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The Basic Characteristics of Skills and Organizational Capabilities in the Indian Software Industry

Ted Tschang

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In just the last few years, the Indian software industry has recorded tremendous growth, coming to be regarded by developing countries the world over as a model for how they can leapfrog stages of industrial development. Its success is a story of hard work and fortuitous circumstances: the hard work being the building of a world class pool of computer programming talent; the fortuitousness being the increasing demand for personnel in the U.S. information industry.

This study examines some of the factors in that success by focusing on the basic characteristics of the skill and organizations. The limitations of the current trajectory, along with scenarios for the evolution of the industry, are also examined.

There is much that other countries can learn from India's experience, but replication of India's success will not be easy, as it involves both hard factors (education and infrastructure) and soft factors (culture and social networks).

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PREFACE

The ADB Institute aims to explore the most appropriate development paradigms for Asia composed of well-balanced combinations of the roles of markets, institutions, and governments in the post-crisis period.

Under this broad research project on development paradigms, the ADB Institute Working Paper Series will contribute to disseminating works-in-progress as a building block of the project and will invite comments and questions.

I trust that this series will provoke constructive discussions among policymakers as well as researchers about where Asian economies should go from the last crisis and current recovery.

Masaru Yoshitomi
Dean
ADB Institute

ABSTRACT

The Indian software industry has come to be regarded by developing countries the world over as a model for how they can leapfrog stages of industrial development. Its success is a story of hard work and fortuitous circumstances: the hard work being the building of a world class pool of computer programming talent; the fortuitousness being the increasing demand for personnel in the US information industry. This paper examines some of the factors in that success by focusing on the basic characteristics of India's skills and organizations. The limitations of the current trajectory, along with scenarios for the evolution of the industry, are also examined.

The basis for the Indian software industry's growth actually goes back decades, to the formative years when Indian engineering and scientific talent was first developed in national and educational and research institutions. From those early roots, at least three types of firms have emerged: the local "offshore development centers," which serviced US multinationals' needs; the multinationals' own development centers; and small startup companies. We analyze the development, contributions and comparative advantages of these firms in the industry using a set of case studies and secondary data. We also identify their relationship to the types of technical and nontechnical skills involved in building organizational capabilities, and the availability and sufficiency of different skills. While there is a strong technical labor pool, there is a shortage of middle-level systems analysis and project management skills, which are typically created through work experience.

In order to continue its growth rate, the entire industry will have to become more innovative and involved in intellectual property creation. The industry is undergoing a change in composition to include more research and development, while more innovative startups are emerging. However, it is still too early to claim success. For instance, the character of startups varies considerably. Each of these changes has implications for overall employment, the skills required and the potential for value creation. There are also implications for the technical skills base. But in light of the domination of US-based companies, more business skills, alliances and other new business models are needed.

Certain economic principles and constraints also impact on the industry's potential for future growth. Thus, while much of the impetus for future success will depend on the industry itself, there is still a clear role for policy to improve the educational system and infrastructure. Further, linkages must be formed between the software industry and the rest of the economy, which in turn requires the latter to function better.

There is much that other countries can learn from India's experience, but replication of India's success will not be easy, as it involves both hard factors (education and infrastructure) and soft factors (culture and social networks).

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1. Introduction and Motivation

The Indian software industry can be considered one of the 20th century's most surprising economic developments, with India apparently coming from nowhere to become a major supplier of labor and software development services to the US and the rest of the developed world. The story has hinged on the US software industry's rapid growth and its excess demand for skilled software professionals. India possessed a surfeit of scientifically trained talent whose skills were easily adaptable to the needs of the software industry. The story of the Indian information technology (IT) industry is characterized by the evolution of capabilities. The first stage consisted of body shopping—the mass shipping of talent across oceans. But this model is being supplanted by the emergence of India-based organizations that are organizing that talent within the country. In addition, the continual emergence of new sectors and trends in software is leading to new waves of unfulfilled demand for software.

This paper will review the state of the Indian IT industry, in particular the skills and organizational capabilities that were developed, and the potential problems and requirements going forward, particularly with regards to an innovative economy. This is done through a combination of empirical interviews, theoretical analysis and review of the (somewhat limited) extant literature. A preliminary framework is developed consisting of three parts: the economics of the "new economy," skills, and organizational capabilities. The level of skills is the main factor credited for India's success. However, as India's IT industry matures, economics could prove useful in understanding the broader constraints and phenomena at work, mainly at the inter-firm level. The organizational level is also important in examining capabilities, which can be seen as the summation of skills and more.

The research questions that this paper seeks to address are:

- Why and how did India succeed in developing its IT industry?
- What was the role of skills and organizational capabilities in that success?
- What are the challenges facing the industry (and what implications can we draw on this issue from previous analytical work)? In particular, what transformations do organizations have to undergo and what skills are lacking?

Discussion of these questions offers policy pointers on how the Indian experience might be translated into guidance for other emerging economies.

[1] Much appreciation is due to a variety of people: including Dr. Masaru Yoshitomi and the ADB Institute professional staff for their comments in internal seminars and discussions; Dr. S. Sadagopan of the Indian Institute of Information Technology—Bangalore, and Mr. Randeep Sudan, Special Secretary for IT to the Chief Minister of Hyderabad, for their valuable help on the ground; and to Mathurot Chuladul for her able research assistance.

Section 2 reviews and constructs some frameworks that are used in the analysis. Section 3 briefly summarizes the software industry's growth and present situation, including India's position relative to other countries. This relies on a brief review of the literature and known facts on the past and current states of the industry. Section 4 looks at the future state of the industry, where it is headed and how various kinds of firms are transforming to meet the challenges. In section 5, we examine the types of skills needed to make this transformation, the skills that have been found lacking and their relationship to organizational capabilities. Section 6 provides a brief review of some of the relevant "new economy" concepts and what they imply for the software industry's prospects. Section 7 identifies some of the more outstanding questions for further research. Section 8 concludes with an examination of the degree to which this success story appears to represent a new paradigm of development, or whether these phenomena can be explained in the context of the existing model of East Asian development.

1.1 Growth of the Industry

The world's IT market has been increasing rapidly, but it is estimated that the impact of the Internet (in particular, the need for many applications to have Web interfaces) will create a worldwide market of about US$1.9 trillion in 2008 (NASSCOM-McKinsey, 1999).

The Indian IT industry has also been growing rapidly at a compounded annual growth rate of about 40.5 percent per annum between 1994 and 1999. Software alone grew at a rate of 59 percent in 1998-1999. The size of the Indian IT industry reached about US$6 billion in 1998-1999, of which about 65 percent was software-related (NASSCOM, 1999). Whereas the entire Indian software industry garnered a mere US$150 million 10 years ago, software exports alone had shot up to US$4 billion by 1998-1999 and the domestic market fetched another US$1.7 billion (NASSCOM, 1999). Software exports contributed 8 percent of total merchandise exports.

India's national plan is to increase these exports to $87 billion by 2008, putting the contribution of software to exports at 35 percent and comprising 7.5 percent of the nation's gross domestic product (GDP). Employment in the software industry reached about 250,000 professionals in 1999 and the industry is expected to create about 2.2 million jobs by 2008.

The IT industry is also contributing to subtle aspects of the economy, such as a major infusion of foreign and venture capital, and high levels of domestic entrepreneurship and international alliances (often with nonresident Indian firms or venture capital overseas).

1.2 Summary of the Literature

In seeking to understand the growth of the industry, Arora et al. (1999) conducted surveys of Indian companies and their US customers. Their surveys showed the extent to which the capabilities of local firms have so far developed. They did not, however, go as far into the historical, social and entrepreneurial roots of the industry's growth. Other work documented how Indian firms' capabilities emerged in earlier periods (Evans, 1995; Heeks, 1996). More recently, there has been a surfeit of industry studies, notably McKinsey, the Harvard Institute for International Development (Bajpai et al.), and several internal and external academics. Last, there are a number of anecdotal stories of how the current industry came about as a result of many "rags to riches" stories. One popular example is that of Narayanan Murthy and his colleagues, who scraped together some dollars (a few hundred in Murthy's case) several years ago to form Infosys. Their company is today listed on the US National Association of Securities Dealers Automated Quotation (NASDAQ), with a market capitalization of about US$15 billion.

For the most part, the studies cited above did not look into the most recent phenomena, such as future growth possibilities, or the role of skills and organizations, in much detail. Nor do they provide a clear distinction between the roles of various types of organizations, such as multinational corporations (MNCs) and innovative startups.

2. A Framework for Software Development Activities

To help answer our research questions, we will first provide a basic typology for characterizing software development activities. It is useful to understand software development as being composed of several distinct types of activities, each requiring different skills, adding different value and having different implications for the enterprises.

Like the engineering of other products, software has a requirements analysis phase, a development phase, and an operations and maintenance phase. Unlike other products, however, software does not have a significant mass production phase, but, rather, has a large emphasis on the customization of the basic application to individual customers' needs, e.g., the customization of an Oracle database product to a Fortune 500 client. Customization is a tedious, yet intellectually demanding, activity involving knowledge of specific or advanced programming languages (as compared to mass production techniques). This illustrates not only the unusual economics of software—in which increasing returns to scale means that replication (i.e., the production phase) is not an issue—but also the fact that value added comes *after the initial production phase.*

2.1 Previous Work

Others have characterized software development with similar typologies. For instance, Arora et al. (1999) summarize the commonly-used waterfall model of software development, which consists of six stages:
(1) requirements analysis,
(2) high level design,
(3) low level design,
(4) coding,
(5) testing, and
(6) postproduction support.

Each stage has feedback loops to the previous stage: meaning that a particular stage does not necessarily lead to a succeeding stage, but could lead back to a preceding stage.[2]

[2] However, a new model known as the *spiral process* has more recently been promoted, requiring iterative loops between multiple stages of the development process.

The software engineering process alone is also quite complicated. A commonly used standard—the SEI Software Capability Maturation Model (CMM)—was developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. These standards help companies evaluate and grade their software *process* capabilities, covering practices for planning, engineering, and managing software development and maintenance, to improve the goals of cost, schedule, functionality and product quality. Many Indian companies now grade and advertise themselves as fulfilling various levels of SEI-CMM advancement as a quality standard and indicator of their capabilities. This not only provides a signal to customers, but also attracts skilled employees, because such people prefer to work at companies with advanced software engineering capabilities, since this will lead to self-improvement and better future personal rewards.

A software value chain has also been described in previous work. Bajpai and Shastri (1998) describe the Indian software industry value chain in terms of the following activities:
(1) data entry,
(2) body shopping,
(3) offshore development,
(4) customized solutions,
(5) premium services,
(6) niche technologies, and
(7) products.

The activities are ranked according to increasing value added as well as increasing risk. While these activities actually describe discrete *lines of business*, elements of these are present in both our framework (presented below) and classifications of *software development activities* by Arora et al. (1999) and Heeks (1996).

2.2 A Comprehensive Software Development Process

Following from our own interviews and from the typologies in previous work discussed, we can tentatively lay out a general typology of the activities in the *software development* lifecycle as they correspond to the phases of the *product* lifecycle.

New product development phase (prior to sales):
(1) Conceptualization: including brainwork (i.e., creativity and innovation), market analysis and product definition
  - requirements analysis and design—requirements for a new product would take place concurrently with market surveys, whereas requirements for the customization of a product may be set by the client or in consultation with the client.
(2) (Initial) Software engineering
  - systems analysis and software engineering
  - coding or programming (of modules)—this may include testing
  - testing (including user testing)

"Installation" phase (at time of sales; could be undertaken by other firms):
(3) Customization: a process distinct to software that requires a software house to tailor the software package to a specific customer's needs, e.g., taking an Oracle database and developing it into an accounting system for a large industry client. Customization may

also involve steps 1 and 2, but the value added obtained may be lower than that of new product development.

After sales (to customer) phase (may be in-house or outsourced):

(4) Maintenance
- operations
- servicing (customer end)

Expiration (of initial version of product) phase:

(5) Product code updating/versioning/improvement—once the code has matured, further product updates and improvements will also have to be made in years to come. This will also require software engineering (step 2).

(The first two steps [1and 2] are often considered to have high value added compared with the others. The fifth step may be intermediate in value added.)

There is much remaining work needed to break this process down into products and services, to distinguish different types of activities and firms, e.g., new product development vs. customization shops. Work is also needed to determine the different individual activities and skills needed for each type of activity.

This framework will be useful later on, as we seek to understand where the Indian industry is situated, where it has to advance to, and the capabilities and skills needed to accomplish this.

3. History of the Indian IT Industry

The Indian software industry is diverse, ranging from foreign multinationals to local multinationals and startups. Its size is still much smaller than that of the United States, with sales of the largest company—Tata Consultancy Services—being Rp16,523 million (about US$352 million), paling beside that of Microsoft's US$23 billion. In a sample of 600 Indian IT companies, about 11 percent had sales in excess of Rp50 million, 13 percent were between Rp25 million and 50 million, 14 percent were between Rp10 million and 25 million, 20 percent were between Rp5 million and 10 million, and the remainder were below Rp5 million.

For illustrative purposes, we can consider the Indian software industry's growth as having been composed of three movements, partly overlapping with one another:

3.1 Unproductive Investments Preparing the Ground

The Indian software industry's story begins in cities like Mumbai and Bangalore, in the latter of which was located one of the largest pools of scientific talent since post-independence. The Government set up numerous aerospace and defense-oriented laboratories in Bangalore, as well as the prestigious Indian Institute of Science. These laboratories, coupled with prodigious amounts of human resources developed by educational institutions nationwide, were to form a critical basis for the region's software industry growth. Yet, this talent languished for decades. Defense and other national establishments were not productive from the economy's perspective. Thus, there was little gainful employment to channel the productive energies of the human resource pool.

3.2 Nascent National Companies, Early Foreign Investment and the Buildup of Experience

The early phase was also marked by the creation of a number of companies, such as the Computer Maintenance Corporation (CMC) (1978), Tata Consultancy Systems (TCS) (1968) and Hindustan Computers Limited (HCL) (1976) (Evans, 1995; Heeks, 1996). Some were set up by larger conglomerates, but only one big family group (Tata Consultancy Systems from the Tata group), and another outstanding case from the Government succeeded (CMC). Some of these started as local hardware manufacturers (at the time that the Indian Government was rejecting large foreign hardware producers such as IBM), but eventually spawned software houses, or themselves gravitated toward software (Evans, 1995).[3] These companies were in the vanguard of India's software export industry and contributed to the country gaining early experience in software development, including international experience.

These firms were successful at competing for and completing large, complex programming tasks, such as CMC's development of the passenger reservation system for India's railways. They also gained valuable exposure to international practices and standards through sales they made to international customers. Consequently, this provided a number of software professionals with invaluable software development experience in large projects. However, there is an argument that these companies' growth did not explode until the state moved from a custodial (i.e., protectionist) role to a promotional one in 1984, after which computer production dramatically increased (Evans, 1995). Most of the currently successful larger enterprises started without business house or government entanglements, including Wipro, HCL and the more recent Infosys (Wipro and HCL's founders being somewhat mixed breeds, as they were also formal or informal offspring of business houses).

This phase of India's—and in particular Bangalore's—development was also attended by the arrival of international high-tech companies in the 1980s and 1990s (continuing even up to today). This rise in foreign investments came with reforms to improve the environment for foreign direct investments, specifically, the creation of special software technology park zones (managed by Software Technology Parks of India [STPIs]). One of the first MNCs to locate during this period was Texas Instruments (TI), which in 1985 opened a design facility in Bangalore, attracted by the easy availability of staff, STPI's provision of a one-stop window for government approvals, and a satellite link and other facilities that ensured TI's smooth operations. The TI venture was cited as helping other MNCs when they were looking for locations, since the existence of a "working model" lowered the risks.

3.3 Exports and the Maturation of Domestic Capability

This phase was attended by the maturation of a number of export-oriented firms as offshore development centers, including the now famous Infosys (founded in 1981), Wipro and Satyam. The export industry initially involved the sending of labor or teams directly to

[3] This stage of the industry's development could be termed the "submarine phase," since most of these companies were not attracting international attention, but were certainly operating and building up capabilities.

US sites—a practice known as *onsite services* (or “body shopping” in common parlance)—and *offshore development*, or the contracting of work from multinationals to be carried out by specialized “service” firms in India.[4] (And a third category of work involved companies performing a mixture of offshore and onsite work [Arora et al., 1999].) Whereas onsite services dominated in 1991-1992 with about 95 percent of total software exports (with offshore services at 5 percent), by 1999-2000, offshore services in India had increased to 42 percent, and overseas onsite accounted for the residual 58 percent (NASSCOM, 1999). For instance, by the end of the 1980s, three quarters of TCS’s work was customization of software for foreign clients. In the space of 20 years, it was able to shift from body shopping to project management for overseas clients (Evans, 1995). Similarly, the offshore development centers (ODCs) have moved from charging hourly rates to charging by the project, and some are attempting to move further up in terms of extracting additional rents from each service. However, this is only possible so long as there are no additional competitors on the horizon.

While the buildup of domestic IT expertise alone could not have caused a shift in India’s economic fortunes, the tremendous increase in demand for skills and outsourcing in the software industry of the United States and other countries was clearly synergistic with India’s supply of skilled labor and nascent computer industry. The insufficient pool of qualified workers in the US created a labor shortage, while the high wages there made India more competitive by comparison, especially at the low wage end. On top of these needs, the ever faster turnover of product cycles in the IT industry is such that it is difficult to develop pools of skilled and experienced labor in the time needed.

A lot of the work that ended up being outsourced to India or Indians was lower value added work, in which US consulting or application firms did not have interest or sufficient comparative advantage. This work can be thought of as a series of discrete but ever-evolving opportunities, one of the biggest being the outsourcing of customization work. A large amount of the work was legacy work, such as on older platforms and mainframe computers, or the porting of such applications to modern platforms and languages. More recently, worldwide concern with Y2K problems in the run-up to the year 2000 also led to significant outsourcing to India (this too being a type of legacy work). Last, the country has benefited from work needed for e-business and IT-enabled services—all trends relating to the explosive growth of the Internet. The changing nature of this work, and the ability of Indian companies to follow the trends, is a testament to the adaptability of its workforce, but also a result of the lack of any viable competition.

3.4 Other Regions in India

While the Indian IT industry story is synonymous with Bangalore’s story, the same phenomena have also been seen or replicated in other regions of India, including Pune and Noida (outside New Delhi) in the North, Chennai (i.e., Madras) in the South, and Hyderabad. Most likely, these regions have emerged as centers for a variety of reasons: an adequate supply of labor, foreign investments, STPI offices and entrepreneurs starting large enterprises

[4] While overseas onsite work is considered to add more value (on average US$90,000-100,000, vs. US$25,000-35,000 for offshore work, mainly because of the higher cost of living at the onsite location, primarily the US), offshore work in India is considered to be more profitable for the vendor (Arora et al., 1999).

at those locations. Yet even though there are 26 STPI offices nationwide and many cities claim to have technology parks, many of these have not succeeded.

One of the more recent success stories is that of Andhra Pradesh (AP) state and its capital, Hyderabad. While slower to start than Bangalore, the state now has about 10 "colonies" consisting of hundreds of small IT (startup) firms, as well as established arms or headquarters of well-known offshore development firms such as Wipro, Satyam Computers and Infosys. By one estimate, about 10-15 percent of these are involved with high-end or advanced technologies, about 30-45 percent are undertaking some sort of software development and the remainder are working on some form of IT-enabled services (see section 4.1 for definition).[5] AP also believes that it can leverage its expertise in other industries—such as filmmaking, engineering simulation and modeling, and financial and IT-enabled services—to broaden the impact of the IT industry.

More recently, new types of policy have been adopted to stimulate domestic IT-using sectors. A typical example is the various state governments' efforts (begun in AP) to usher in electronic government, and to bring access out to rural areas. Unfortunately, many government programs have failed in the past, in part because they were based on individual leaders whose visions often extended beyond their terms (Heeks, 2000). While that is not to say that the same fate will await the current batch of programs, it is important to learn from past failures and not only from successes.

3.5 Some Factors Behind India's Success

We have illustrated how the IT industry resulted from a combination of a deep existing skills base, coupled with increasing international demand for those skills. India has long had a strong mathematical and logical/analytical tradition, and the supply of mathematically trained graduates, as well as engineers, was initially a valuable stimulus to the industry.

Certain policy interventions (e.g., infrastructure, educational policy, STPIs, etc.) and entrepreneurship were also necessary ingredients in some instances of success, although many would argue that the software industry initially grew *in spite of* the Government and its restrictions, especially during the early protectionist periods. More recently, venture capital has been necessary to stimulate further growth, particularly of startups.

Another less well-researched but commonly understood factor has been India's connection to its overseas Indian population. While many people argued that Indians that left for the US have not helped the industry's early development, in more recent times, there is increasing evidence that a large number of nonresident Indians (NRIs) have returned, bringing skills, knowledge and more recently, financial capital, with them.

Many Indians residing in the US have become influential entrepreneurs and workers in the high-tech industry there, as documented by Saxenian and others. Such connections may

[5] Estimate by Mr. Ajay Sawhney, IT Secretary to the AP Government. Another estimate by Mr. J. A. Chowdary is that there are about 10 startups at the high end.

have been the underlying reason why some of the outsourcing of US corporates' needs to India have taken place.

In many of our interviews, Indian companies were seen to have set up an office in the US—often a sales or headquarters operation. This type of setup can also be beneficial by allowing these firms to tap into the US expertise of NRIs, both in those offices as well as in the broader Indian community. Close network ties are being formed along higher education institutional and other dimensions. Even in India, there are widespread ties among those educated in schools such as the prestigious Indian Institutes of Technology (although many of those graduates have also left for the US).

3.6 Barriers to Growth

Even as the IT industry formed, it has had to overcome many other impediments, such as poor telecommunications, roads and other infrastructure, and the poorly functioning nature of the rest of the economy—which is generally inefficient or operating older-vintage capital. Some STPIs provided means to overcome these impediments. For instance, STPIs provided reliable power, telecommunications and land, and streamlined governmental procedures (overcoming the Government's infamous red tape) for foreign investors and domestic companies alike.

Recent surveys of US clients suggest that they are dissatisfied that Indian firms' have little or no domain knowledge and poor management skills (Arora et al., 1999). Our own interviews with Indian firms suggest that the former reason is not so evident, but that the latter is prevalent. Many firms are weak on project management because such professionals are hard to retain. These workers continually try to move up the ladder, and from company to company, seeking to "leave the system" when they can find residence in the US, most likely working for a US-based company. While there is widespread acknowledgement that this propensity of employees to jump ship is hurting the industry, at the same time, their rapid movement reflects a strong desire to learn and upgrade themselves. This could eventually contribute to a more rapid accumulation of knowledge between firms, since new employees can be expected to deposit knowledge in each company they join.

In our interviews with Indian firms, some indicated that in contrast to Silicon Valley, India did not really have an "innovative" economy, while others acknowledged that the level of capability demonstrated in India is still far behind that of the US. This lack of innovation includes a lower degree of risk-taking behavior and lack of a free exchange of ideas among employees of different firms, let alone within firms. However, interviews with other firms suggest that this attitude may vary between companies. In another respect—the free flow of labor—the labor market in India does somewhat resemble that of Silicon Valley.

One of the weakest areas in states with lofty goals like AP has been the educational system. The private sector has been encouraging and helping the state to develop its higher education system, starting with the Indian Institute of Information Technology (IIIT) in Hyderabad. This is similar to the one in Bangalore, but has a much greater level of industry involvement, including company-specific schools (e.g., Oracle and Cisco) for postgraduate training in specific fields. The intention is to use the IIIT as a magnet for attracting the best, as well as to be a standard-setter by which all other technical schools in the state can be judged. The private sector is rapidly moving into education and some companies offer basic IT education opportunities to tens of thousands of people. New universities are also sprouting, but the issue now will be quality, not merely quantity.

Improvements in how the markets are locally capitalized (e.g., via access to venture capital) have only been seen recently in places like Hyderabad. McKinsey also noted that a crucial aspect for further growth lies in the attitudes of existing software players, who will have to climb the value chain by acquisitions. This behavior is now being seen in the bigger companies, but, as we will show in the next section, the issue of organizational change is a complicated one.

Last, even though policy reform on investment, infrastructure and education has been substantial, there are other areas that need reform, such as improvements in the intellectual property law. The US has been aggressive in promoting its version of a global framework for e-commerce, but it behooves India and other developing countries to stand up to ensure a more representative playing field.

3.7 International Comparisons with India

India's share of the *total* global software market (including domestic production) is still low, but the country enjoys a considerable market share in *exports*, with about 18.2 percent of the global cross-country customized software market (NASSCOM, 1999). India's exports relative to other countries are shown in Table 1.

Table 1. International High-Tech and Software Exports and Numbers of Employees

	High-tech exports (% of manufactured exports) **1998 (a)**	**Software exports** (million **$US**) **1998**	**Number of employees in software industry**
PRC	15	50 (b)	150,000 (e)
India	5	2,650 (c)	180,000 (1997/99 est. (d))
Ireland	45	3,290 (d)	21,630 (d)
Israel	20	700 est. (d)	-
Japan	26	173 (d)	-
Korea, Rep. of	27	-	-
Singapore	59	-	-
Thailand	31	-	-
United States	33	2,956 (d)	1,627 (d)

Sources:

(a) High-technology exports are products with high research and development intensity such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery. World Development Indicators 2000, World Bank.

(b) Figures do not include the software used in telecommunication switches, US Department of State. http://www.state.gov/www/about_state/business/com_guides/1999/eastasia/the PRC99_05.html

(c) NASCOMM (1999). *The Indian IT Industry*. www.nasscom.org

(d) *OECD Information Technology Outlook 2000*, OECD.

(e) Wu and Yuan (2000). United Nations University/Institute of Advanced Studies, Mimeo.

The Indian software industry is roughly comparable to the Irish and Israeli industries in terms of revenues and exports (Arora et al., 1999). This is confirmed by the table. All three countries have common characteristics such as abundant personnel that are relatively inexpensive and English-speaking. However, the level of earnings per software professional is substantially lower in India and high-tech exports as a proportion of overall manufactured exports is still far lower than other countries.[6]

Perhaps India's most unusual characteristic is its strong export orientation. While Ireland and Israel were close to India in software export performance, the rate of growth is fast in India and will likely continue to outstrip the other smaller countries, in part because of the huge surplus of personnel.

3.8 Factors Underlying Growth: International Comparisons

As noted earlier, the growth in India's IT industry can be traced to its educational and research and development (R&D) systems (the latter functioning more as a skills training system than as a source of new ventures). Table 2 illustrates this at a national level for India and the other countries. Two aspects are striking: India's high illiteracy rate, which may hold back the broader gains of the economy, and the People's Republic of China's (PRC's) much larger pool of scientists and engineers, which makes it a potential power in the software industry.[7] The PRC, however, still has problems with its higher educational system, something not reflected in this table.

Table 2. Educational and R&D Levels

	Total number of scientists and engineers per population (average over 1987-1997)	**Total number of technicians in R&D per population (average over 1987-1997)**	**Expenditure for R&D** (% of gross national product) **(1987-1997)**	**Science & engineering students** (% of total tertiary students) **(1987-1997)**	**Illiteracy rate** (%) **aged 15 and over (1998)**	**Patent applications filed (1997)**	
						Residents	**Nonresidents**
PRC	527,066	232,188	0.66	43	17	12,786	48,596
India	131,314	95,180	0.73	25	45	10,155	---
Ireland	8,263	1,803	1.61	31	--	946	82,484
Israel	---	---	2.35	49	4	1,796	28,548
Japan	609,740	102,721	2.80	21	--	351,487	66,487
Korea, Rep. of	95,848	13,899	2.82	32	2.5	92,798	37,184
Singapore	6,538	849	1.13	--	8	8,188	29,467
Thailand	5,874	2,224	0.13	18	5	238	5,205
United States	937,012	--	2.63	19	--	125,808	110,884

Source: World Development Indicators 2000, World Bank.

The PRC has often been said to have a better potential for developing its domestic software industry than India. Also, the basic numbers in Table 3 suggest that the PRC and other countries have much better communications and computing accessibility than India as a whole. However, this has not been the case for a variety of reasons, such as a poor policy

6 This can also be roughly confirmed by dividing exports by the number of employees in the industry, as shown in Table 1.

7 On the other hand, the PRC has developed strong competencies in manufacturing hardware, whereas India has not been able to create these, for various reasons. This paper will not, however, focus on this dichotomy.

environment for protecting intellectual property,[8] and possibly others such as the PRC's lack of strong organizational capabilities and international social and business networks needed for developing software export markets.

The PRC's strength has often been said to lie in its domestic industry, even though that has comparatively lower profits than an export industry. Further, in the long run, the likelihood of a domestic industry taking off will have a lot to do with the level of preparedness of private enterprises and the public for undertaking Internet transactions. On the other hand, whether the Indian industry continues as an enclave or can contribute to the broader economy will depend on broader reforms and changes taking place in the nonsoftware sectors, and on the linkages the latter can forge with software sectors. Whether India can make this transformation is a subject for another paper. For the remainder of this paper, we will restrict ourselves to describing the IT industry's organizational capabilities and skills base, and their role in the technological upgrading process.

Table 3. Communication and Internet Infrastructure in 1998

	Total population	**Number of phones** (% of pop)	**Number of mobile phones** (% of pop)	**Number of personal computers** (% of pop)
PRC	1,238,600,000	7.0	1.9	0.9
India	979,700,000	2.2	0.1	0.3
Ireland	3,700,000	43.5	25.7	27.1
Israel	6,000,000	47.1	35.9	21.7
Japan	126,400,000	16.6	37.4	23.7
Korea, Rep. of	46,400,000	43.3	30.2	15.7
Singapore	3,200,000	56.2	34.6	45.8
Thailand	61,200,000	8.4	3.2	2.2
United States	270,299,000	66.1	25.6	45.9

Source: World Development Indicators 2000, World Bank.

4. The Evolution of Organizational Capabilities and the Future of the Indian IT Industry

The Indian software industry has come a considerable way in a relatively short amount of time. But some have noted that in order to continue its breakneck growth, the industry will have to diversify, if not wean itself away, from offshore development and other services, possibly by taking risks to develop original products and productized services (NASSCOM-McKinsey, 1999). There is an indication that at least some firms are taking this seriously, while others are trying to make a transition in a more tentative manner. According to one survey (Arora et al., 1999), given the high margins in the services sector, others may still be content to continue with business as usual.

Based on our interviews, we will evaluate different scenarios for organizational transformation, and the different strategies employed by organizations as they seek to increase their capabilities.

[8] Steven Anderson, presentation, the Asian Technology Information Program (ATIP), Tokyo, January 2001.

4.1 Limiting Factors

The ability of the Indian IT industry to continue its high rate of growth depends on two things happening:

(1) Evolution of existing firms' capabilities—existing or new firms climbing the value chain. As we noted, this can happen if existing firms buy up small innovative firms, or move ahead steadily on developing product development expertise, then ally themselves with global product developers.

(2) Existing firms maintaining the rate of growth in exports (e.g., by increasing the share of IT-enabled services). One possible way of accomplishing this is if new services could be developed out of new products from the firms higher up in the value chain, from both outside of India and within.

While the first carries higher risks, it also carries greater long-term rewards should more competitors come up the value chain from behind India.

Utilizing a business competitiveness approach, McKinsey's study argued that in order to reach the target of US$85 billion in software exports, India would need to build up more than 10 large world class companies, as well as a few hundred smaller ones, covering four broad areas: value added services, software products, IT-enabled services and e-businesses (NASSCOM-McKinsey, 1999).[9] Further, the report suggested that these companies should build up expertise in the current core area of custom-developed legacy/client server systems.

These projections are based on assumptions of rapid growth in three of the new or high value-added areas: $10 billion in software products, $17 billion in IT-enabled services (e.g., call centers, back office services such as customer relations management and human resources) and $4 billion in e-business. At the same time, it assumes slowing growth (but still with a dominant share—$30 billion) in IT services such as enterprise applications and the maintenance of legacy systems (NASSCOM-McKinsey, 1999). However, these rosy projections will not come to pass if the Indian industry fails to make that transition, either in snaring their share of international IT-enabled services, in making traditional industry more efficient with e-business or in making inroads in the international software products market.

Some factors in the business environment may already hold back these events from occurring, such as the already existing infrastructure and labor supply constraints. The affect of other factors—such as the emergence of new international competitors—is less clear. Last, further growth would depend most importantly on conscious decisions taken to shape corporate strategy and to acquire the supporting skills base. Consequently, all aspects of the business environment, such as public infrastructure, the human resource base, new financing, new ventures-based growth, and an environment supportive of entrepreneurship, innovative thinking and experimenting, will have a bearing.

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9 The assumptions behind this are questionable, as has been noted by NASSCOM itself.

The domestic market will also need a shot in the arm. This will only occur if the IT user base is expanded, not only among households,[10] but also other businesses and governments. The poor economic performance of other businesses is holding back the growth in trends such as e-business. One government director noted that small- and medium-sized businesses with poor margins are having trouble financing expensive IT purchases, though this may improve if cheaper enterprise applications are developed by domestic IT companies and are coupled with in-house developers (in firms within a particular industry). In addition, one IT human resources (HR) manager noted that the IT industry has pulled away some of the best engineers from other sectors and has inflated wages in other industries.

In the end, given the higher risks of climbing the value chain, in the interests of maintaining growth in employment opportunities as well as the existing substantial foothold in the IT industry, it is prudent for policy to continue to support both the strategies of business as usual and of innovative productization.

We believe that Indian IT firms' organizational capabilities and skills will have to change for them to participate in higher value-added work. Many of our interviews confirm this. The scenarios for the three basic types of companies—offshore developers, MNC affiliates and startup companies—are laid out next.

4.2 Offshore Development: Transition

ODCs—mainly larger domestic software companies—still play a big part, largely carrying out customization activities. But they are increasingly moving into "productized services" (defined as products that are sold as a service).

There are several difficulties that Indian firms face in trying to make the transition from offshore development services to higher value-added products. One of the main reasons is that offshore development is still a high margin, profitable business. A second is that it can still take advantage of a huge supply of software workers. This has been called a *human resource augmentation mode*, in which more and more projects are taken up, adding equal amounts of labor per unit of contract activity to service those contracts. A third reason for this persistent behavior is that the returns from services are more guaranteed than from products, which have potentially higher returns at higher risks.

A last, organizational issue that plagues the transition of the Indian software industry is that organizations (such as offshore development companies) that reach a certain size and get used to operating in certain lines of business generally face a more difficult time in restructuring their organization for new lines of business. The older US computer companies (e.g., IBM, Hewlett Packard [HP]) have shown dexterity in making a transition by moving to consulting services. However, it is difficult to see how service companies can "go upstream," by building products to compete against established players such as Microsoft and Oracle. This view was supported by one top manager of a leading Indian IT services company, who noted that his company stayed in the service arena by way of its momentum and the ease of deriving revenues from that line of business. Even though his company had some success in

[10] It is worth noting that a recent survey suggested that household uses of personal computers are not necessarily for productive purposes.

developing a Web-based product, its slow turnaround time negated any substantial gains to be made in market share. This situation was in part attributable to the “attitude” of top management and to what might be described as organizational culture. In fact, the attitude problem covers a wide range of issues. Some criticism has been leveled at the “mindset” problem (e.g., large firms that merely charge clients by hourly or project rates, which lowers their profit margins, or firms that eschew marketing in favor of technical specialists).[11]

Despite its negative correlation with product development, ODC work could also benefit product development. Companies can use the revenues from services to fund new product development. This was a goal expressed by one small offshore development firm in Chennai. This model of enterprise growth may benefit some companies who do not have access to venture capital or are lacking in a high enough market capitalization with which to make acquisitions.

4.3 MNCs: Moving Up the Value Chain

MNCs are also moving up the value chain. Examples of affiliates increasing their value added over time were seen in all our interviews with MNC affiliates’ development centers: SAP India, Sanyo and Kindle Software—all in Bangalore—and Intergraph India in Hyderabad.

Originally, many MNC affiliates started in India with coding and product upgrading or maintenance, e.g., code maintenance at Kindle and in SAP, working off variations or upgrades of the company’s main “product spine.” Intergraph India developed products based on the US parent’s conceptual work on new products for the global market. This situation is, however, leading to more advanced design and development, or autonomy. For instance, Sanyo is involved in the complex work of developing embedded software (hardware that embeds software type instructions).

Sanyo’s development group was a greenfield (i.e., first-time) operation, relying on management with experience from other MNCs and local companies. The center was allowed an unusual amount of autonomy from the Japanese parent (this was partially attributed to the openness and senior position of the local Japanese manager in charge, who ensured that the development center was well connected to the higher ranks in the corporation headquarters).

Others have been making more incremental moves up the value chain. Local affiliates of Kindle (a large Irish company making banking software), SAP (a leading enterprise software maker) and Intergraph (a US company making various engineering software products) are all moving from the improvement of existing products or “code maintenance” to new product development. In some cases, locals have agitated to get these higher value-added activities. SAP found that engaging in advanced work helps them to attract and retain good employees, who constantly want to improve their skills and marketability. (Eventually, most employees either want to leave for the US or work in a startup with stock options). In the case of Intergraph India, the chance to undertake conceptualization is their next sought-after “prize.” Conceptualization requires a convergence of domain knowledge with that of

[11] Business Line (3 March 1998). http://www.indiaserver.com/businessline/1998/03/03/stories/15030395.htm

software development and other activities, including, as another interview indicated, marketing and knowledge of the competitive terrain. The atmosphere at SAP-India was much like a US IT corporation in terms of the flat hierarchy and open communications (e-mails could even be sent to the top management in Germany). However, this was not always the case. In the beginning, SAP-India was set up with traditional control-oriented, hierarchical German management, which failed to take root in the Indian culture.

4.4 Startups: Freshly Innovative from the Gate?

In contrast to the first two types of businesses, a few smaller companies that we interviewed showed vision and the willingness to take risks by going into products and newer areas. In these cases, the risk these companies faced did not include losing an existing business or market capitalization (unlike with established firms); instead, they stood to gain such rewards. While startups are typically thought of as being innovative, in India, all kinds are seen, ranging from imitative (of others' technology) adaptive and innovative, with an increasing number of the latter emerging.

To paraphrase the words of a hardware-software firm's chief officer (PortalPlayer, personal communication, October 2000), it was "not that hard to assemble a team of top India-based talent that could go head to head with the leading companies in the world." The problem with the marketing of intellectual property (IP) could be solved by allying with or being acquired by MNCs. This is what some Indian MNCs are starting to do, by buying up smaller companies. Whether or not this strategy works can be gauged by standard measures of success such as profit margins or market share. Also, whether the economy reaps a real gain in growth or employment can also be questioned if the only thing achieved is simply to be bought by a foreign MNC.

Some startups that we interviewed were in the consulting area, and some were starting out in more of an HR augmentation mode.[12] For instance, 24/7 Customer.com focuses on customer relationship management and is planning to scale up to employ thousands of staff at call centers that can answer help requests for their US clients. Two startups that focus on consulting services are Mindtree consulting—an internationally-based consulting firm with roots in both the US and India—and BangaloreLabs, a network consulting firm. These two firms are moving up the consulting service value chain, to occupy not only the medium value-added niches but also to attack those held by traditional corporate strategy consultants such as Andersen Consulting.

Another approach or business model is for firms to understand their "customer's mentality." Both Mindtree and 24/7 Customer.com focus on their "customer's customer," meaning that they try to understand their customers' needs before they arise. This suggests that they will have to build up the domain knowledge of their customers, something that US clients perceived to be missing in their Indian partners. This domain knowledge is perceived by some in the industry to be a key to successful growth in the future.

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[12] This is analogous to the concept in economics whereby growth occurs through the accumulation of inputs, as opposed to total factor productivity gains.

While these approaches may have the potential to differentiate firms as innovative or unique (i.e., not easily replicable) models with barriers to entry, this remains to be seen. Further, these companies are trying to add value across more than one segment of the value chain they operate on. But whether they can compete with (i.e., add more value than) established firms that already occupy a particular segment (e.g., HP in network consulting, or Arthur Andersen and McKinsey in strategic consulting) remains to be seen.

There are distinct differences between startups and offshore development firms. The consulting startups we interviewed tended to rely on a business model or value proposition that they sell to the client, which may involve selling a "framework" solution. They believe they have unique advantages, because unlike other firms providing similar services, they may additionally seek to straddle or integrate multiple segments, or attempt to assist their clients at a deeper level or at the heart of their client's enterprise. In contrast, the traditional ODC firms appear to be more hands off (i.e., domain-independent), and rely less on "frameworks" but focus more on projects that improve their clients' basic functions (for example, the development of accounting systems for a client that is still to a degree enterprise-independent). Both models appear susceptible to the claim that they are still operating in an HR augmentation mode.[13] One question to research is whether a business model–based growth strategy is more defensible against potential entrants over time than a technology-based one. The answer would probably lie in how much the former depends on market power and first mover advantages, versus how much can be achieved through the simple acquisition of technologies. The economic aspects of these issues are taken up in a later section.

5. Some Empirical Evidence on Skills and their Relationship to Organizational Capability

In this section, we lay out the role of skills and organizational capabilities in greater detail, given the possible scenarios that the industry faces (as set forth in section 4). In particular, we will develop a framework for skills and their relationships with different types of organizations seen in the Indian IT industry, to see what skills can facilitate the transition to higher value-added work. We will also examine our empirical evidence for these assertions.

In the following sections, we will develop these observations on skills:

(1) Skills and organizational capabilities played a vital role in the Indian IT industry's growth. In particular, early business enterprises contributed rudimentary technical and business skills to the development of the IT industry.

(2) The current skill sets are also a limiting factor for further growth, being too narrowly focused on technical skills, and too limited in broader and middle-level experience.

(3) Higher business and technology skills are needed for future growth of the industry, if it is to be more innovative and have greater control over IP and its development.

Eventually, we hope to be able to show that the skills obtained in one organization may contribute to the development of other types of organizations (i.e., organizations with advanced technical and product capabilities).

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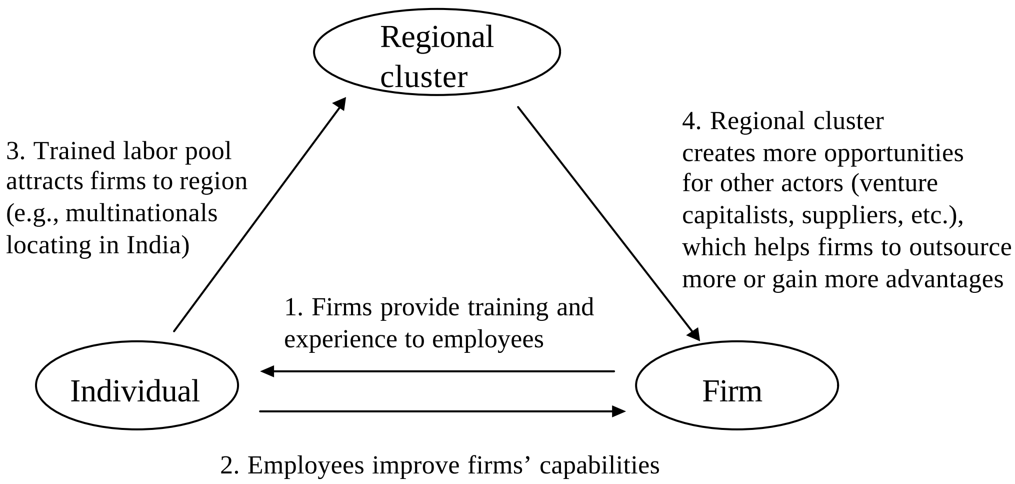
[13] Note that even successful startups in the US, such as Freemarkets, a premier B2B (business to business) auction house, are also susceptible to the same criticism.

5.1 A Framework for Relating Skills, Organizational Capabilities and Regional Clustering

Since skills are a major part of an organization's capabilities, and since regional clustering (i.e., agglomeration) is also a significant factor, we first lay out a framework for examining how three levels of activity—individual skills, organizational capability and the regional clustering of firms—can be related.

In economic geography, the study of the relationships between firms, individual capabilities (as exhibited in the labor pool) and regions has been a popular subject. A complex web of relationships is suggested by the various regional level studies and observations of places such as Silicon Valley. Figure 1 illustrates some of the most important relationships between the three levels of analysis. Our focus later will be on how individuals' skills contribute to the capabilities of firms, and to a lesser extent, on how firms act as a source of skill formation.

Figure 1. Linkages Between Individual, Firm and Regional Levels



Link 1 has been well established in studies of other industries in the past (see for example Koike and Inoki, 1990), but a more rigorous study of the IT industry will be useful, particularly if made within the context of new work organizations and the needs of firms. Further, at the highest level of value added—innovation—previous work has also recognized that a large proportion of the skills needed for innovation are tacit and learned on the job, rather than explicitly rooted knowledge such as patents and documents (Angel, 2000). We will examine some of these types of skills and sources later, but it may be useful for future work to have a greater explicit focus on the character of this knowledge.

Some studies also shed light on the converse relationship: link 2—how firms benefit from different types of employee skills. Our current data limits us to studying this at a higher level of analysis. One recent study of the semiconductor industry supports the link 2 relationship by contrasting Silicon Valley's hiring practices with those in the rest of the US.

Among other things, the study found that firms in Silicon Valley hire a majority of employees with considerable occupation-specific experience, hire mostly from the local labor market, while also recruiting large numbers from outside (Angel, 2000). These findings demonstrate the necessity of not only a local "experience-producing" industry, but also openness in the labor market. Further, smaller startup firms tend to hire employees with experience, which provides one possible explanation why startups thrive in Silicon Valley. Generally, however, this relationship of how individuals contribute unique firm-specific assets to organizations has not been so well studied. Firms are an important bedrock for supplying these experiences to individuals. In a sense, this is because innovation is a continuous process and the continuity of that process cannot be automated by machines, but rather, is a function of human talent that is capable of *creating*, and not simply *recreating*, knowledge. These knowledge accumulation processes have also not been well studied and are worth tackling in more detail.

The last two links at the regional level are important to understanding the overall development phenomenon. These tie into the concept of spillovers (discussed more in the next section). First, a large labor pool (as well as other firms) will attract firms to a region, as is shown in the case of India (link 3). Further, clustering creates more opportunities for suppliers, venture capitalists, lawyers and others, which then creates a supporting infrastructure for other firms that need these special services (link 4). Studies of clustering in Silicon Valley also illustrate that the density of inter-firm networks also contributes to firms' ability to vertically disintegrate (i.e., outsource parts of their product value chain) and engage in "flexible production" patterns (Saxenian, 2000).

5.2 Types of Skills

In order to address the linkage between skills and organizations, we will first provide a categorization of the different types of skills involved. The prevailing view of the industry as well as our interviews suggest that skills can be divided into two types:

(1) Product Development Skills: There are at least four types of technical and managerial skills needed to develop a software product (which roughly map onto the earlier typology of software development activities):

(a) basic technical skills such as coding and programming languages—these can be learned in codified form, but their application requires experience (learning by doing). Further, they cannot be enhanced by oneself, but new skills have to be continually learned over time (e.g., new programming languages or authoring tools).

(b) systems skills—including project management, requirements analysis and systems analysis, i.e., the ability to break down complex systems and coding tasks into discrete components.

(c) advanced or high end technical skills—e.g., including mathematical abilities and other fundamental (scientific) knowledge used in science and innovative product development.

(d) innovative technical skills—these are the creative, interdisciplinary and other technical abilities needed for new product innovation. These skills and knowledge are not only required to undertake engineering concept work, but also to understand whether a new conceptual idea is feasible from a technical point of view.

(2) Business Development Skills: Every task from software as services to software as products involves not only technical conceptualization skills, but also business skills. Various types of business skills are needed, particularly for developing and marketing innovative products under a company's own brand. We suggest two kinds of "business development" skills that enterprises engaged in product innovation need:

(a) entrepreneurial skills—various management and networking skills are needed for managing startups, e.g., how to source venture capital, manage a startup, form alliances and otherwise understand the process of bringing an idea to fruition. In a related way, starting up a greenfield MNC operation may also require some of these entrepreneurial skills, but MNCs may embed some of this knowledge within the corporation.
(b) other conceptual skills—including new products requirements analysis; knowledge of market and customer needs; and innovative and creative abilities. (Note that these have more to do with the "big picture," as opposed to technical conceptualization skills, which focus on the detailing and validation of that big picture.)

For innovative activities, a combination of business development skills (2a and 2b) and high-end technical knowledge (1c) is necessary. This involves knowledge of the latest technologies; the ability to translate that knowledge into innovative products; and knowledge of the market (i.e., what is important to clients and what competition exists).

It is worth noting that other kinds of skills—such as soft or relational skills—have also been cited, both in our interviews as well as generally in the skills and human resources literature.[14] These, however, are not the focus of this study.

5.3 Skills, Value-Added Work and Sources of Skills

In this section, we will examine link 2 in Figure 1 by considering how different types of skills map onto types of organizational value-added work (using the latter as a proxy for organizational capabilities). In particular, we consider three types of value-added product development work:

(1) Body shopping—this is the most elemental form of work, essentially only requiring technical skills, although some with advanced knowledge.
(2) ODC work, in which the firm acts as a contractor to an established software producer (the equivalent to ODC in the electronics manufacturing industry is the "original equipment manufacture" [OEM] category). Unlike body shopping, this also requires fairly advanced systems skills, an increasing degree of knowledge of the customer and the ability to undertake more sophisticated analysis of the customer's requirements.
(3) Own-brand development (OBD) (the equivalent term in the electronics manufacturing industry is "own brand manufacturing" [OBM])—this requires innovative and independent thinking.

[14] Many firms now also emphasize soft skills as well as creative thinking within problem solving. One company—Cognizant Technology Solutions—sees the best people for IT as those that combine technical skills with soft skills such as communication ability, interpersonal skills, dealing with clients and people management (http://www.cioljobs.com/resources/CRdisplay.asp?id=149). The Intergraph India respondent noted that, in his view, many Indians lack the skills to operate in multicultural environments (personal communication, October 2000).

The table below illustrates which types of skills are expected to be necessary for each type of work. It also illustrates link 1 by showing what kinds of training firms provide to employees (although it does not explain the more complicated question of how this occurs). The table shows that the difference between OBD and ODC work is in the former's need for conceptual technical skills and business skills. All companies will need coding, project management and other base skills, but depending on the firm, these can be either located in-house or externally (in their "supplier network").

Table 4. Type of Work and Characteristics of Skills

Type of skill	Type of work	Sufficiency of skills in Indian industry	Source of skills
(1a) Basic technical	BS, ODC, OBD	Strong	Education, professional certification
(1b) Systems	ODC, OBD	Weak	Experience
(1c) Advanced technical	BS (skills needed), ODC, OBD (especially)	Moderate to strong	Education, experience (from MNCs, etc.)
(2a) Entrepreneurial	OBD	Moderate to strong	Experience, learning by doing (and from mistakes), culture (some cited)
(1d, 2b) Conceptual (both technical and business)	OBD	Weak	Different types of experiences and learning

To further illustrate links 1 and 2, we will next see what our empirical evidence can say about the various skills' origins and their contribution to organizational capabilities.

5.4 Sources of Skills

Table 4 illustrated some of the ways in which different types of skills are built up. Universities and training institutes produce a significant number of graduates each year. In India, there were 4,930 graduates with masters in technology and in sciences, 9,500 with masters in computer applications, 20,180 with bachelors in technology and in sciences, and 9,500 with bachelors and masters in computer applications (the total at all levels including diploma holders is 73,580 graduates) (NASSCOM, 2000). These are the main sources of 1(a) and 1(c) skills.

We know less about the actual quantitative proportions of the table, namely, the composition of different types of skills in organizations, the sufficiency of those skills in India and the contribution of various sources to those skill pools.

Further, we have an incomplete knowledge of how people move around between different organizations. In our interviews, the qualitative evidence suggested that individuals walked many different paths between organizations in building up their skills and experience. Some people working for startups had MNC or other experience, but others had previous startup experience, and some people working for MNCs had startup or non-MNC experience. All this suggests that many types of experiences are equally useful to different types of firms.

While the main source of knowledge and skills in all fields is the higher education establishment, in the rapidly changing software field, firms are now recognized to be critical in providing additional or advanced skills and knowledge. Based on our (somewhat limited) interviews, we can make the following assertions on firms as sources of skills:

(1) *Knowledge of advanced (software) technologies, products and platforms* can mainly be gained by working for MNCs or through academic research.

(2) *Business development knowledge* is difficult to acquire, involving knowledge of the end users as well as competing products and one's own product. The acquisition of this may require locating close to the dominant end-user market, which is the US in most cases. In small startups, only a top executive or the head of a sales team may hold this type of knowledge.

   (a) In particular, *entrepreneurial skills* can be developed only through learning by doing (and failing), i.e., experimentation in startups (although sometimes, advisors from overseas or domestic firms and venture capitalists could advise on strategy).

   (b) Our understanding of *conceptual skills*—their nature and origin—is weak and much more research needs to be done on this.

5.5 The State of Product Development Skills in India

While India has apparently great depth in basic technical skills, industry has greater demand for other skills than are available. According to NASSCOM surveys, the skills most in demand over the next three years will be in areas such as business applications of software development (23 percent of respondents), Web-based applications (34 percent) and Application Service Providers (ASPs); systems skills such as software engineering (18 percent) and project management; and specific technical skills such as Java and OOPS, etc. (NASSCOM, 2000). In addition, advanced technical skills and knowledge appear to be lacking. Since the Indian software market was focused on low-to-middle value-added or "production line"-oriented activities, the differential in advanced knowledge between India and places such as the US in advanced technology was not too crucial. For future work, it may be important to determine whether this differential is a lack of advanced *knowledge or skill* at the *individual level* (or in the employee mix), or a lack of advanced *work* at the *company level* (i.e., its line of business).

One commonly held argument is that Indian companies are behind the curve, at anywhere from a couple to a few years behind US companies in technology (Arora et al., 1999). We also detected this in our interviews, but we saw another trend, in which at least all three startups (PortalPlayer, Mindtree Consulting and BangaloreLabs) indicated that they were on "the cutting edge," either technically or in terms of their business model. Offshore development firms such as Wipro that were working on customization could also claim to have developed leading edge products, but at least in one case, found that their marketing effort and product turnaround time was not good enough to capitalize on their technical abilities. This suggests that a better understanding of the product innovation process is needed for the software sector. Capability will have to be differentiated not only in terms of what people know, but also by what they can do.

As India moves into higher value activities, higher level skills (or their absence) can become critical. All three types of organizations (foreign MNCs, startups and established domestic ODCs) will require knowledge of *advanced technology*, but as suggested in our interviews, some feel that such knowledge is lacking in India. One interviewee (from Intergraph India) felt that this is because Indian universities lag behind their US counterparts by 10-15 years in market- and industry-related research, and that this shows up in India's inability to generate intellectual property or software products. Others (BangaloreLabs, Wipro, etc.) noted that this was already changing—universities' research was being helped, but mostly through interaction with MNCs, not domestic companies. The academic component of advanced technical knowledge (1c) also appears to be weakest: for instance, there are only about 100 Ph.D.s in IT-related areas graduating per year nationwide in India (NASSCOM, 2000). The new IIITs are one attempt to change this, but they may need to have a much larger critical mass of researchers and educators in order to effect change.[15]

The nature of technical skills may also be changing. According to Wipro,[16] three years ago, not much formal education was needed to operate computers at the level of early IBM mainframes, but with the recent rise in Internet technologies and e-commerce, more formal (computer science) education is needed. However, it may be that with advances in computer "authoring tools" (e.g., programming aids), tasks like coding could eventually also be automated, removing the need for theory in the practice.

As noted earlier, because of employee attrition, many companies, including ones we interviewed, are lacking project management skills (and another interviewee from 24/7 also observed that systems analysts are lacking). This missing "middle layer" is worrying industry leaders.[17] It is directly related to the outflow of software developers to the US and other countries each year. There are about 250,000 Indian software developers employed in the US (which is almost the same number as in India!), with 40,000 to 50,000 traveling to the US and Europe each year.[18] Heeks (1996) earlier also reported that India loses about 15 percent of its software workers each year, mainly to the U.S. On top of that, the US is raising the number of H-1B temporary visas (mainly for foreign engineers and programmers) from 115,000 to 195,000 per year for the next three years.[19] That difference alone can potentially absorb the total annual output of Indian IT-related degree and certificate holders, not to mention those from other countries coming up the line.

Our study has mostly focused on individual skills, but future work will have to examine competencies at the organizational level in more detail. This would be useful because any observed deficiencies in organizational capabilities, such as innovative capabilities, could be due not only to lack of individual skills, but also of individual knowledge or capabilities at the *organizational level*. If organizational competencies are only a matter of individual *knowledge*, the source and location of that knowledge will be important. Since most IT knowledge is arguably in the public domain or accessible through educational institutions, providing people with access to good training and technical libraries may be sufficient for fostering such skills. On the other hand, if it is a matter of individual *skills*, experience in the *translation* of technologies to products may be critical, as for instance when MNCs and local firms provided experience in product development skills. If it is a matter of issues at the organizational level, this may involve skills distribution and appropriate usage,

[15] Based on various interviews.
[16] Personal communication, October 2000.
[17] One interviewee even suggested that an unexpected reason why they *can* get people with middle level experience is because some Indian male professionals who reach a certain age wish to return to the country to ensure that their daughters grow up with Indian cultural values!
[18] Dataquest (17 November 2000). http://dataquest.ciol.com/content/search/showarticle.asp?artid=18872
[19] Reuters (6 December 2000). http://www.ciol.com/content/search/showarticle.asp?artid=19397

organizational learning, organizational memory (e.g., procedures, organizational culture, etc.), and even management strategy and leadership.

5.6 The State of Business Development Skills in India

Business development skills like marketing are key to success in software markets, but whether this is because such skills "make or break" a company, or because such skills are associated with already strong market positions that were locked-in through various other means, is not clear. In our interviews, we did not examine business development skills in great depth, so the issue could still benefit from further research. The evidence appears to be mixed, depending on the skills and companies involved. A couple of interviewees bemoaned the lack of conceptual skills and risk-taking, but the leadership of startups at least appears to have the appropriate conceptual and entrepreneurial business abilities. That is, on the one hand, the majority of the startups we encountered were run by experienced people, but this entrepreneurial knowledge is harder to identify. On the other hand, some interviewees noted that business skills were generally lacking, and the absence of experienced people may be due to constant migration. One perspective holds that an engineer could learn business expertise, but not the other way around.[20] Many people did not have a track record of starting companies, but prior management or other industry experience appeared to substitute for entrepreneurial ability. In the end, entrepreneurial knowledge may be as much *an attitude, a natural ability, or an environmental or cultural factor* than a book-learned skill. The knowledge of where to find venture capital and partners, and how to negotiate these, are all learned on the job in one's environment. One big difference noted between MNCs and ODC firms, compared to the startups interviewed, was a "can-do" attitude among the startups, i.e., the feeling that there were no limits to their growth prospects.

As already mentioned, conceptual business development knowledge—including knowledge of product markets—appears to require being located near end-user markets, namely the US. In the software field, product cycles are so short that the acquiring of product market knowledge must be "just-in-time," so that products can be decided on and developed. As such, it is important for firms to locate a corporate headquarters or high-level sales office in the US.

Local startups that seek to operate globally have an additional handicap in that they require not just entrepreneurial knowledge, but also knowledge of foreign (i.e., US) or international product markets. It is, therefore, no surprise that the more well-known startups that we interviewed have good connections to their main markets, e.g., offices in the US, Europe or other parts of Asia. The flip side to this is that the Internet provides access to a tremendous amount of resources, including product development.[21]

Last, it is worth noting that some of the companies we interviewed appeared to "substitute" a business model for homegrown technology. An example was that of 24/7, which offered a customer relations management service based on off-the-shelf technology.

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[20] Director of STPI-Hyderabad, personal communication, October 2000.
[21] PortalPlayer, personal communication, October 2000.

This did not require "rocket science" skills, but in the company's plan, the potential existed for creating higher value by way of data mining and other in-depth analyses of their clients' data.

This brief survey suggests a profile of the companies and the skills involved in software development, but considerable work is still required to identify how organizational capabilities are built up over time, the types of skills involved, their mix and the way in which they contribute to these capabilities. Additional work is also needed on how organizations improve the skill pool, both directly in their own shop as well as indirectly through the transfer of knowledge by employee movement to other organizations.

6. Some New Economics Relating to the IT Industry

The preceding analysis suggests some of the organizational forms and evolutionary paths that are being taken by firms in India's software industry, as well as some of the limits. We can see how the industry's prospects can be understood in various terms, such as its advantages (i.e., the large amounts of skilled, intellectual labor), its disadvantages (e.g., infrastructure, lack of a national innovation system) and its position in the global software production system (e.g., ODC work). On top of this, in addition to being able to create new technologies, firms will have to discover new ways of leveraging this knowledge to enter dominated markets or to capture new markets. This will likely require new alliances, strategies and business models.

Underlying some or all of these points are more fundamental economic rules operating in the labor and product markets, and which in the case of software involve substantial differences from the rules of traditional industry. This section briefly highlights some of the more pertinent of these economic rules.

One important economic concept has been that of *returns to scale*, that is, the incremental cost of producing an additional unit of a product. In the terminology of the new economics, software production has often been suggested as involving *increasing returns to scale*. In the simplest terms, this means that each additional unit of software can be produced at a lower cost than the previous unit. This is not necessarily the case in HR augmentation types of work, where *constant returns to scale* (i.e., additional units of product cost the same to produce) are more likely. This is because additional personnel are used to service new software projects at the same profit margins.

Another important implication for the Indian software industry relates to the concept of technological *lock-in*, or the means by which one maintains a natural advantage—in price, technology or market terms—over competitors in the industry. A first mover advantage occurs when the industry is the first to develop competencies, and if it creates a barrier to further competitors' entry, this creates a type of lock-in advantage. This is also believed to be one of the main reasons why Microsoft and other U.S. firms so dominate the tradable software market (Mowery, 1996).

A second reason that this sort of lock-in can occur is the existence of *learning curves*, that is, as long as continual learning is needed to improve one's competence, being a first mover and continuing up that learning curve will ensure that competitors will be "locked-out." This was the case for East Asian electronics manufacturing (e.g., Taipei,China contract manufacturers). The question is whether the software industry has similar types of learning curves and lock-in opportunities.

Another notion that is as much social as economic is that of *spillovers*. That is, the idea that private or public activities can generate public goods such as broader knowledge that others can take advantage of. Publicly funded and disseminated research is a classic spillover. In the production of knowledge (including software), knowledge spillovers occur when employees move between organizations. Other types of spillovers occur when firms indirectly or directly produce knowledge and services that other firms can use (usually without paying directly for them).

Related to spillovers is the notion of how IT may generate broader economic growth. Broader efficiencies in the economy can come about in two ways: production-led linkages, in which the IT sector improves the overall performance of other sectors (e.g., business improvements through e-commerce), and consumer-led growth, such as when a larger IT user base can help stimulate demand for a domestic software industry. In fact, many state government programs explicitly have this goal of stimulating domestic IT growth, but this approach can generate problems.[22] Further, it has still not been demonstrated for the case of a non-first mover country as to how a strong domestic software market and its innovations will complement and feed into the strengths needed for innovating in the export market.

While we have been able to provide only a cursory overview of these concepts, it should be clear that these and others can form a basis for understanding how the evolution of organizations, competitiveness of different strategies and the eventual prospects of the industry can play out.

7. Conclusions: Does India Represent a New Model of Growth and Is It Replicable?

In conclusion, it might be worth reexamining what our evidence points toward, and whether this represents a new growth model that other countries could follow.

The historical model of economic growth in the East Asian experience is that of a "follower" country that first learns to imitate, then modifies or adapts products. This experience has been characterized as a "long hard slog," and the buildup of capabilities is a long-term affair of building skills for one stage, then moving to the next higher value-added stage. The basic model, as typified by the experience of countries such as Japan and the Republic of Korea, was to produce by replication of existing products (i.e., undertaking manufacturing for others), followed by adaptation, and finally, in some cases, product innovation. Many East Asian follower countries have not been able to move beyond the

[22] One possible danger in this is that unless designed properly, government procurement programs can inadvertently protect domestic suppliers from competition. This was seen time and again in the US Government's procurement programs, in which computer companies that were awarded large procurement contracts from agencies such as the Department of Defense ended up losing competitiveness. In seeking to create economies of scale for itself with multiyear contracts, the US Government increased the competitive product lifecycle for those companies beyond their "natural" (competition-led) limits. Many of them—such as Zenith, Wang, CSC and DEC—no longer exist.

production phase, into new product development. Moving up the value chain gave firms the chance to earn higher rewards (or value), although at higher risk.

In this sense, the basic Indian software experience also follows the East Asian pattern. India started with its employees and firms at the lower end of the value chain. Thus, the "long hard slog" started with the typical body-shopping situation (involving shipping employees to the US to do simple coding on well-defined or mature products), followed by the capabilities to customize software (i.e., adaptation stage), update products (i.e., modifying stage) and engage in project management (in offshore development centers). All this resembles the upward progression of East Asian countries and suggests that countries hoping to follow in India's footsteps will have to expend a lot of effort. Further, several unseen factors that supported the industry's success may be hard to duplicate (e.g., immigration and reverse migration).

However, in other notable respects, the Indian software experience does not fit the East Asian model of growth. The most important factor is that the Indian experience was not based on manufacturing, but, rather, more on "service" and intellectual work. India's capability for manufacturing computer hardware and other electronics has been and still is relatively poor. As shown earlier, the Indian software industry overcame this handicap by engaging in higher intellectual content and value-added activities (i.e., software development), and further, unlike manufacturing, customization is the main activity for implementing software in organizations. (In international markets, there is also a marked shift in value added from hardware to the software companies.) It is almost as if every automobile had most of its value created in the crafting of its form to every individual buyer's taste.

Now, however, India's software industry faces a serious transition problem. Whether firms can remain in HR augmentation mode, by continuing to capitalize on the huge pools of untapped but trained human resources, or have locked in their advantages or have simply been "trapped" (i.e., path-dependent outcomes), are all open questions.

We have argued that the ability of the industry to upgrade is dependent on progressing in skills and organizational capabilities, and the formation of linkages, including a better innovation system, business alliances and other means of entering strategic new areas, and linkages to the rest of the economy. Some skills are already in short supply, such as those relating to business and the middle layer of product development.

Whether or not the Indian software industry experience can be followed by other countries is debatable. This would partly depend on the replicability of the initial conditions, but also on the market structure (e.g. competitors and potential customers). Other case studies suggest that even if countries have one or more of the comparative advantages – e.g. Russia's surfeit of programmer talent or Malaysia's foreign-investment-driven climate – they still lack other necessary ingredients to make themselves successful software exporters (Tessler and Barr, 1997). In the end, even having the enabling policies, hard infrastructure and labor pool still may not ensure a country's success, since "soft and social infrastructure" may end up being a prime determinant of success. These may include the workforces' facility with the English language, social networks between the developing economy and advanced countries (through which contracts and advanced technological knowledge are obtained), and "customer-focused mentality" (something thought to be missing from most Russian programmers). In addition, contracts are more easily awarded to experienced and reputable firms, which causes a chicken and egg problem of sorts for inexperienced firms in newly developing industries.

8. Topics for Future Research

This paper has only opened the debate on the issue of skills and organizational capabilities. Some of the more critical topics that can be addressed in the future are:

(1) The linkage between individual knowledge and skills, organizational capabilities, strategy and performance is still not well understood, in particular, the types of individual and organizational knowledge important to organizational performance. The forms of business knowledge needed, the manner in which they are formed and how they interact with technical knowledge may also be important.

(2) One application of this is to the industrial upgrading process. Whether or not, and how, this upgrading process occurs can be of great relevance to the industry (i.e., whether current competitive advantages in ODCs can be preserved through learning curve and other effects, and if not, how to achieve upgrading) (e.g., through organizational transformation and better skills).

(3) In order to compare the capabilities of regions and firms (e.g., India vs. Silicon Valley), it is necessary to develop more finely detailed typologies of skills, organizational capabilities and knowledge spillover mechanisms. Whether or not a defensible expertise can be developed solely within a stage (i.e., without upgrading) requires a better understanding of the software engineering process.

(4) The factors underlying upgrading go beyond skills and organizations, to include knowledge spillovers, the broader innovation system and linkages within it. This innovation system includes universities, venture capitalists and the inter-firm networks (e.g., suppliers, collaborators and alliances). The differences between India and the prototypical system as seen in Silicon Valley need to be drawn out.

(5) Finally, in order for the industry to have a broader effect on the overall Indian economy, the prospects for linkages between the software sector and other traditional sectors, and the importance of users to the domestic software economy, will need to be examined closely.

Interviews Conducted

Note: Unless stated, information about a particular firm may not necessarily have come from the interviewees in that firm.

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Director of the Software Technology Park of Hyderabad
Director of IT for Karnataka state
Finance Manager and Company Secretary, Tidel Park, Chennai

Firms

Managing Director, PortalPlayer
Director/Chief Operating Officer (COO), and Project Leader of Sanyo LSI Technologies
Human Resources Manager, Kindle Systems
Product Coordinator, SAP
Human Resources Manager, HR Vice-President, Bangalore Labs
General Manager, Intergraph India Limited
CEO/Cofounder and COO, 24/7 Customer.com
General Manager for Training, Wipro
Vice-Chairman/COO and Business Analyst, Mindtree Consulting
Assistant Manager, Pentasoft (subsidiary of Pentafour, a large Indian software firm producing multimedia software for the movie industry)
Human Resources Manager and Head of Finance and Accounts, SCM Microsystems
Lawrence and Associates, US software offshore company (nonresident Indian founder)

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