerged as a leading player in the global market. Furthermore, India has diversified and upgraded the range of services offered within the software services segment. It has also emerged as a major outsourcing destination for IT-enabled services (ITeS).

An important shift in the provision of software services has been the movement from "body-shopping", i.e. providing services at the client's site, to an offshore delivery model that requires the bulk of software development to be undertaken within the supplier firm and then transmitted to the client firm. According to Mani (2013), offshore exports have increased to 82 per cent of total software exports. The growing share of offshore development, relative to that of on-site services, is one of the indicators of domestic capability improvement. This movement to offshore delivery also involves an ability to coordinate projects, a competence not required in the provision of on-site services. The complexity of offshore projects outsourced to Indian software firms has grown, with many lead firms offering to supply the entire range of software development stages (Bajpai and Shastri, 1998).

There are several other indicators of upgrading as well. Of total IT exports, the share of engineering services and hardware has increased from 7.1 per cent in 2007 to 11.4 per cent in 2011.[2] Within the software services segment, although the Banking, Financial Services and Insurance (BFSI) vertical continues to account for the largest share (IDC NASSCOM, 2012), telecom and manufacturing verticals had come to account for 37 per cent of IT service exports from India by 2008. Both the growing share of engineering services and telecom and manufacturing verticals indicate an ability to provide relatively more sophisticated services over time. Exports from engineering research and development (E R&D) surpassed US$10 billion in 2012, registering a 14 per cent growth rate over the previous

[2] NASSCOM: Indian IT and BPM Industry: FY 2013 Review and FY2014 Outlook. Mumbai, 12 February 2013, accessed from www.nasscom.in/.../FY13%20Performance%20Review%20and%20FY14 on 16 October 2013.

year. Traditional verticals such as automotive and semi-conductors have registered a higher rate of growth due to increasing E R&D offshoring, while emerging verticals such as energy and utilities have also grown recently (NASSCOM, 2012). There has also been a small but significant shift towards exports of software products. Total exports of software products have increased from US$1 billion in 2008 to 1.5 billion in 2012, encouraging establishment of a separate association for software product firms. Production for the domestic market, too, has witnessed upgrading, as table 8.1 illustrates.

Ilavarasan (2011) highlights another aspect of upgrading of the Indian software industry – the establishment of software-related R&D centres. He points out that, of the 160 R&D centres that have sprung up in the country, two-thirds are in the software product development domain, 15 per cent in engineering services, and 20 per cent are related to embedded software systems. He further argues that firms are also diversifying into high-end consulting, embedded-software development, engineering and R&D services. Mani (2013) too notes instances of product, process and business model innovations in the sector. Mani also uses the trend in number of patents secured by software firms to indicate the upgrading efforts of IT firms in India.

The upgrading of output has been accompanied by upgrading of the processes employed. An increasing number of software firms in India adopt global standards such as ISO 9001 for quality management and ISO 27000 for information security. To quote a NASSCOM document on this, "India-based centres account for the largest number of quality certifications achieved by any single country. Over the last three years, there has been an 18 per cent increase in the number of

Table 8.1 Domestic sales and exports of software services, software products and engineering design services in India

Year	Domestic software sales (US$ billion)	% share of		Exports of software (US$ billion)	% share of	
		Software services	Software products and E R&D		Software services	Software products and E R&D
2005	4.2	83.3	16.7	13.1	76.3	23.7
2006	5.8	77.1	22.9	17.3	76.9	23.1
2007	7.1	77.6	22.4	22.0	77.5	22.5
2008	10.1	77.9	22.1	30.5	72.8	27.2
2009	10.9	75.4	24.6	35.4	72.9	27.1
2010	12.0	75.4	24.6	37.3	73.2	26.8
2011	14.5	75.9	24.1	44.8	74.6	25.4

Source: UNCTAD (2012).

companies acquiring quality certifications, a 30 per cent increase in performance certifications and a 20 per cent increase in security certifications".[3] Thus, we find that, over time, the Indian software sector has not only increased its share in the global market but has also managed to upgrade both processes and the nature of services.

The availability of the right mix of technical, general and linguistic knowledge in the labour force, the key input for the software industry, created the opportunity for the Indian IT sector to upgrade (Nübler, in this volume). The labour force is considered an important competitive asset, contributing to the accelerated growth and critical to building up the technological capabilities of the industry in India. There has been a sustained supply of trained, relatively low-cost professionals, providing an options space for developing various domains in IT and ITeS. Given this crucial role of low-cost skilled labour in the growth and technological dynamism of this sector, our discussion of technological capability-building will pay attention primarily to this dimension. In the next section we map the various capability requirements along the different segments of the software value chain. We highlight the changing individual and organizational capability requirements as the industry transformed itself from a provider of low-end programming services leveraging low-cost programming labour to one that is simultaneously diversifying and upgrading the range and quality of services delivered. This will be a prelude to our subsequent analyses of the process of capability formation.

8.3 Skills, knowledge and information requirements in the software sector and organizational capabilities

An interesting feature of software services sector is the co-existence of rapid technological changes in software technology and tools along with continued labour intensity in software development. Knowledge at the level of the individual and the labour force, therefore, is a key driver of competitiveness in the Indian IT sector. Notwithstanding the importance of the skills and human capital of individual workers in the production process, the rapid upgrading within value chains was made possible by the particular knowledge structure and mix of knowledge sets in the labour force and collective competences that translated the knowledge structure into productive capacities driving the software sector. This section analyses the requirements of the software sector in terms of skills, knowledge and information

[3] http://www.nasscom.in/quality, accessed on 20 September 2013.

requirements and of organizational competences involving coordination, quality control, problem identification and problem solving, facilitation of on-the-job training and learning. The following section will then show how, over decades, India has developed those capabilities that enabled the country to take advantage of the rising global demand for software production.

Software consists of a set of instructions that enable computer hardware to perform the required operations. Given the variations in the type of languages in which instructions are written and types of uses for which they are written and the nature of the market, software constitutes a highly heterogeneous category; as a result, the knowledge sets and skills required across these different segments of the industry are diverse. Further, different languages and packages need to be deployed across a range of client domains – retail, health care, automobile, telecom, etc. As noted, Indian software firms specialize in customized software, with few firms moving into generic product development. Despite the diversity in the types of software, software development across these segments can be roughly divided into the following sequence of tasks or activities (Heeks, 1996):

1. Idea/problem identified
2. Justification/feasibility
3. Analyses and specification of software requirements
4. Prototyping
5. Designing software
6. Coding/writing software
7. Testing
8. Software delivery and installation
9. Maintenance

A reading of these tasks reveals that there is a fairly clear demarcation of conception and design from implementation. Stages 1 to 3 would not only involve an understanding of the process requirements and their translation into source codes,[4] but also need considerable market information and knowledge of processes to develop the product idea. Subsequent stages essentially require an ability to program in specific software languages. Although there is a scaling down of skill requirements as we go down the process chart, the latter tasks, namely, coding, testing and maintenance, require a considerable amount of labour. India entered

[4] Source code consists of the various steps of instructions in human-readable form that need to be given to the machine. It is derived from a flow chart of the processes required for the final output/product. To be read by the computer, these instructions need to be translated into machine language.

the global software value chain through these relatively low-skilled segments of software development. Client firms would perform stages 1 through 5 in-house and outsource the last four segments of software development. These segments demanded large amounts of low-skilled labour able to code in a specific language and to follow instructions for coding. Hence, an important initial condition was the ability to tap into a large pool of labour that could follow instructions in English for software writing and then write the software code.

However, as Brooks (1975) has pointed out, this model, with a clear-cut distinction between high-end conception and low-end execution does not quite capture the way software development actually takes place within firms. The process, he argues, is much more messy and iterative, with frequent feedback loops from coding and testing to design and back to coding. Hence, while it is important for programmers to have a sound knowledge of coding, it is also important that they understand the requirements and specificities of the domains for which they develop software. This demand for an understanding of system and domain requirements, particularly, increases when the complexity of software development increases. Another important requirement is communication skills for interaction with client firms. With the movement to offshore services and entry into turnkey projects that involve elements of design, domain knowledge becomes more critical. While not all programmers are required to master domain knowledge, it became imperative that at least some sections of the workforce should comprehend how user systems function. Additionally, growing complexity of software projects undertaken warranted a build-up of competences at the firm level to develop process systems that ensure that different modules can be developed by separate teams and then integrated.

Finally, the movement into development of embedded software warrants access to high-end domain and technical skills that were seldom required in the earlier phases of the industry's development. Development of embedded software requires engineers who have bachelor's or master's degrees in electronics or computer science but who also have experience in hardware integration and an ability to understand and develop complex algorithms. Therefore, the industry continues to require large numbers of programmers with knowledge of programming in specific languages even as they gradually demand higher-end, domain-specific technical and coordinating capabilities. Given the variation in skill requirements across projects, firms prefer to recruit people with an ability to learn skills. The emphasis on "learnability" in recruitment and the importance of tacit knowledge for some of the skills required imply that firms have to invest in extensive in-house and on-the-job training. In addition to individual competences and skills, firms also need to build upon employee learning to generate a body of knowledge that can be transferred among employees and across specific projects. Therefore, we can delineate the following capability requirements of the sector as it seeks to transform itself over time from a low-wage-based provider of software services to a provider of a range of both high- and low-end services:

1. Basic programming skills
2. Communication skills
3. High-end programming and low-end domain knowledge for turnkey projects
4. High-end domain knowledge for embedded software and domain-specific software development
5. Intra-firm coordination capabilities for turnkey projects
6. Firm-level process capabilities to trap and consolidate project-specific learning and so build up dynamic sectoral capabilities.

To understand the process of capability building, it is important to understand how state policies enabled the entry of Indian software firms into the global software services value chain. Indeed, institutions of legislative and executive governance have been crucial for the generation of such capabilities in the India.

In India the imperative of import substitution till the early 1990s has fundamentally shaped this process. While there has been an argument that the growth of the IT industry in the country is due to the ”benign neglect” of the State, more serious studies point to the contribution of executive governance strategies of the national government in the build-up of knowledge and infrastructure that enabled the sector to enter into global markets (Balakrishnan, 2006). The long history of public intervention in higher education, calibrated measures of protection to ensure that firms had access to high-technology imports even as they were forced to develop domestic capabilities, and promotion of the Electronic Corporation of India Limited (ECIL) as a national champion for computer manufacturing are clear governance efforts to create and incentivize capability building and can be seen as “smart”. Software was recognized as a potential sector for exports and employment generation as early as 1972 with the launch of the Software Export Scheme and the provision of concessions for exports through the establishment of export processing zones (Saraswati, 2012). In effect, these policies enhanced the mix and diversity of knowledge embodied in the labour force, creating opportunities for upgrading. Furthermore, as well as enabling access to technologies, they enhanced other production factors and infrastructure.

In the mid-1980s the emphasis in policy shifted towards increasing domestic competition and building competitiveness in the world market. An important intervention has been the setting-up in the early 1990s of software technology parks with excellent data transfer and communication facilities. This executive governance measure has been critical to firms' ability to move into offshore services (Parthasarathy, 2000). Thus, the build-up of certain capabilities under the earlier growth regime facilitated formation of new capabilities more appropriate to the new phase. This is particularly evident in the creation of a low-cost skilled labour pool, as the following section argues.

8.4 The evolution of a knowledge structure: Public policy and public–private response

The importance of human capital for development of the Indian software industry is well recognized in the literature (Arora and Bagde, 2010; Athreye, 2005a). However, success was not driven merely by the skills of individuals, but rather by the development of a particular mix of knowledge sets in the labour force. The evolution of this knowledge structure is critical to the understanding of the success of the Indian software sector (Nübler, forthcoming). Upgrading in the sector hinges upon endowments of the labour force and their organization and mobilization to build up capabilities at the level of firms and the industry. Given the growing knowledge- and design-intensity of production, it is imperative for firms seeking to shift into new software activities and domains and to upgrade technologies to have access to the right mix of skills and knowledge in the labour force. At the same time, it is also important for them to learn/adapt their skill sets to changing market requirements. Skill formation is therefore conditioned simultaneously by governance mechanisms within and outside the value chain, such as intra-firm training and learning routines governance by producer associations, and public governance that enables the formation of institutions providing technical education and ensuring quality standards. This section will highlight how public and firm-level governance mechanisms have worked to create a knowledge structure in the labour force that enhances the opportunities for diversification and generates a steady supply of human capital to meet skills requirements in response to expected changes in the sector.

The criterion of "learnability" that we mentioned earlier has translated into a demand for those who are seen to have good analytical skills and an ability to grasp new skills quickly. Firms tend to be of the opinion that such abilities can be more readily found in engineering graduates than in other disciplines. Engineers are believed to have a better ability to understand process logic. Further, entrepreneurs believe that the more meritorious students enter into engineering colleges, rather than the physical or social sciences, due to the high reputation and social standing attached to engineering occupations.[5] In the initial phases, before firms could build their reputation through output delivery, they had to rely on the quality of labour force to signal their capabilities to potential clients. Firms would claim that they recruited only engineering graduates and only from the best colleges. Another reason for the preference for engineering graduates is their abundant supply. In the following sub-section, we outline the role of executive and legislative governance by the State in the emergence of this abundant supply of engineers.

8.4.1 Technical education: State-directed executive and legislative governance in India

Until the mid-1980s the imperatives of import-substituting industrialization (ISI) warranted investments in higher education, particularly in technical education. Backed by public funding, the technical education system could feed the growing needs of an industrializing economy. Engineering was seen as a major career option, given the demand in the heavy and capital goods sectors and in public services such as transport and electricity. This support provided the initial set of incentives to specialize in engineering. While there were a handful of engineering colleges even during the colonial period, several measures were taken to create new institutions in the 1940s. The All India Council for Technical Education (AICTE) was constituted in 1945 to regulate technical education in the country, to prescribe and monitor standards for recognition and affiliation. While tertiary technical education was provided almost entirely by the public sector till the mid-1980s, since then there has been a gradual move towards opening up this stream to the private sector, with the public sector assuming the role of a regulator (Basant and Mukhopadhyay, 2009). Private provision of education was seen as an ideal solution to the problem of fiscal constraints, on one hand, and the need to expand tertiary education, on the other. Investments in education were deemed socially productive, and, hence, tax concessions were offered, paving the way for a surge in investments by private capital. Education being a policy subject of regional state governments, this process was uneven, with some states – particularly the southern states – being the early movers.

Banerjee and Muley (2008) point out that, while the sanctioned intake in engineering colleges seats increased from 2,500 in 1947 to 653,000 in 2007, growing at a compound annual rate of 9.7 per cent, this rate particularly accelerated in the last decade. Between 1997 and 2007 the intake of engineering students rose

[5] Information gathered through fieldwork carried out for Rothboeck, Vijayabaskar and Gayathri (2001).

from 115,000 to 653,000 – a compound annual growth rate of 19 per cent. The number of colleges offering engineering degrees had grown to over 1,500 in 2006, of which 1,121 institutions have been set up in the previous ten years. This expansion, as table 8.2 shows, has allowed for a steadily increasing supply of technical human power in India, particularly in IT-related disciplines.

Out of the total output of engineering graduates, the premium Tier I colleges, the Indian Institutes of Technology (IITs) and Tier II colleges, National Institutes of Technology, account for only 1 and 2 per cent of the total, respectively (Banerjee and Muley, 2008).[6] This segment, however, constituted a dominant share of early emigrants to the United States and played a major role in signalling the quality of Indian technical labour. It was, in fact, the public-sector-created engineering pool from these tiers that established the initial set of networks through which body-shopping or offshore software development could take place. Major additions to the Tier III intake have come from the private sector, which accounted for 76 per cent of the sanctioned intake in 2006 (ibid.).

This increased supply happened to coincide with a phase of declining employment absorption in the manufacturing sector since the 1980s (Raveendran and Kannan, 2009). Just as there were greater opportunities available for students to pursue engineering, there was a decline in demand in the traditional manufacturing sector, leading to an "excess supply". Left with few other employment options, a substantial number of engineering graduates joined software development firms. Another important factor that drew labour into the sector was the relatively attractive remuneration and incentive structures on offer in this sector. This was in turn enabled by the policy that removed the ceilings on salary levels that existed in the country.[7]

Apart from increasing the number of seats on offer, the entry of private capital also fostered competition between colleges to build reputations, as the fees they could charge depended upon their ability to attract good employers. Increasing capacities in engineering streams that were seen to be more in demand, such as electronics and computer science, was another outcome of this trend. New courses, such as Master's in Computer Applications (MCA) were started, directed towards training students in software applications. These new colleges predominantly offer

6 Tiers indicate the reputation and quality of engineering education provided in India. Tier 1 institutions, according to Banerjee and Muley (2008), refer to the top colleges and universities in this regard, followed by the other two tiers.

7 "Corporate salaries of senior executives till the early 1990s were determined by the central government's office of the Controller of Capital Issues ... With liberalization in 1991 these restrictions were gradually relaxed and largely abolished." (S.L. Rao: "Money grabbing habit: Better salaries have meant greater greed", *The Telegraph,* 12 November 2012).

Table 8.2 Indian IT labour supply: IT software and services, 2007–08

Engineering graduates	536 000
Degrees (four years)	290 000
Diploma and MCA (three years)	246 000
IT professionals*	303 000
Engineering IT graduates (degree)	180 000
Engineering IT (diploma holders)	123 000

* IT professionals include computer science, electronic and telecom professionals.

Source: Adapted from NASSCOM Factsheet 2010, accessed from http://www.outsource2experts.com/PDFS/NASCCOM_2010_Global_Outsourcing_Report.pdf on 16 October 2013.

Bachelor's degree courses in engineering or technology and are affiliated to public universities to ensure a degree of control over quality. Another aspect of human capital development has been the diffusion of knowledge of written and spoken English.

8.4.2 Diffusion of English: Enriching the knowledge structure for transnational communication

India's colonial legacy has fostered institutions that make possible the diffusion of communication skills in English. While the British intention to rule through "the natives" produced a class of native bureaucrats trained to communicate in English, access to knowledge of the English language also signified social mobility among the upper caste middle classes as access to premium jobs was linked to command of English. While most government schools provided education in various regional languages, a range of private schools enjoying a good share of public subsidies offered education in the medium of English. Given the primacy of English communication even in post-colonial government, English language ability continues to command a premium. This promoted an incentive regime that favoured English as the medium of instruction. While taught as a second language even in government schools, English was invariably the medium for imparting tertiary education. Although good instruction in the English language commanded a price, investing in it continues to be a major route for social mobility. This demand for English-language instruction has also led to the rise of private coaching centres in small and medium-sized towns. The diffusion of knowledge of English among the engineering labour pool clearly facilitated the development of India's globally operating IT sector.

In sum, a variety of institutions, created at different levels and different times, have contributed to expand the knowledge structure in the labour force and provide Indian firms in the IT sector with a relatively abundant supply of skilled labour. India's initial phase of industrialization (ISI) and higher education policy created the demand for and supply of technical knowledge, while the legacy of colonialism introduced incentives to acquire English-language skills that persist even today. These developments took place at the national level. These institutions have broadened the knowledge base, which created opportunities for Indian IT firms to enter and upgrade in global value chains in IT.

8.5 Procedures for developing knowledge and skills required in labour markets

In addition to governance measures that have created a knowledge structure in the labour force, firms and public–private initiatives have also developed specific governance institutions for dealing with the dynamic demand for skills in the Indian IT sector. In other words, the country not only created capabilities for development of the software industry, but it also developed "smart" institutions or collective competences to respond to skill needs arising from market and technological change within the software sector.

8.5.1 Firm-level procedures for skill formation

Despite substantial investments in human capital formation, value chain requirements continue to create new gaps in skill supply and demand, forcing firms to continuously invest in firm-level training. Even in the initial phases, given the emphasis on "learnability", firms tended to invest substantially in in-house training at the entry level. A recent report states that about 2 per cent of industry revenues is spent on training, 40 per cent of which is spent on training new employees (India Brand Equity Foundation, 2013). Formal training programmes exist in all large enterprises. Infosys Technologies is reputed to have one of the largest training campuses in the world. Such training equips new employees with programming and problem-solving skills in addition to exposing them to organizational procedures and routines. Some firms, in fact, are reputed for their training capabilities; employees from such firms tend to have better market opportunities. Firms also rely on external training institutions for specific skill sets.

Another major incentive for firms to invest in training lies in the growing tightness of the labour market due to a gap between supply and demand (Athreye, 2005a and 2005b). This tightness led to (i) wage increases, which adversely affected cost competitiveness in the low-end services segment; (ii) increased attrition rates, pushing wages even higher; and (iii) loss of in-firm investments in training as a result of attrition. All these factors constituted important challenges as well as incentives for Indian firms to move up the value chain (ibid.). Given the reliance on large number of engineering graduates, basic programming work obviously did not employ their skills fully. Moving into more complex software services for larger segments of business processes requires domain knowledge that engineering graduates possess. Over time, as firms moved into more complex software development, they encouraged employees to specialize in specific domains. While in the initial years such specialization was seen as an obstacle to career advancement for individuals, given the low-end work undertaken for various domains, the current presence of a critical mass of development work in specific domains creates adequate incentives for employees to opt for specialization.

8.5.2 Addressing skill gaps: Recent public and public–private initiatives

In spite of the apparently large stock of human capital, there have been consistent fears of labour shortages in the software sector since the late 1990s. This "shortage" was primarily due to the practice of established firms recruiting only from a specific set of premium engineering colleges and, further, imposing a set of merit criteria that excluded even many in the engineering streams. Despite the boom in the numbers of engineering colleges, entrepreneurs continue to perceive a lack of "quality" in these institutions, which studies have recently borne out (Basant and Mukhopadhyay, 2009). This situation has fuelled a range of private initiatives to develop specific software skills. Such institutions are not affiliated to any universities. Instead, they offer certificate and diploma courses, which have gained importance over time through recognition in the labour market for software programmers. Some of them also train students to take other global certification tests in software development or other emerging skill certifications. The reputation of such certifications is established solely through their credibility in the labour market. This sector has grown along with the software industry, with revenues estimated to be around 23.5 billion rupees in 2012.[8]

[8] According to estimates by Dataquest, 17 September 2012.

In fact, some of these schools provide quite sophisticated training. An example of this is the National Institute of Information Technology (NIIT), one of the world's largest training institutions. NIIT offers a 3½-year graduate programme (GNIIT) that includes one year of internship with a software development firm. NIIT also works with public and private schools to provide educational support in software development skills and at present has expanded its training services to several other countries as well. Another major player is APTECH, which has very interesting placement tie-ups. Hexaware Software, which was initially a part of APTECH and was then spun off as an independent entity, directly contacts the placement cell of APTECH and recruits students who have completed various certificate courses. APTECH offers a range of short- and long-term courses across a range of high- and low-end software skills for both students and working professionals. While NIIT and APTECH are the major players in this domain, there are several others that provide similar training that addresses the emerging skill gaps in the sector.

State and central governments are also taking steps to tackle this growing problem. First, several Institutes of Information Technology (IIITs) have been set up on a public–private basis in different parts of the country. A number of leading software firms are also involved in improving the curriculum, quality of teaching and physical infrastructure to meet the changing needs of the sector. Further, NASSCOM works with the University Grants Commission (the apex state body that regulates the functioning of universities) and the AICTE to revise technical curricula to meet emerging demand. Another public–private venture, the Software Engineering Institute, offers training in sophisticated software engineering. Oracle, for its part, offers product management skills training in collaboration with the Indian Institute of Management (IIM) in Bangalore, in addition to supporting research and training at Anna University and IIIT Hyderabad, while Motorola provides training and technology support to 15 engineering colleges in and around Bangalore.

The expansion of technical education has broadened the base of the labour market by allowing for more entrants. However, it has also simultaneously created a segment of the technical labour force whose English-language and communication skills are inadequate, as they tend to have completed their primary and secondary education in a language other than English. To remedy this, several "finishing" schools, operating in association with the Ministry of Human Resources and Development (MHRD), have been set up to supplement technical skills with "soft" skills. A variety of institutions were created within firms and both private and public–private partnerships to fill in perceived gaps in the skills of the IT workforce. Furthermore, firms created procedures to enhance human capital and the tacit, procedural knowledge of their workforce through training procedures. Higher attrition also prompted firms to invest substantially in documentation and standardization of processes and procedures to minimize their losses. Such cooperative and firm-level institutions can themselves be seen as carriers of collective competences, which facilitate learning and high-quality processes at the firm level. The next section maps the emergence of such standards and their role in building firm-level capabilities.

8.6 Process upgrading through standards: Legislative governance for quality, procedures and firm routines

Once inter-firm competition intensified and firms began to innovate new offshore and global service delivery models, they had to move beyond signalling merely the competences of individual employees to signalling organizational capabilities (Athreye, 2005b). This incentivized the acquisition of quality and security certifications mentioned earlier in this chapter. Quality assurance through the establishment of recognizable quality standards has been critical to the upgrading of the Indian software industry, learning at the enterprise level and the development of high-performing collective procedures (see also Nübler, in this volume). Internationally recognized certification of skills increases employability and also substantially reduces the transaction costs of recruiting. This in turn provides incentives to employees to acquire such skills according to international standards, since this makes their skills highly transferable across firms. Such standards also extend to organizational processes. Standards serve to signal to clients the quality of internal processes. Adhering to such standards helps to reduce errors in programming and to build documentation and better human resource practices. Importantly, certifications make sure that software development capabilities are embedded in teams rather than in individual programmers. This is a particularly important coping mechanism for firms struggling with the problem of high attrition and consequent loss of skills embodied in personnel. The nature of standards has also changed with the changing requirements of the upgrading process. While the initial specialization of the Indian software services sector was in segments that required mostly codified programming skills, its entry into more complex and customized software development warrants a set of codified, tacit and semi-codified firm-specific capabilities. Obviously, establishing standards for such tacit capabilities is not easy. We highlight the modes through which such standards were developed over time.

In the early years of exports, the exposure to quality business processes, frontier technologies and communication protocols required for negotiating with clients was lacking. The early forays into body-shopping partly compensated for this lack. Programmers, by being present on-site and interacting with clients, were exposed to learning-by-doing that stood the sector in good stead when firms upgraded to offshore software development. As mentioned, given the lack of reputation and credibility in the early years, firms reportedly used the quality of labour as a signalling device to indicate their competence. They claimed not only to recruit exclusively engineering graduates but also to recruit only from institutions that had already established reputations in the United States through students who had emigrated to study and work in US-based firms. The subsequent broad-basing of recruitment meant that firms had to move away from using the reputation of engineering colleges towards relying on a set of other globally recognizable standards not only to signal to clients but more importantly also to ensure the quality of their own workforce. In addition to firm-level responses to such challenges, there are also a set of public–private initiatives addressing this dimension of capability formation.

8.6.1 Firm-level procedures to update skills through certification

In most IT firms fresh recruits are put through in-house training and are expected to clear some tests at the end of the training programme. There is, however, a constant threat of redundancy of their specific skill sets. Many software programming skills are prone to become outdated with the advent of new modes of computing and development. Firms provide a range of incentives for employees to update their technical and project management skills by acquiring individual certifications. For instance, whenever a newer version of a software product is released, the firm usually gives a period of six months within which the professional needs to upgrade his or her skills and obtain a re-certification in that software (Arora et al., 2000). Individual employee mobility is also increasingly tied to acquisition of certain certifications, either in the technical or in the managerial domain. Online learning modules are made available for employees to prepare for such certification tests. Incentives for certification are also provided during periods called "benching" when employees are not deployed on specific projects. Given the large-scale demand for labour, at any given time there is a section of the labour force that is "on the bench" and can be deployed as and when any new requirements arise. During such periods employees are required to obtain additional certifications that can benefit them and the firm in the long run.

8.6.2 Standards for documentation: Codification of tacit knowledge

The software development process, as discussed earlier, is still not entirely subject to codified development procedures. As a result, learning-by-doing routines are a crucial mode of acquiring capabilities. However, since this learning is embodied in the individual programmer, attrition deprives firms of such vital competencies. Documentation of software development processes is therefore critical to codification of this tacit knowledge, and prominent firms have devised extensive documentation and dissemination procedures of these across their workforce. The process of documentation and codification has been aided by firms' move to acquire process and quality certifications.

As IT is a process-driven industry, signalling the quality of software development processes has been a major marketing device (Arora et al., 2001). As noted earlier, India is home to the largest number of firms that have obtained quality certifications such as ISO-9001/9000-3 (standards prescribed by the International Organization for Standardization) and the Software Engineering Institute's 5-level Capability Maturity Model (SEI-CMM). Currently, more than 50 per cent of the world's CMM Level 5 companies are based in India. In addition, India is also very close to hosting the highest number of ISO companies in the world. Such certifications, in addition to enabling firms to attract new clientele, also facilitate codification of tacit knowledge gained in the process of development, which has proved useful for firms diversifying into other service segments such as R&D and IT-enabled services.

Standard setting has also been a major governance initiative by both public and private institutions in the domain of training quality. There is a growing recognition of the lack of quality of technical education in the country, with the National Employability Report of 2012 reporting that 83 per cent engineering graduates in the country are unemployable.[9] A NASSCOM study conducted in 2011 has shown that 75 per cent of IT graduates are not ready for jobs in the Indian IT sector.[10] This lack of quality among engineering graduates has pushed state and central governments, along with private stakeholders, to promote standard-setting institutions. One such initiative is the national roll-out of skill certification through the NAC (NASSCOM Assessment of Competence), which creates national standards for competence. Others include accreditation to private training institutes ranging

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[9] http://engineering.learnhub.com/lesson/21444-83-percent-of-indian-engineering-graduates-unfit-for-employment-survey-findings, accessed 12 March 2013.

[10] Ibid.

from foundation-level courses to the post-graduate level in IT-related fields. The National Centre for Software Technology (NCST) also conducts tests for competence in software at various levels. While in 2010 nearly 90 per cent of the revenues of private non-formal training came from initiatives addressing individuals outside the context of the firm, this training has been supplemented by the rapid growth in recent years of corporate training initiatives, with many multinationals starting their own authorized training centres to provide their own certified courses. These institutions train potential employees to get certifications such as Microsoft Certified Systems Engineers (MCSE), Microsoft Certified Systems Developer (MCSD), Certified Novell professional (CNP) or e-commerce certifications. According to Brainbench Inc., although India ranked behind the United States in the number of certified software professionals (145,517 against 194,211), the number was 30 times greater than in Germany (the country with the largest number of certified professionals in the EU) and 100 times more than in China in 2005 (cited in Kaul, 2006). Such a profusion of globally recognized certifications has been a major mode of labour market upgrading. Importantly, it has also enabled employees with lower skill levels to acquire new skill sets and thus broaden their skill base in the sector. Standards can therefore play a vital role in enhancing capabilities by stimulating learning, codifying collectively acquired knowledge and creating competences at the level of the firm or sector. They further safeguard firms against the loss of knowledge through the mobility of individuals, emphasizing the collective nature of such capabilities.

8.7 The role of institutional networks in enhancing capabilities

In addition to firm-level governance and public policy measures such as formal training institutions, Humphrey and Schmitz (2002) point to the importance of networks of learning both across firms clustered in a region and across firms within the value chain. Learning through various informal learning sources has been critical to build up competences that contribute to the evolution of the Indian software sector. In this, the role of entrepreneurial networks, producer associations and the circulation of labour emerge as key sources of learning for firms. Diasporic networks, entrepreneurial and trade networks, diffusion of practices of multinational corporations through labour circulation, client–service provider networks and government–industry networks all play a pivotal role in this regard, particularly in the transfer of tacit knowledge. This learning importantly extends also to knowledge about markets, access to finance and builds reputation. The roles of different types of networks therefore need to be understood to explain the growth and consolidation of capabilities required in software production. The following section addresses the spaces of learning opened up by the various networks in the software services value chain. We map the roles played by such networks in the build-up of various capabilities.

8.7.1 Diasporic networks: Brain drain to brain gain

There is an increasing recognition of the role played by the diasporic communities in building capabilities in their home countries (Saxenian, 2006). The case of Taiwan (China) serves as a model for some of the initiatives undertaken in other low-income countries, including India. In California's Silicon Valley, a number of Indian professionals work in top positions in technology firms and a sizeable number of entrepreneurs are of Indian origin (Pandey et al., 2004). As many had graduated from Tier 1 colleges, they quickly forged networks for information-sharing and mobilizing finance for entrepreneurial ventures (Mani, 2013; Pandey et al., 2004).

These networks were critical not only to body-shopping but also in the move to offshoring of services. The initial impetus for offshoring and credentializing Indian service firms was, in fact, enhanced by the presence of such expatriates. Even the entry of Texas Instruments (TI) into Bangalore that pioneered the offshore model was enabled by the presence of an expatriate Indian as one of TI's vice-presidents (Patibandla and Petersen, 2002). There are several other similar instances of Indian technocrats in US firms and other multinational firms creating links with Indian entrepreneurs and labour pools. The Indus Entrepreneur (TiE) Network, a network of Indian technocrats based in Silicon Valley, has played a major role in building up entrepreneurial capabilities in hubs such as Bangalore. In addition, missions undertaken by regional governments sought to attract investments among the Indian diaspora: representatives of regional governments reached out to the diasporic community from their states with requests for investment in their home states. There are also instances of such networks helping their host training institutions to conduct special training and exposure programmes for current students.

The Indian government, too, recognized the importance of diasporic networks for tapping into the capabilities of expatriate technocrats. It formed a high-level committee on the Indian diaspora in 2000 to facilitate interaction between the expatriates and their home nation. One initiative is an exchange programme called "The transfer of know-how through expatriate nationals"; it encourages expatriate nationals to undertake short-term consultancies in their home country. Through these various programmes and incentives, the government seeks to attract the managerial and technocratic skills required as the industry moves into more complex processes.

8.7.2 Learning through multinationals

Lateef (1997), Parthasarathy (2000) and others cite, as an important factor contributing to the beginnings of software exports from India, the establishment of subsidiaries of multinational firms for software development in India to take advantage of the low-cost skilled labour pool. Although domestic firms undertake substantial exports, the Indian software industry is also home to a sizeable number of multinational corporations, as evident from the growing presence of foreign firms in the membership of NASSCOM.[11] Other studies point to the networks of learning facilitated and enabled by the multinationals (Athreye, 2003). The presence of multinationals is of two kinds. One set of multinationals are global leaders setting up some back office operations in India, whereas the other set consists of expatriate Indians setting up operations in India.

Since the entry into global markets, the presence of multinationals has created incentives for learning and capability formation in five distinct ways. First, the tightness in labour markets and the agglomeration of software development fostered high levels of labour circulation, including between multinationals and domestic firms. This circulation facilitated networks of learning as employees who were exposed to organizational routines of the multinational firms could carry over this tacit knowledge to domestic firms. The circulation of labour across firms, while depleting firms of skills simultaneously also provides them with an opportunity to acquire skills that they lack through the market. This is particularly useful when firms seek high-end skills that are not available through formal training processes.

Second, in terms of organizational routines, multinationals were the first to implement certification procedures for internal processes and also developed propriety tools for software development. Development of proprietary tools was particularly useful for improving the productivity of software development. It involves use of blocks of code written by a firm for earlier services for new software development, thereby cutting the time and labour involved.

[11] http://www.slideshare.net/pratimaonline/bpo-voice-why-nasscom-is-important-for-indian-outsourcing-industry, accessed on 16 October 2013.

Third, domestic firms could also develop better business models as they learned from multinationals. Athreye (2003) points out that even the movement of Indian firms from providing onsite services to setting up offshore development centres was itself enabled by learning from the business models of multinationals. It was TI that pioneered the process of developing software in India and transmitting codes to its parent firm in the United States via satellite. In addition, telecom, software and hardware multinationals also outsourced software development work to domestic firms, which helped employees to acquire domain-specific skills that fed into the move towards more complex software development and diversification into R&D services.

Fourth, learning was also possible through the formation of joint ventures between Indian and foreign firms. A classic example is that of Nortel Networks, which established a joint venture with an Indian firm. The Indian partner went on to set up an independent firm that in fact proved to be a competitor for Nortel in the same product space. This model, Athreye (2003) points out, was also adopted by other multinationals such as CISCO and TI. Fifth, multinationals also forged links with academic institutions for both research and training, as discussed earlier. Funding of research and teaching in frontier areas in some of these institutions are some of the key activities undertaken.

8.7.3 Entrepreneurial networks: The role of NASSCOM

In addition to institutions such as TiE, the formation of the trade association, NASSCOM, has been a key driver in the evolution of the software services sector. Started in 1988 with 38 members (who accounted for 65 per cent of total exports), NASSCOM now consists of more than 1,100 members (Kshetri and Dholakia, 2009). In addition to having affiliates in several countries, it has dedicated staff in the Indian Embassy in Washington, DC, for lobbying with the US industry and government. This lobbying activity has become particularly important in the context of the backlash in the United States against outsourcing due to a fear of loss of jobs.

NASSCOM undertakes a range of activities ranging from enforcing standards to helping explore new business opportunities, supplying market information, working with the government to identify critical gaps in capabilities and seeking support to address them. For instance, it enforces certain security standards for its members with regard to networks and data transmission and seeks to bring data protection standards up to European and US levels. It also has invested substantially in brand building. Another important role has been its lobbying and working with the national and regional governments on various issues affecting the industry. It collaborated with several state governments to formulate IT policies and also with the Ministry of Information Technology to tackle Internet-related crimes, software piracy and data theft. Further, several members serve on government committees. This power enables them to lobby successfully for infrastructure and other government subsidies such as tax exemptions. Its lobbying with government has helped enlarge the scope of the domestic market, with state governments earmarking a share of their budgets for building IT infrastructure such as e-governance.

The various formal and informal institutions underpinning these networks and the transfer of knowledge therein provide examples of how "smart" institutions may facilitate and incentivize learning and capability accumulation within social networks in the process of upgrading.

8.8 Conclusions and implications for sustained upgrading

The preceding discussion has highlighted how multiple governance mechanisms and public–private networks enabled the entry and upgrading of the Indian software sector in the global software value chain. Based on insights from literature on value chain governance, this chapter maps the build-up of competences as an outcome of interactions between firm, chain and sectoral governance mechanisms. Importantly, mediatory institutions such as the industry association and the Indian diaspora have facilitated such interactions. We have endeavoured to distinguish policy measures that facilitated the entry of the Indian software sector into the global software services value chain from policy responses to sustain and upgrade within the global value chain. Initiatives in the first phase, rooted in an imperative of import substitution, fostered the development of both social and physical infrastructure that enabled domestic firms to leverage low-cost human resources to gain a foothold in the global value chain. Subsequent public governance, embedded in a larger policy shift towards trade openness, was embedded in a regulatory environment that assigned a facilitating role to the State and was shaped by greater interactions with industry associations and assigning private capital a bigger role in building up educational infrastructure. We have sought to identify the synergies between public governance mechanisms and firm-level capability building through creating incentives and providing support infrastructure primarily in human capital accumulation. This interaction between sectoral demands and governance response has been vital to both the entry and the subsequent growth and upgrading in the global software services value chain. In other words, the build-up of collective competences at the firm level has been a co-evolutionary process, with public policies responding to sectoral demands that in turn are shaped by perceived barriers to upgrading or growth at different stages in the sector's evolution.

Even amidst such sectoral dynamism, gaps persist in the build-up of capabilities. A key gap, identified by Ilavarasan and Parthasarathi (2012), concerns the lack of linkages between small firms and large domestic or multinational firms in the sector that can sustain capability-building among small firms. They point to the inadequacy of intermediary institutions such as venture capital funds and an inability to tap into skill networks despite the continuous formation of new small firms. Evidence from this chapter in fact underscores the need for such intermediary institutions to enhance skill and capabilities to negotiate and move up in the global value chain. As it emerges from these discussions, industry associations can be ideal for this role, as NASSCOM has demonstrated.

Another constraint has been the lack of quality teaching resources and a mismatch between supply of and demand for skills. The high salaries offered to employees may also have implications for sustainability of the sector by depleting teaching resources and resulting weakness in the quality of higher education, as Tilak (2013) has pointed out. Even within engineering disciplines there has been a distortion, with more supply and demand from students for electronics, computer science and IT and few takers for other disciplines such as mechanical and civil engineering. This is happening at a time when projections indicate that future demand will be more for engineers with a basic grounding in other disciplines and topped by skills in software development. As a consequence, the government has decided not to create any more institutions offering degrees solely in IT like the IITs. The Indian experience clearly highlights the need for linkages between the educational system and industry. "Smart institutions" that can remain sensitive to the changing requirements of industry and adjust their curricula accordingly have been crucial to the success of the IT sector in India. Effective use of the State's supply capacity and inviting the private sector to bridge the demand gap in terms of skilled labour requirements are both central to creating a favourable ecosystem in which firms can move up. In this context it also important to recognize the role of various formal and informal networks that facilitate learning within and outside firms. Relevant policy initiatives need to pick out these networks and strengthen them.

The next important issue concerns monitoring of standards. The high levels of unemployability of engineering graduates in general and lack of job readiness among substantial numbers of IT graduates clearly point to lack of adequate attention to the judicious governance of skill formation. Despite the rise of new institutions to address this gap, skill shortages continue to pose barriers for upgrading by domestic firms, small firms in particular. Poaching of human capital by multinationals increases such barriers (Saraswati, 2012). We also find that despite limited movement into the software product market, barriers to upgrade in this direction created by branding, advertising and market access by global players persist. This problem is exacerbated by the fact that Indian firms continue to spend relatively little on R&D.

NASSCOM, which wields considerable power in policy-making, has been found wanting in its vision for leveraging the sector's potential to enhance dynamic linkages with the domestic economy. Although many export firms have diversified into the domestic market, work with industries to generate new software that may improve capabilities in the user segments has been limited. This disjuncture and lack of embeddedness due to weak domestic linkages are likely to limit the possibilities of positive spillovers that upgrading in global value chains could generate in the domestic economy. While the various governance mechanisms that we have highlighted have facilitated sectoral upgrading, the extent to which such upgrading can generate positive spillovers in the rest of the economy will be critical to social upgrading. The Indian case highlights the need for a simultaneous emphasis on upgrading within the value chain and on a set of measures that ensures social embedding of these processes.

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