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Plugging into Global Value Chains of the Software Industry: The Experiences of India

By

Shaopeng Huang
Jai Asundi
Yuqing Xing

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National Graduate Institute for Policy Studies
7-22-1 Roppongi, Minato-ku,
Tokyo, Japan 106-8677

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Shaopeng Huang

Research Institute for Global Value Chains, University of International Business and Economics, Beijing, China.

Shaopeng.huang@gmail.com

Jai Asundi

Center for Study of Science, Technology and Policy (CSTEP), Bengaluru, India

asundi@cstep.in

Yuqing Xing

National Graduate Institute for Policy Studies, Tokyo, Japan

yuqing_xing@grips.ac.jp

Abstract

The rise of the software service industry has been the most impressive achievements of the Indian economy in the last few decades. The success story of Indian software service industry is essentially a story of plugging into the GVC by taking up part of the mostly labour-intensive, low value-added tasks outsourced/offshored by lead firms from the developed country. With a view to expand our understanding of GVCs beyond manufacturing, we analyse in this paper the software services industry in India in the context of GVCs. By examining the organization of software value chains, the endowment profile and sources of comparative advantage of India, the relations between foreign (lead) firms and indigenous firm, and the role of Indian governments, this paper try to pin down India's particular position in the global value chains and its upgrading status, and to demonstrate the structural barriers and future challenges if Indian firms are to upgrade further their positon in the GVC.

Keywords: GVCs, software; Indian software industry, upgrading

JEL Classification: L8, F2

1. Introduction

The emergence of Global Value Chains (GVC) offer a new path toward industrialization. Developing countries can plug themselves into GVCs in accordance with their comparative advantage and achieve industrialization. In the last few decades, taking advantages mainly of the availability of a large pool of English-speaking engineering talents at low costs, India has successfully participated in GVCs of the software services industry (Pattnayak & Chadha 2019), providing services such as routine software programming/coding and maintenance, as well as ICT-enabled services of Business Process Management (BPM), to global customers (IBEF 2019). It has become a leading destination for multinational enterprises (MNEs) to outsource their labour-intensive software services and business process tasks, and Indian companies such as Tata Consultancy, Wipro and Infosys have been among top software services companies in the world. Overall, the rise of the software service industry has been one of the most spectacular achievements of the Indian economy in the last few decades, and it has significantly facilitated the economic growth of India.

With a view to expand our understanding of GVCs beyond manufacturing, we analyse in this paper the software services industry in India in the context of GVCs. The paper is organized in the following manner. We begin with a discussion the endowment profile and sources of comparative advantage of the Indian software services industry, a section on the organization of software value chainsthen follows. In section 3, we present the general trend and impacts of the Indian software services industry. Section 4 and 5 deals with the relations between foreign (lead) firms, indigenous firms, and other relevant players; and the role of Indian governments respectively. In section 6, we examine the role of training and skill upgradation. Section 6 is devoted to the discussion on the upgrading status and future challenges before we finish the paper with some concluding remarks.

2. Endowment Profile and Sources of Comparative Advantage

2.1 Human resources

It is noted that the software services industry is particularly suited to the profile of resource endowments of India (Bhattacharjee & Chakrabarti 2015). To be more exact, abundance in quality engineering human resources has been a must for the software services industry; at the same time, the industry is relatively independent on physical infrastructure and financial capital, for which India does not have a comparative advantage (Arora & Athreye 2002; Coward 2002).

It is generally believed that the abundance of well-trained, low-cost software professionals are at the heart of the success of the Indian software services industry. Indian software professionals tend to enjoy absolute (and comparative) advantages compared with their US and European counterparts. At the year of 1997, it is estimated that wage costs in India were about 1/3 to 1/5 of the US levels for comparable work (INFAC 1998). Other estimates around that time suggested that all factors considered, the overall costs of software development in India were only half that

in the US (Arora et al. 2001). However, at around the turn of last century, there were concerns over the sustainability of the labor cost advantages given the tight labor market conditions at that time (NASSCOM 1999). It turned out, in the years that followed, that the cost advantages remained largely unchanged notwithstanding the wage inflation (NASSCOM 2013), presumably due to the large stock of engineering graduates in India, and more generally, the large pool of technically trained manpower with English proficiency (Arora & Athreye 2002; Athreye 2005; Heeks 2006). With the availability of cheaper and quality manpower, a significant amount of software production continued to be outsourced to India, laying the foundation of the sustained growth of Indian software industry in recent years (Bhattacharjee & Chakrabarti 2015). A recent report by HackerRank (2020) confirms that as of 2020, the average annual salary for Indian software developer is $38,229, which, over all these years, is still almost (a little more than) 1/3 that of their US counterparts at $109,167 (Figure 1).

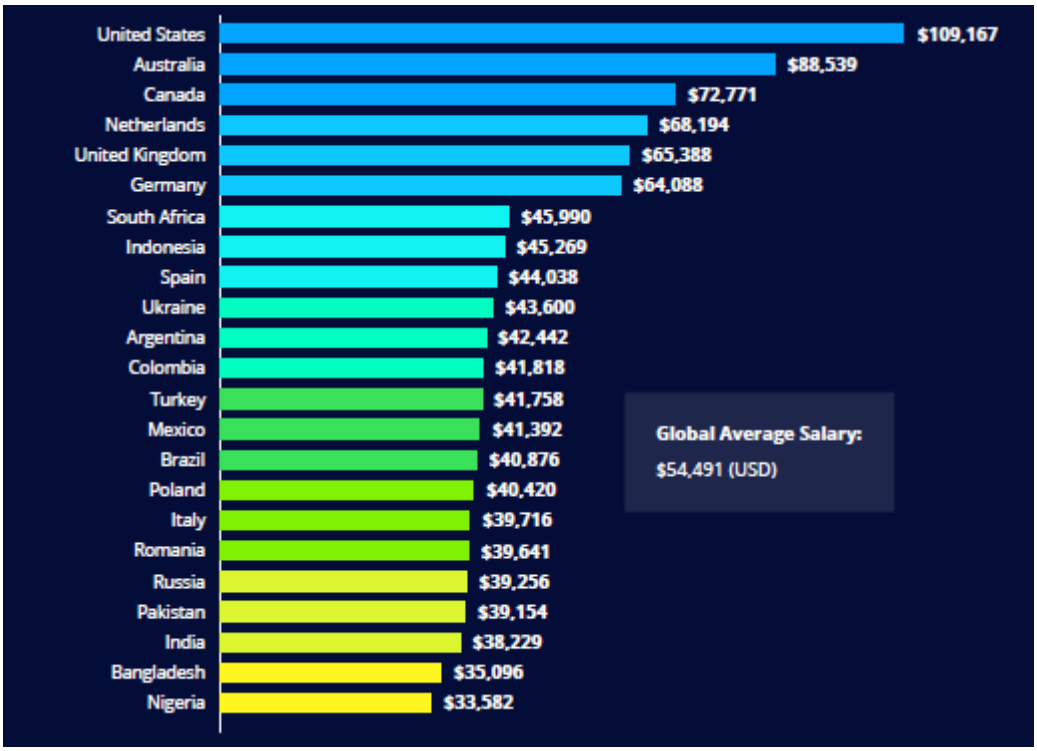


Figure 1: Annual Salary of Software Developers Worldwide

Source: 2020 HackerRank Developer Skills Report.

Apart from the advantage of low wage costs, other attributes of the Indian workforce seem to be tailor-made for the software services industry, e.g., quality engineering education, skill sets, and English fluency. (Joshi & Mudigonda 2008). Specifically, India has the world's second largest English speaking population (72 million) after US, and the second highest number of STEM graduates (2.6 million in 2016) after China (Forbes 2017). For the academic year of 2016-2017, there were 3,289 AICTE (All India Council for Technical Education) approved engineering

colleges[1], offering 1,553,809 seat for undergraduate educations; while at postgraduate level, the corresponding figures are 2,234 and 197,018 respectively. Moreover, several socio-cultural factors have positively influenced the attributes of the workforce, e.g., the submissive nature of the Indian workforce (due to the historical prevalence of hierarchical social structure); their disciplined and structured approach to work; and their design and project management skills. Given these, most of the Western countries which outsourced their jobs to India have successfully managed to increase the active working hours of their workforce without any trade union opposition (Nicholson & Sahay 2001).

Apart from the rising wage rates, another major issue facing the industry is its high attrition rates, which challenges substantially the ability of Indian firms to progress beyond providing low-end software coding, development and maintenance services (Arora *et al.* 2001). To a considerable extent, this reflects the relatively inelastic supply of engineers with formal degrees (as compared to those trained by private training institutes), and the marked preference for engineering background (of all types, not necessarily confined to software development or computer science) by Indian software firms, which was supposed to signal to their customers the quality of the employee and services. Moreover, there is a brain-draining issue, as most talented and experienced software professionals tend to move to the US through the H-1B visa route (Nidumolu & Goodman 1993) or to firms overseas.

Firms are responding to the problem of employee attrition in a number of ways which include, the provision of a career path leading to managers based on meritocracy, opportunities for improving skill sets through ongoing training and professional development programs, monetary compensation and incentive schemes, and other perks and privileges (Nasscom 2010).

2.2 Infrastructure (In particular, communication infrastructure)

Good communication infrastructure is considered vital for the continued growth of the software services industry (Arora et al. 2001). This is most obvious in software service exports, and especially for offshore software development. Until the end of last century, the data communication infrastructure in India was expensive and in limited supply. Some US clients did find the problem with the communication infrastructure in general and the slowness of the networks in particular a major irritant. Clearly, the poor communication infrastructure has halted back the growth of software services for and through the Internet.

In the past decade, the Indian government has been working towards improving the physical (including communication) infrastructure to ensure time-bound creation of modern infrastructure enabling the delivery of services. To this end, the government has doubled its spending on infrastructure from US$ 500 billion in the 11th Plan (2008–12) to US$ 1 trillion in the 12th Plan (2013–17) (Bhattacharjee & Chakrabarti 2015). Further, the encouragement of private partnership

[1] AICTE approved Institutes are deemed to be Universities by the Indian Government.

through the public-private partnership (PPP) has been helping the provision of quality infrastructure. In general, these efforts improve the ability to travel and move about, allowing firms to expand within the country by creating software development centres and by enabling personnel to travel to client sites easily. Most substantially, in recent years, the presence of high bandwidth network in most cities and towns—partly as a result of the infrastructure endeavour—allows for seamless connectivity and hence ability to conduct outsourced work. Ubiquitous Computer availability has also promoted India as a hub of GVC in software services.

2.3 Entrepreneurship and Indian Expatriate

Besides computers, office space, and communication infrastructure (in particular internet connectivity), there are virtually no other major costs for setting up a software service unit (Coward 2002). Accordingly, entry barriers to this industry are low. This, coupled with increased profitability from software production, and a series of government initiatives such tax incentive, ushered in a new wave of entrepreneurship in the early 1990s (Arora *et al.* 2001; Kapur & Ramamurti 2001). Most of these entrepreneurs (typically skilled engineers) were returning migrants of the 1960s to 1970s "brain drain". Having accumulated substantial skills and financial resources overseas, many set up their own star-up firms in India (Balasubramanyam & Balasubramanyam 1997), which were then developed into many of the leading Indian software firms of today, e.g., Tata, Wipro, Infosys, and Polaris (Kumar 2001). For example, F. C. Kohli, founder and the first CEO of Tata, is a graduate of MIT and worked in the US for years before heading Tata; Wipro Chairman Azim Premji is also a graduate of MIT; and all the Infosys founders have worked in the US for various firms before starting Infosys.

More generally, the presence of a large Indian expatriate, especially in the Silicon Valley, has acted as intermediaries that brought back substantial business opportunities in India (Patibandla *et al.* 2000; Kapur & Ramamurti 2001; Coward 2002). Although the exact magnitude of the Indian expatriate' contribution (in terms of hires, revenues, exports etc.) to the Indian IT/software industry is not known, according to Sexenian *et al.*(2002), half of the Indian expatriate in the Silicon Valley had business contacts in India, and a quarter of them had actually invested in India. Similarly, Arora et al. (2001) reported that in the CMU Software Dataset, a majority of the Indian software firms were led by individuals used to work for a western organisation in the previous years, and of the firms interviewed by them in the Dataset, all entities had connections to the US/Europe through which they obtained their first contracts. One of the expert we interviewed observed confidently that 50-75% of the revenues and hires by Indian software firms were based on such expatriate connections through the 1990s and early 2000s.

3. The Software Value Chain

This paper examine the development of Indian software services industry from the perspective of global value chain. Simply put, 'global value chain' (Kaplinsky & Morris 2001; Ponte *et al.* 2019) refers to the full range of geographically dispersed activities required to bring a product or service

from conception, through the different phases of production, up to the delivery to final consumers and more.

Some generic framework of global value chains (Gereffi 2018) has been put forwarded in the literature. However, such a generic framework is not readily applicable to all industries, so that it should be adapted in accordance with the features of industry under analysis, as in our case.

Several representations of software industry value chains have been developed in the literature that present different sequencing of the stages in and encompass different activities with varying degree of detail (Kumar & Bhatia 2014). In one representation, the main value-adding stages/activities of the software value chain include: *architecturing (consulting, analysis, concepts); developing code; testing; implementation, marketing and distribution; maintenance; helpdesk and training and education* (Sharpe 2009). In a slightly different representation (Arora *et al.* 2001), the value-adding process of software development involves the following stages: *conceptualization, requirement analysis, high-level design, low-level design, coding, testing and support.* In both cases, the stages roughly correspond to those described in the waterfall model of software development (see Figure 2)

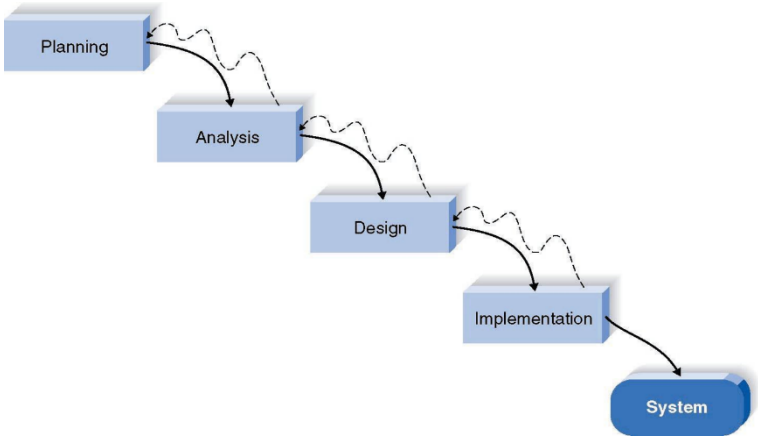


Figure 2. The waterfall model of software development.

Source: Royce(1970); Dennis *et al.* (2015)

The UNCTAD's perception of the software industry value chain—which tries to differentiate the quite distinct nature of production (market orientation), the scope of value creation, and accordingly, the different role of developed and developing countries in the global software value chain—is also illuminating. According to UNCTAD (2012), the software value chain consists of two components: software services and software products. Software services encompass all activities associated with software development including specification and analysis, design, implementation, testing and maintenance. The process of software development then turns into two types of software products, application software and systems software.

In another informative representation (Messerschmitt & Szyperski 2003), the software value chain is divided in two categories: i.e. requirements value chain and supply value chain. The former

includes activities related to: a) requirement/needs analysis of users; b) design of specific approaches to meet the requirement; and c) implementation of software. The supply value chain includes downstream activities and encompasses four primary stages: implementation, provisioning, operation, and use. The implementation phase basically overlaps and connects both value chains.

[Insert Figure 3 Here]

Figure 3. A Typical Software Value Chain

Given the above introduction, for the purpose of this paper, a typical software value chain is presented in Figure 3 where the whole value chain it is divided into three major phases, the pre-development phrase, the development phase, and the post-development phase. In the pre-development phase, two major value-adding activities/tasks are identified, i.e., R&D (e.g., on software/hardware tools and platform) and the analysis of the needs/requirements of users. In the development phase, major value-adding activities include *conceptualization, design, coding and testing*. Such an iterative development process results in *customized or generic software products*, materialized through the *assembly process*, or more generally, *the producer-side deployment process* before they are available for use. The value chain then proceeds into the post-development phase, which consists of the two stages, i.e., marketing & distribution, and after-sale services. In the marketing and distribution stage, apart from the traditional methods of marketing and distributing/delivering software products through intermediaries and direct sales, with the advent of cloud computing and software as a service (SaaS) (Marinescu 2013), software product can now be distributed/deployed to a large number of customers continuously over the internet. Similarly, in the after-sale services stages, value-adding activities/tasks such as maintenance, help desk and support, training and education can be carried out either using the traditional methods, or through the SaaS methods.

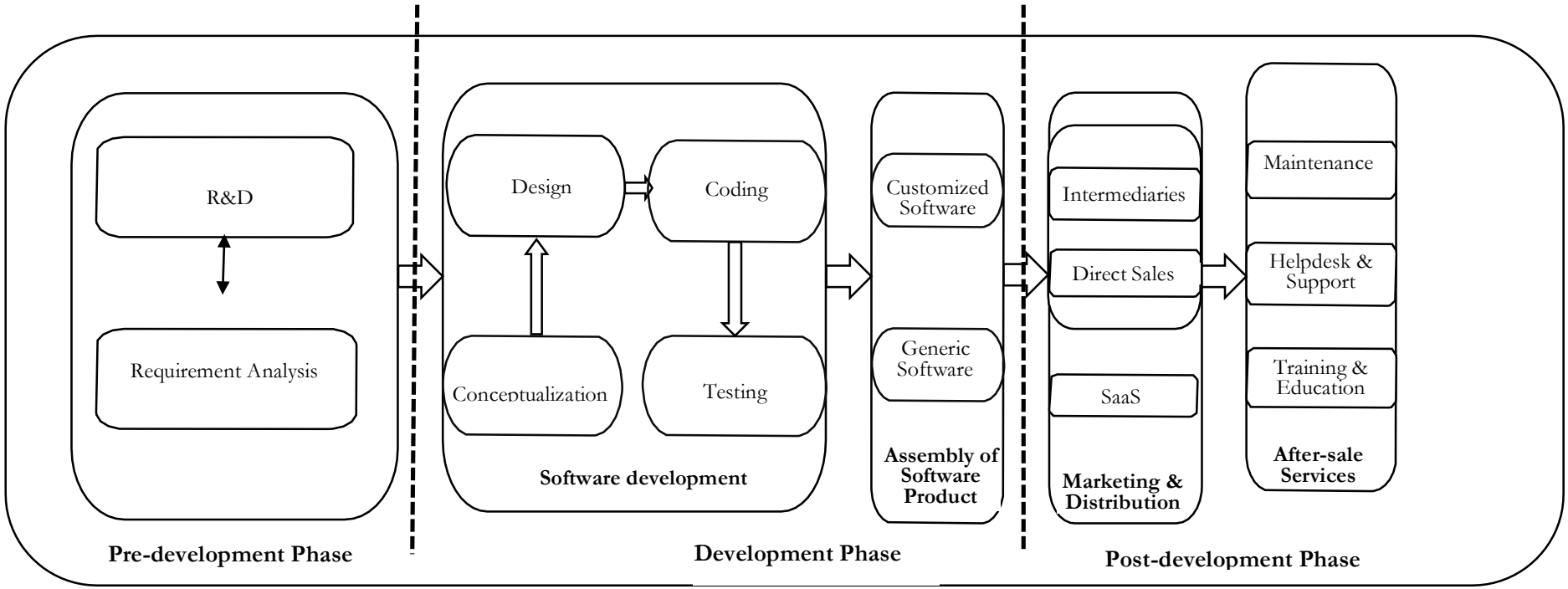


Figure 3: A Typical Software Value Chain

It has widely recognized that the process of software development is a knowledge/skill-intensive. As noted by Hoch *et al.* (2000) that software development requires "nothing but knowledge in codified form", labor with adequate training and appropriate knowledge/skills is the crucial input, In term of the capital requirements, the necessary investments in hardware and software development tools are comparatively low and do not constitute substantial entry barriers as in other industries of ICT (e.g., hardware and telecommunications). Competitive edge in the software industry, therefore, built primarily on innovative capabilities and product differentiation.

For quite a long period from the 1990s to the 2010s, globalization offers substantial opportunities for the utilization of comparative advantages of the countries which has significantly reshaped the traditional configurations of software industry value chain. Most notably, the high modularity of the software development process allows the fragmentation in production/supply of many activities/tasks, in which many of these activities/tasks along the value chain are outsourced and offshored to countries where activities can be carried out most effectively and cost-efficiently. Typically, the following software development activities have been the subjects of the offshore outsourcing (Hoch *et al.* 2000): (1) coding, software testing and maintenance; (2) IT R&D; (3) high-end jobs such as software architecture, product design, project management, IT consulting, and business strategy. Cost-efficiency, increased flexibility and innovation as a result of the capitalization of external knowledge are the most-mentioned motives for software development outsourcing (Heeks *et al.* 2001). As time moves on, the motive for outsourcing of software development has gradually shifted away from cost-cutting towards accessing top-talents in emerging markets as well as achieving a better business focus and operational flexibility, e.g., facilitating round-the-clock production (Aspray *et al.* 2006; Hätönen 2008).

It is noted above in figure 3 that software product can be categorized into two broad categories, (1) customized developed software, and; (2) generic software products (software packages). Customized software development involves intensive interaction between the developer and the end-user, accordingly, an element of service is indispensable. Generic software products, by contrast, are rarely specific to a single user, although it may targeted some specific segment. Some large business (package) software products, e.g. ERP software, are highly complex, requiring substantial customization before they are practically useable. Typically, such customization is fulfilled by external software consultants (e.g., Accenture or IBM Global Services) who provide "solutions" to end-user that involve some combination of services, custom developed software and commercial off-the-shelf software (and possibly hardware) products.

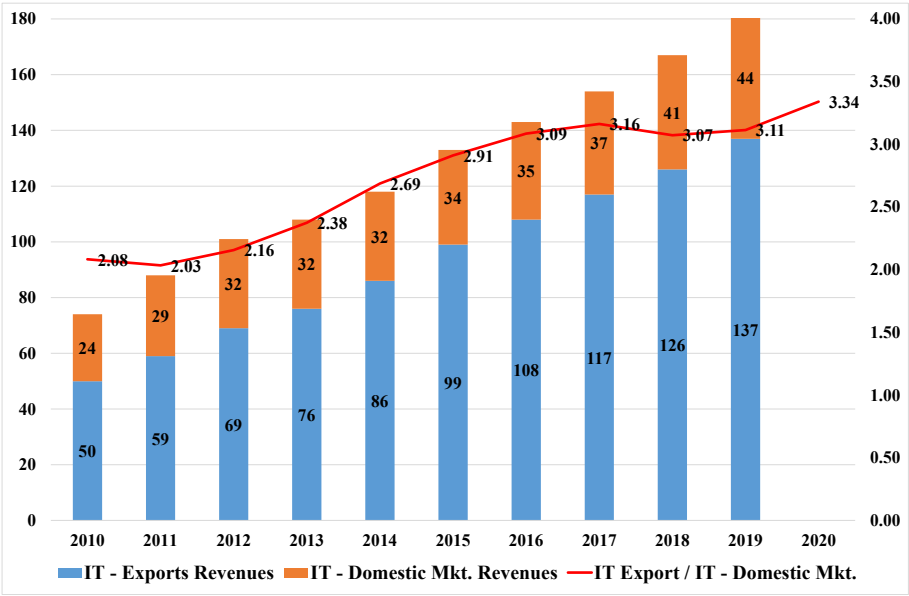
It should also be emphasized that GVC suggests that a firm cannot generally pursue all activities. Outsourcing, subcontracting and other collaborative arrangements are mechanism by which firms specialize. Lacking access to advanced technology (technology gap) and end-market (marketing gap) (Hobday 2000; Schmitz 2007), most small firms participating in the GVC have no choice but

to depend on lead firm in the GVC in these two regards. For reasons mentioned above, lead firms in the GVC (typically large MNCs) outsource/subcontract some of their production and service needs to other suppliers, most typically labor-intensive, low value-added activities outwith their core business. This offers opportunities—and at the same time—imposes constraints to growth for developing country firms. That is, it allows tapping into markets otherwise closed to these firms but it also confine those new suppliers to market niches the buyer is willing to forgo.

Given the above introduction on the structure of software value chain, it is observed that in the case of India, software industry largely consists of export rather than serving the domestic market. It also seems that software exporters largely provide services rather than package products. Further, in the value-adding process described above in figure 2, Indian software exports consist largely of low-level design, coding, and maintenance services, which are considered to be low in the value-ladder in the software global value chain. Overall, with all the hype of impressive growth rate, the Indian software industry has seemingly indulged in a peripheral position in the world software market.

One of the predominant characteristics of the Indian software industry is its disconnection with the domestic market (D'Costa 2004). In 2002 the revenue of Indian IT industry[2] was $16.5 billion, representing 3.15% of Indian GDP. In 2010, the number climbed to $74 billion, making it a 4.4% of the GDP. By the year of 2019, the two numbers reached $167 billion and 6.1% respectively. By contrast, in 2002 the IT exports, were $9.9 billion, around 20% of Indian total exports. While by 2010, the number was $50 billion, taking up 23% of the total exports; and by 2018, the two numbers raised to $126 billion and 39.1% respectively. The –more or less disconnection of India's software industry with the domestic market is evident in the ratio of IT exports (consisting overwhelmingly of "software services" export) revenues in relation to domestic IT market revenues (see Figure 4). In 2010, the ratio of IT exports to domestic IT market revenues was 2.08; the number climbed up continuously, by the year of 2019, the same ratio has been 3.11. To put this alternatively, the percentage of IT exports as a share of overall IT markets has increased over the period from 67.6% to 75.7% (Figure 4), although a falling Rubi contributes partly to this trend by making the USD value of domestic market seemingly lower.. This tends to suggest, the growth of Indian software industry is largely exogenously driven. More specifically, in the year of 2018 US accounts for 62% of all IT export revenues, followed by UK at 17% , the rest of Europe at 11% and Asia at 8% (See Figure 5). Relatedly, although domestic projects—such as Mumbai's stock exchange and Indian railways' reservation systems (OECD. 2000)—are assumed to be larger, more complex and more challenging, there are seemingly limited spillovers in the export market from the wide range of project experience derived domestically (Arora *et al.* 2001; D'Costa 2004).

[2] The Indian IT industry—a.k.a. IT & IT-enabled services (ITeS) industry—is divided into four major segments (Pattnayak & Chadha 2019): i.e., IT services; business process management (BPM); software products and engineering services; and hardware. For IT services, BFSI (Banking, Financial Services and Insurance) are the major vertical sectors. It is worth noting that the first three segments fall under the so-called "software services", given that there were virtually no software "products" sold. In the fiscal year of 2019 (IBEF 2019), the market size for these four segments are US$ 92.49, 36.2, 34.39 and 14.48 billion respectively, accounting for 52%, 20%, 19% and less than 10% of the Indian IT industry.



Unit: Billion US$

Figure 4: Indian IT Industry Revenues

Source: NASSCOM reports of various years

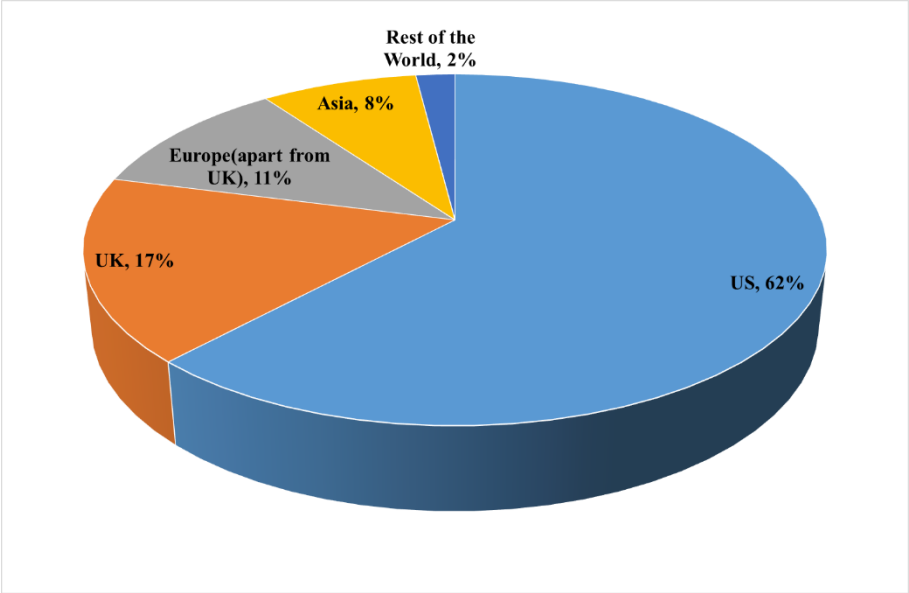


Figure 5: Country-wise breakup of IT Export

Source: NASSCOM reports of various years; World Bank (https://wits.worldbank.org/CountryProfile/en/Country/IND/StartYear/2014/EndYear/2018/Indicator/BX-GSR-GNFS-CD)
Note: cf. note 2 for the scope of IT export.

A second defining characteristics of the Indian software industry is a clear divide of software

services and products. As mentioned above, IT Exports accounted for 75.7 % of the total Indian IT market in 2019. The impressive growth of Indian IT exports, however, has been fueled predominantly (80% plus) by software services[3].

More specifically, the Indian software services industry was built on the basis of providing middle- to low-end coding services as part of an overall software development process. The architecture, conception, and design of the software were undertaken by consultancy companies such as IBM and Accenture, or by the clients themselves. The Indian IT companies entered the value chain to carry out coding, testing and routine maintenance of the software development. In order to do this, the Indian industry came up with a process innovation known as the global delivery model (GDM) (Ahmed 2019), in which a software development service was broken up into a number of tasks. Some of the higher-end tasks requiring frequent face-to-face interaction with the client were carried out on-site by the Indian firms' dispatched IT professionals, who were to work on the client's site (as indicated by Arora *et al.*, a more accurate description of this practice is the "supply of staff augmentation services to overseas clients", or "body-shopping"). Other less demanding tasks (in terms of face-to-face interactions) were carried out offshore by engineers in Indian offices. The completed and tested software service was finally put together for delivery to the client. This GDM, with its division of onshore and offshore work, was able to arbitrage the difference between salaries paid to IT engineers in the high-income and the low- or middle-income countries such as India. In addition, it makes possible the round-the-clock production. The GDM reduced both the costs of IT service provision and the time required for its delivery, enabling the Indian software (services) industry to capture a majority of the global software services market (Dossani 2010). As China has developed itself as the epitome of outsourcing in manufacture, India has become the epitome of outsourcing in software services.

What is missing in India's basket of IT exports is software products (generic software packages), and such a profile is in sharp contrast to that of comparable nations such as Ireland and Israel (Arora et al. 2001). Surely, exports of routine software services enable India to mobilize large numbers of technical professionals who are capable of providing low cost, labor-intensive maintenance of legacy systems and other software and IT services outsourced by foreign clients, mostly foreign MNCs. However, such specialization in mundane software services is also a reflection of India's inability to penetrate higher-end market niches, such as generic software packages and SaaS[4]. There are several reasons for this. Above all, development of generic software package and SaaS requires generally a dynamic domestic market wherein there are intensive interaction between users and developer. Obviously, small and underdeveloped domestic markets

[3] Among the four segments of the IT industry, 81% of the revenues for IT services segment come from the export market, while for BPM and software products and engineering services, the share are 87% and 83.9% respectively. As Indian hardly export any IT hardware, we are confident that the share of "software services exports" (roughly, the sum of the exports for the above three segments) in IT exports (the sum of all the exports under the four segments) is higher than 80%.

[4] As of 2020 amongst the biggest software firms are Google, Amazon and Facebook, whose products are services and the SaaS has become a predominant service even in the corporate environment. Microsoft is also moving its products to the cloud and providing them as part of a SaaS offering.

can't satisfy such requirements. Moreover, generic software products and SaaS demand high marketing capabilities and heavy marketing outlays, which places most small firms from developing countries at a disadvantage.

In many senses, India's rapidly growing software services industry has many parallels with East Asia's electronics and computer hardware industries. In the first place, this industry is overwhelming dependent on foreign market and MNCs, partly as owners and mostly as buyers, who outsourced low-end software service operations to India to take advantage of its comparative advantage in the abundance of low-cost adequately-trained engineering human resources so as to remain internationally competitive. Moreover, Indian software firms participated in limited varieties of value-adding tasks, typically low-end coding tasks, which is quite similar to the case of the export-processing trade in the East Asia where both the end market, the critical part and component, and the technology are all controlled by lead firm. In this sense, the Indian software industry, just like its East Asian counterpart in the electronics and computer hardware industries, takes advantages of its abundance in hard-working, adequately trained human resources, plugs into the global value chains to realize economic development[5].

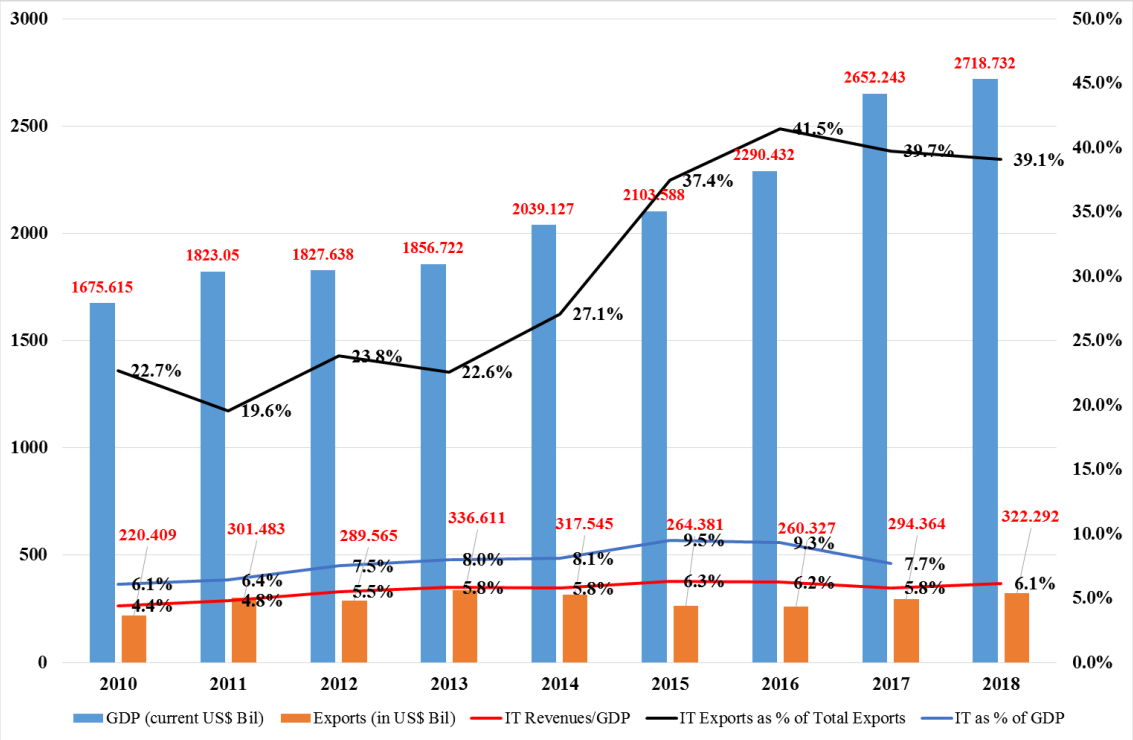
4. The Impacts of the Indian Software Services Industry

In terms of its growth, export, employment, and social upgrading, the development of the Indian IT industry in general and software industry in particular have had profound impacts on India. In 2018, the IT industry generates as much as US$ 167 billion in revenues and more than US$125 billion in exports, with the IT revenues/GDP ratio and the IT exports/total exports ratio being 6.1%, and 39.1% respectively, while back in 2010 the two corresponding figures were 4.4% and 22.7% (See Figure 6). According to NASSCOM (2018), the sector has increased its contribution to India's GDP from 1.2% in 1998 to 7.7% in 2017. In terms of employment, no other industry has generated as many jobs for the middle class. In 2018, the IT industry employs directly about four million people. According to some scholars (Jalote & Natarajan 2019), indirectly the IT industry supports an additional 12 million jobs in the same industry. NASSCOM in earlier reports even claims that every single software job results in 8 related local jobs, although no rigorous study is referred to. Compared with the 72 thousands direct employment back in 1991, the average growth rate of employment for this industry over the past three decades is estimated to be an impressive 16% (see Figure 7). Indeed, the industry is the major trigger for the government to push for an increase in annual output of engineering colleges to over 700,000 graduates.

According to NASSCOM (2016), average wage hike in the Indian IT industry has ranged from 8 to 12% over the past decade. However, there is a wide variance in wages within the industry. Sufficient supply of fresher talent keeps entry level salary stagnant, while middle managers get most rewards through increased variable pay and incentives, and top talents are able to get global

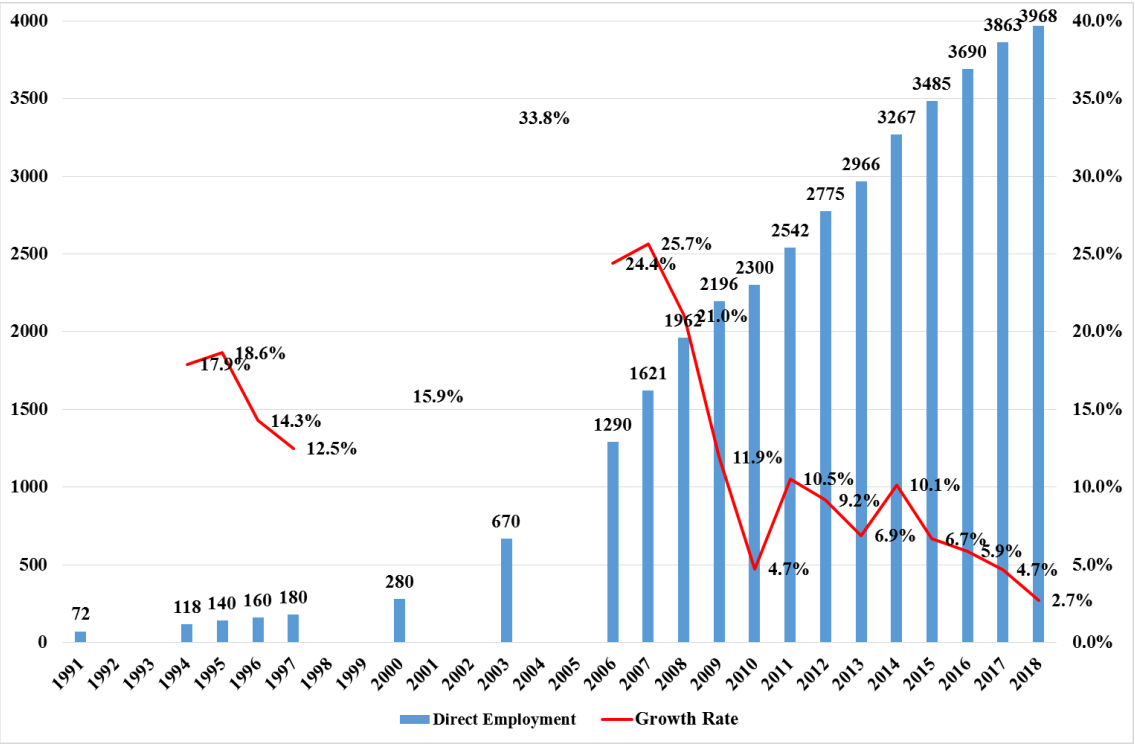
[5] The big difference though is that for software services the investments in physical infrastructure are much smaller. It is far more easier for a software service firm to move to higher end services compared to a electronics/hardware manufacturer.

equivalent compensation. Overall, wage increases in the IT/software industry are seemingly not enough to erode India's competitive advantage (Bhatnagar 2006), as the differential between client countries and India remains substantial. Moreover, countries comparable to and in direct completion with India (in terms of overall costs/quality/delivery metrics) have significantly higher wages than India. It is generally expected that the expanding capacity of Indian engineering colleges will ensure sufficient supply of fresh talents against demand in the near future.



Figures 6: Growth of IT Industry and IT Exports, their Shares in GDP and Total Exports

Sources: NASSCOM, World Bank



Figures 7: Growth of Employment in the IT Industry

Source: NASSCOM, Arora et al. (2001)

Apart from the general impacts mentioned above, a few aspects of economic-social upgrading resulted from the development of software/IT industry is noteworthy.

Female empowerment. The IT industry has been supportive of women in the workforce, an aspect where India has traditionally lagged (Jalote & Natarajan 2019). According to NASSCOM (2016, 2020a), Women represent 51% entry level fresh hiring, and have a 50 per cent higher chance of getting job offers. Altogether, there are over 1 million women employee in the industry, accounting for 34% of the total workforce. Most encouragingly, women have moved up all the way from supportive roles to higher positions including leadership, as evident in the fact that 24% plus of women employees are at managerial positions, and 1 in 10 entrepreneurs is a woman. In short, the sector has helped empower women and furnished them with highly aspirational career options.

Start-up ecosystem. The IT industry has been functional in the building up of a dynamic start-up ecosystem in India which has attracted over US$10 billion investments from venture capitalists around the world from 2016 to 2018 (notably, SoftBank has invested $6 billion in Indian start-ups). Start-ups such as Flipkart, Ola, Swiggy, Power2SME and CapitalFloat have digitally enabled millions of jobs opportunities in cab hiring, e-commerce and food delivery, particularly for small and medium businesses, and have been the one of the most dynamic forces in the Indian economy.

Digital infrastructure and digital transformation. In the past decade, Indian IT companies have also been functional in the deployment/adoption of digital infrastructure enabling the provision of certain critical online-services such as banking, healthcare, and education to citizens and corporations in an efficient manner. Most of these systems—e.g., the Ministry of Corporate Affairs system for corporate tax filing, the income tax management system; India Stack digital infrastructure; the Goods and Services Tax system; the passport system; and the Indian rail reservation system etc.—have been developed, maintained and managed by indigenous IT companies.

More generally, the talent pool in the IT industry has been helping improve the digital capabilities of Indian enterprises, as some technical and managerial talent from IT companies have moved to Indian enterprises to accelerate their digital transformation initiatives.

5. Relations between Foreign and Indigenous Firms

Historically, Indian diaspora played acritical role in the development of Indian software industry. Back in the 1980s, Indian professionals working in the IT/software industry in Silicon Valley has achieved substantial technical, managerial, and entrepreneurial success, creating a positive image of the capabilities of Indian professionals. Arora et al. (2001) reported that these Indian diaspora in the United States helped bridging/filling the marketing and technology gap (Hobday 2000) by matching the U.S buyer with the Indian suppliers. Field interviews with U.S. customers also reported that the impetus for outsourcing to India came from employees of Indian origin (Bhatnagar 2006).

More specifically, these Indian diaspora expedited "bodyshopping" by showcasing the value of Indian programmers and fostering connections between software firms in the United States and India. Some of them returned to work for MNCs establishing/managing Indian subsidiaries (e.g., Karan Bajwa and Sandip Patel, former and current IBM's MD for India; in fact, Arvind Krishna, current CEO of IBM, is of Indian origin), while others launched their own firms in India (e.g., Wipro's Azim Premji) (Bhatnagar 2006). In both cases, the operations are headed by entrepreneurs of Indian origin, supplying software professionals such as programmers and analysts to clients in the US and competing with many of the leading indigenous Indian firms in the same industry. Over time, Indian software exporters started establishing overseas subsidiaries, the distinction between domestic and foreign firms tends to diminish (Arora *et al.* 2001). In short, the overall ownership structure of the industry is mixed between Indian owned and foreign owned, and is well distributed.

The interactions of relevant players—be they foreign, indigenous or diaspora—in the industry are most evident in the evolution of Bangalore IT-cluster. In Bangalore, since the late 1990s, regional development has been strongly driven by offshoring BPO (business process outsourcing) that enabled local software firms to act as back offices servicing many MNC, especially from the United States (Athreye 2005). Liberalization in the late 1980s and early 1990s attracted FDI from the US

and Western Europe, led by Texas Instruments' establishment of its offshore development centre in Bangalore in 1985 (Parthasarathy 2004). In the decades that followed, there is a substantial increase in the presence of MNCs and their subsidiaries in India, particularly in some IT clusters such as Bangalore, and the spill-over of technological knowledge within the region resulted to a rise in the number of domestic IT firms (Narayana 2011).

By around 2000, Bangalore has emerged as a major international hub of the software and IT services, and contributed significantly to the Indian economy (Arora & Athreye 2002; Saxenian 2007). By 2018, the share of IT exports of Bangalore accounts for approximately 38% of the nation (PPMSD, 2019).

Even before the presence of MNCs, local firms in Bangalore had acquired some advantages. The access to a well-educated, English speaking, low-cost labour force that was proficient with Unix turned out to be crucial in gaining initial access to the international division of labour in the IT services industry (Parthasarathy 2004). Local firms also benefited from strategic coupling with firms in Silicon Valley, mediated by the Indian diaspora, who had entrenched themselves in the technical community of Silicon Valley. Since 2000, the reverse migration of Indian IT professionals from the US, after spending years abroad, brought home valuable expertise, entrepreneurial skills, access to global networks, and venture capital (Saxenian 2007).

The bottom up process in Bangalore (and other cities such as Pune and Hyderabad) has led to the flourishing of entrepreneurial activities in the region in fields linked to the existing IT cluster, directly or indirectly. However, it has also been found that regional collaborations are cognitively constrained by the organisational structure of the export-oriented IT cluster. Overall, the cognitive specialisation in the IT industry tended to limit the development of cooperation between export-oriented IT sector and other local/domestic industries, hindering a fuller exploitation of local/domestic linkages with emerging industries other than software/IT (Chaminade & Vang 2008). The so far limited local innovation networking favoured instead independent entrepreneurial initiatives to seek complementary knowledge overseas, thus curbing the spill-over effect of software/IT to other industries, raising concerns about the sustainability of the development of the software industry and its prospect for upgrading (Plechero *et al.* 2020).

6. The Role of the Indian Government

The story of Indian software industry has been portrayed mostly as a success story of private initiative and entrepreneurship, resource endowments, a liberalised/globalised external environment, some good luck/timing; and to a less extent, a mixture of benign neglect and active encouragement from a normally intrusive government (Arora *et al.* 2001; Kattuman & Iyer 2001; Pack & Saggi 2006).

To be more exact, some noted that Indian governments at various levels were not so involved initially. It is only after the success of the software service industry became evident that it came to

ratify the success rather than to catalyse it. Therefore, the growth of the Indian software industry is attributed to the benign neglect, rather than the active strategic support of the state (Kattuman & Iyer 2001). Others observes, however, that the above view tends to underestimate the role of the government in making India a destination for software services outsourcing (Noronha & D'Cruz 2020). In particular, the following (mostly direct) measures by the Indian government might have contributed to the dynamic growth of India's software industry.

Establishment of Software Technology Parks. Most notably, the establishment of software technology parks (STPs) in 1990—which is a 100 percent export oriented scheme for the development and export of software and related services, and which integrates the concept of export processing zone and science/technology parks—is widely regarded as a critical governmental measure to facilitate the development the software industry (Aggarwal 2013; Rawat 2013; Dhar & Joseph 2019). Established in 39 locations (as of 2003), the STPs provided the high-speed data communication infrastructure, enabling the software companies to develop software on the computers of their overseas clients from access terminals located in their respective premises in STPs (Bhatnagar 2006). Some fiscal incentives and an investor friendly environment are also offered under the Software Technology Park (STP) Scheme (Ministry of Electronics and Information Technology, 2020). Specifically, all approvals and regulatory matters are administered under a Single Window Clearance Mechanism; a 100% tax holiday on corporate income tax are given to STP units for their software exports[6]; all the imports in the STP including computers are completely duty free[7]; there are no location constraints for STP, a company can set up STP unit anywhere in India; uninterrupted electricity, concessional land and office space are offered in the STP.

Software export is considered a zero-rated service under GST. Under India's GST (Goods and Services Tax, i.e., value-added tax) regime (Ministry of Finance, 2017), exports are considered as zero-rated supply. Accordingly, software exports are treated as zero-rated services so that any exporter of good and service is eligible to claim input tax credit on the basis of export receipts and the tax paid on the raw material/input used. By getting input credit, the software exporter is able to lower the costs of their inputs from local firms.

Liberalized overseas investment rules. In the early 2000, the Reserve Bank of India has adopted several measures to support the IT and software industry (LIN 2012). These included, among others, allowing the acquisition of overseas parent-company shares by Indian employees; companies whose software sales were over 80 percent could grant stock options to both non-resident and resident employees; foreign exchange could be freely remitted for buying services;

[6] Given the average corporate tax rate being around 25%, such tax holiday is a significant amount for firms in India that goes straight to bottom line.

[7] The Tariffs in the period for electronic machinery was quite high (35%), hence the STPs were a significant benefit to firms. The Tariffs were part of the general philosophy of protecting local infant industry and encouraging local firms. This however was not very successful due to the rapid progress and strides made by western organisations

and software companies executing contracts abroad could use income up to 70 percent of contract value to meet contract-related expenses abroad.

In recent years, Indian government has made rules for investment inwards as well as outwards easier with fewer restrictions compared to before. Under current liberalized regime, FDI (inwards as well as outwards) in different sectors is permitted either through Automatic route or Government route. Under the Automatic route, the non-resident or Indian company does not require any approval from Indian government, whereas under the Government route, approval form the Indian government is required prior to investment. In the list of sectors, electronic systems, the sector most relevant to software industry, is considered under the 100% automatic route (Department for Promotion of Industry and Internal Trade, 2020), which means, as far as outward investment is concerned, a software company does not require any prior approval from the regulatory authority for setting up a JV/WOS abroad (Reserve Bank of India, 2020).

"Make in India" initiative and data localization policies. Several Indian laws and regulation are converging data localisation. Above all, Reserve Bank of India (RBI) mandates all system providers to house entire data relating to payment systems only in India (Reserve Bank of India, 2018). Other regulations requires holding accounting data dating back to 2014 locally. Similarly, the draft ecommerce law (The Economic Times, 2018) requires firms to locally store "community data collected by Internet of Things devices in public space" and "data generated by users in India from various sources including e-commerce platforms, social media, search engines, etc,".

The policies to make in India as well as storage of data in India pushes firms to have adequate capacity and capability to do the same in India, which is expected to foster growth of this capacity in India.

Improved educational infrastructure. Last but not least, state's investment in technological and educational infrastructure in the 1960s and 1970s, though originally designed for import-substitution industrialisation, has been identified as a historical precondition for the development the IT services industry in the 1980s (D'Costa 2011).

In recent years, several dedicated government initiatives aiming at the expansion/improvement of the quantity/quality of education infrastructures have been announced. In particular, the Indian government has announced the creation of 17 new Indian Institutes of Technology (IIT) across India (Jalote & Natarajan 2019) to further improve the quality of engineering education. Furnished with some of the country's best engineering faculty and education infrastructure, IITS are expected to supply millions of engineers adept at machine learning, cloud computing, and other new-age digital technologies in the next decades, supporting India as a sustained source of skilled digital talent for global enterprises.

7. Training and Skill Upgradation

A strong emphasis on skills development and upgradation through training has been instrumental in the growth of the Indian IT industry. Even in their early stages, Indian IT companies spent significant time and money training their employees, developing their skills ahead of time. Currently, Indian IT services companies spend over US$1.6 billion a year on employee training (Jalote & Natarajan 2019), mostly in new platforms/technologies/ methodologies, which helped companies address the changing technology needs of their global customers rapidly.

Training beyond the University is typically provided by IT/software companies themselves. For example, large Indian IT/software companies such as TCS, Infosys, Wipro, HCL (EconomicTimes 2019; FinancialExpress 2019) have built—either indecently or jointly with industry body such as NASSCOM—large campuses-like training facilities that are equivalent to colleges, providing training for their employees in various areas relevant to their global customers, particularly in emerging technologies such as Artificial Intelligence (AI), Big Data Analytics, Cloud Computing, Virtual Reality, Internet of Things (IoT), Cybersecurity and so on. The major industrial association, the the National Association of Software and Services Companies (NASSCOM), also launched in 2018 an ambitious initiative, *Future Skills*, aiming to train another two million people in emerging technologies over the next few years via its platform built to bridge the industry-academia skill gap (IASToppers 2020; NASSCOM 2020b).

In addition, a whole host of private training institutes have mushroomed across the country to provide training in various technologies, physically and online. Notably, the proliferation of new courses on international online learning platform such as Udemy, Coursera and others have provided a new avenue for employees to upgrade their skillsets and seek better opportunities. Meanwhile, most platform development companies like Microsoft, Oracle, SAP etc. have certification courses which many employees of IT/software companies or individuals complete for upgrading their skills. All these certifications and courses are supposed to be effective (based on brief interviews of senior personnel in a couple of companies) and give developers a leg up on hiring for specific platforms.

It should nevertheless be noted that although capabilities in some emerging technology such as AI has been widely viewed as the key technical capability for the future provision of digital services; and that Indian IT majors have been working on AI systems and are carrying out substantial retraining of their professionals on this subject, Indian companies, however, do not have a place in MIT's list of 50 'smartest companies' in the world where five Chinese companies—Baidu, Huawei, Tencent, Didi and Alibaba—could be found (MIT 2017). This tend to suggests that Indian companies still have a skill/training gap in these key emerging technologies (Ahmed 2019).

8. Upgrading Status and Future Challenges

Above, it has been noted that given technology and marketing gaps (Hobday 2000; Schmitz 2007), most small participating firms in the GVC depend on lead firms in these two regards. Lead firms in the GVC (typically large MNCs) outsource/subcontract some of their production and service

needs to other suppliers, mostly labor-intensive, low value-added tasks outwith their core business. This offers opportunities as well as imposes constraints to growth for participating firms from developing countries, as it allows them to tap into markets otherwise inaccessible but it also confines them to market niches of lower value-added potentials.

In this context, for the part of firms from developing countries, "low value added" trap is a major concern when participating in GVCs led by MNEs. This is exactly the case for the Indian software industry, given that it started with routine/mundane services such as lower-end, less value added coding and maintenance compared with other tasks, and have been troubled by a narrow specialization at the lower end of GVC, the erosion of the wage advantage in higher-end high-tech services, and the growing scarcity of higher-end skills and capabilities.

To what extent and by what means the Indian software industry have moved into the higher-value added and more skillful tasks/segments of the GVCs? What are the major constraints (institutional, physical infrastructure, financial or capability) for the part of Indian firms to move up the value chain?

8.1 Upgrading Status

Broadly speaking, the growth and evolution of the industry can be divided into three phases (Jalote & Natarajan 2019).

In the first phase (*pre-2000 era*), the Indian software industry was largely comprised of firms exporting lower-level design, coding, and maintenance services to global clients, e.g., solving Y2K issues for their clients; helping companies managing their legacy applications and infrastructure. Such offering is made possible by the first wave of the global Internet and dot-com era which created intercontinental Internet infrastructure enabling Indian firm to deliver software development-related services to global enterprises remotely. Realizing availability of talent and the potential opportunities, some MNCs started establishing their own offshore development centers in India in this phase.

The second phase (*circa 2000-2010*) is characterized by the rise of Indian software multinationals and R&D centers. With accumulated experience in dealing with complex IT systems and confidence in working with international customers, several Indian companies—TCS, Infosys, Wipro, and HCL, to name a few— became multinationals, offering an extended range of higher-end services such as executing large and complex projects involving end-to-end solutions on IT infrastructure management, providing IT consultancy, and other related services. MNCs, including some next-generation firms such as UBER, increasingly came to realize India's potentials in providing software services and have scaled up their direct presence in India by setting up their own IT, BPM and R&D centers covering virtually all key industries, diverting substantial part of their digital engineering work to their Indian development centers. To date, 1,250 MNCs from around the world have set up their own centers in India, involving over 400,000 engineers working

in these global R&D centers in India.

The third phase (*circa 2011 to present*) is characterized by the rise of Indian unicorns firm operating in an innovation-driven dynamic environment. Overall, the combination of available talent, the decreasing rates of brain drain, the expanding presence of MNCs' R&D centers, and the inflow of global venture capital has facilitate the growth of IT start-ups, predominantly consumer-led IT platform startups largely focused on the India market. These IT platform startups, initially replicas of U.S. companies (like Flipkart, which is an equivalent of Amazon, Ola – which is a competitor to Uber, and Swiggy which competes with Zomato/Uber-Eats), soon came up with unique innovations for the India market such as the pioneering cash-on-delivery model in e-commerce. By the end of 2019, 18 start-ups are with over US $1 billion in market capitalization. Most notably, Flipkart, India's largest e-commerce company with a valuation of US $21 billion, was acquired by Walmart in 2018 (Indiatimes 2018). OYO Rooms, a technology-enabled franchise hotel chain started by a 20-year-old, is now the largest in India, overtaking both traditional Indian and global hotel chains. Start-ups are driving innovation at an accelerated pace. To keep themselves innovative, large firms have been actively seeking partnerships with the start-ups and are looking for acquisition opportunities, both for talent and intellectual property. For other large established firms, while product development is not their primary focus, providing sophisticated, robust IT services has become their forte. In short, in this stage there is a significant increase in the numbers of developers that move up the value chain by developing and acquiring sophisticated skills and capabilities, mostly associated with the creation of IT platforms. Thus it is the development of the local business market that has allowed firms to grow in stature when it comes to leading edge applications.

8.2 Future Challenges

High cost of capital and rising wages for top talent. The most-mentioned major constraints is the high cost of capital in India resulting from its underdeveloped financial market. This is compounded by the ever increasing wages for top talent given the high demand by international and national firms. In the absence of a dynamic domestic market, the global opportunities to top talent will leads individuals to seek higher remuneration in foreign locations, putting further pressures on India's shortages of critical skills, eroding its wage advantage in the higher-order skill levels. A redirection of emphasis towards the domestic market is expected to alleviate some of the constraints associated with the narrowly specialized and overly export-dependent software services sector.

GDM-based Business model. The success story of India is essentially a story of process innovation of a GDM (Global Delivery Model) for providing middle- to low-end software services such as routine design, coding, and maintenance services to overseas clients on the basis comparative advantage in the abundance of low-salaries IT professionals. However, unlike a product innovation, a process innovation such as GDM is not patentable, nor can it be kept secret (Ahmed 2019). Global ITservices giants such as IBM and Accenture, have set up their own units in, rather than outsource

to, India to provide end-to-end software services, meaning that a substantial chunk of the value-added is now captured by these MNCs rather than by indigenous Indian firms.

New Technology and the Changing Role of IT. There is a growing list of new technology which might potentially erode the competitive edge of the Indian software industry. Of immediate importance, is that of artificial intelligence (AI) in the sense that a lot of mundane programming work can be automated, which reduces the cost of programming so that abundance in low-wages ordinary programmers becomes less relevant. Indeed, mundane programming is and will be automated, in the long run, Indian software firms do not really have an option between carrying out routine programming with by low-paid programmers and having it automated. In addition, according IDC (International Data Corporation) (2017), by 2018, a substantial portion of the IT spending by business organizations will be on third platform technologies including cloud computing, big data analytics, mobile computing and so on, at least half of which will be on cloud infrastructure and applications alone. In other words, new technologies such as cloud computing will not remain novel in the coming years; instead, they will become the core of daily operations of IT industry. Indian software firms will have to adapt to this change in order to provide these new services, or even to continue their existing service offerings.

Another related concern for the Indian firms is the changing role of IT in the wave of digitalization. Nowadays, IT is far more than just a tool to be used in some parts of a firm's manufacturing or services activities. It has been a core technology that enables a firm to organize the full range and every aspect of its business. As a result of this digitalization, large firms are less willing to outsource their IT work, since in-house IT services seems to function better. For example, Bank of America, who used to be a major outsourcer, had a $3-billion digital innovation budget in 2016 to spend on financial technology, which it ran almost entirely in-house (Singh 2017). In supporting digitalization by clients, the role of a specialized IT services firm is not to just provide services, but to act as partner of its clients who advise them, help them and work with them in developing their digitalization systems and for co-innovation (Chandran 2016).

Overall, as pointed out by NASSCOM chairman Ganesh Natrajan in 2016, 'the Indian IT industry is facing "a perfect storm" created by three forces. The first is the digital transformation of clients with applications and infrastructure moving to the cloud and clients asking for new services such as mobility, analytics and cyber security that cannot be delivered using the traditional dual shore model. The second is the automation of knowledge work, which reduce or even eliminate the need for the existing routine workforce. The third is the forces of protectionism, which makes difficult cross-border movement of personals, reducing revenue opportunities and shrinking profitability (Knowledge@Wharton 2017).

Low R&D Spending. The Indian firms have successfully tackled many issues in the past, because the core skills required did not change dramatically and good programming skills as well as the capacity to train a large number of software professionals helped them to get through. However, even the application of new technologies like cloud computing, AI and digital technologies might

require a different set of skills which can only be developed through intensive investment in R&D as well as general capability development.

However, for Indian IT Majors, the percentage spending of total revenue on R&D is still less than 1 % (Jalote 2005). In the last few years, Indian IT firms have increased their spending on R&D for developing new technologies like AI, data science, IoT, automation, digital, and so on. Infosys, for example, has been investing in quite an aggressive way (1.3 per cent of sales) since 2007 in comparison to their Indian competitors. Compared with the R&D spending of global firms, it is obvious that that Indian firms, which mainly followed the GDM model in the role of low-end mundane services provider, are way behind their foreign counterparts. For example, global firms such as Google and Microsoft spend almost 15 per cent of their revenues on R&D, whereas IBM spends about 7 per cent. In the top 2,500 global R&D spenders, there are about 275 global software and computer services firms, of which 161 are from the USA, 32 from China, and only 5 are from India (CTIER 2016). Companies like IBM and Accenture, who are literally international rivals to the Indian IT companies, have R&D intensities of 5.7 per cent and 2 per cent respectively and have invested significantly in new high-end services and are focusing increasingly on products. If the Indian IT industry is to truly become more competitive and move up the value chain, firms would need to increase their R&D expenditure more than what they currently spend and concentrate on developing new products (CTIER 2018).

9. Conclusion

Summing up, the rise of the software service industry has been the most impressive achievements of the Indian economy in the last few decades. The success story of Indian software service industry is essentially a story of plugging into the GVC by taking up part of the mostly labor-intensive, low value-added tasks outsourced/offshored by lead firms from the developed country. By doing so, Indian firms are able to tap into otherwise inaccessible market although "low value added" trap is still a concern. By examining India's particular position in the global value chain, this paper demonstrates that there are still many structural barriers to overcome if Indian firms are to upgrade their positon in the GVC.

Specifically, in the Indian software industry, there are the disconnections between software export markets and domestic markets, between software products and services, and between IT manufacturing and software development, with the net result being the dominance of GDM model characterized by a narrow specialization at the lower end of GVC, the erosion of the wage advantage in higher-end high-tech services, the growing scarcity of higher-end skills and capabilities, and the forgoing of huge opportunities by not leveraging domestic market linkages. To overcome these structural barriers, it is imperative for Indian firm to consolidate their operations by strengthening/developing their technical, commercial, and, in particular, innovative capabilities, so as to extricate the industry from its low end trajectory and to capture more lucrative software niches. Moreover, it is also crucial to nurture the domestic market so as to generate spillovers through dynamic interactions and linkages.

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