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