Small Firms in the Indian Software Clusters:

Building Global Competitiveness

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1. Introduction

Over the past two decades, the forces of globalization and the information and communication technology (ICT) revolution have led to the growing integration of developing economies into the global economy, and considerably changed the positions of emerging economies, perhaps most notably the BRICs (i.e., Brazil, Russia, India, China), in the global market. Thus, the patterns of their economic development are having an important influence on the course of the global economy.

Various bodies of recent literature—in regional economics, industrial organization, and economic geography—focus on the dynamics of local and regional economic activities in agglomeration, particularly those clusters of small- and medium-scale enterprises (SME) in technology-based or high-technology industries, in both developed and developing countries. Encouraged by successful examples of SME-centered industrial clusters in developed countries, such as in Silicon Valley in the U.S. (Saxenian, 1994), Emilia Romagna in Italy (Piore & Sabel, 1984; Pyke et al. 1990), and Baden-Württemberg in Germany (Schmitz & Musyck, 1993), many developing countries have recently adopted policies to develop industrial clusters for promoting national and regional economic development. In these successful examples of clusters in developed countries, researchers have found the very strong horizontal inter-firm linkages for cooperation among firms, particularly among innovative SMEs.

In developing countries, however, experiences of cluster formation have had mixed results (Schmitz & Nadvi, 1999). Because multinational corporations (MNCs) often have a dominant presence in the development of clusters there, the formation of the clusters themselves, and their internal structures, may show different patterns from their counterparts in developed countries, which typically enjoy close horizontal networks among small firms. In developing countries, governments, large enterprises, and foreign direct investment (FDI) often play an important role in the formation and growth of industrial clusters. What roles, if any, do domestic small firms play in the development of clusters?

The Indian software clusters, most notably Bangalore, have recently grown remarkably as a major destination of global outsourcing for software development and services. The Indian software industry depends about 80% of its income on exports, making it India's leading export

industry. Initially, the industry achieved its impressive growth, by exporting relatively low value-added software services to foreign markets, especially the U.S., taking advantage of the abundant supply of relatively low-wage and English-fluent IT workers. In more recent years, however, many global IT firms have started up operations in various software clusters in India, leading to a considerable shift in focus to higher value-added activities such as R&D, and rapidly expanding activities in IT-enabled services (ITES) and business process outsourcing (BPO).

In the 1990s, software clusters emerged in several regions of India. While a handful of large domestic firms and MNCs played a key role in driving the growth of both the industry and its exports, many small start-up firms were established in these clusters. These newly emerging small firms, which have better technological capabilities and focus more on exports, differ considerably from the traditional firms, which focused on domestic markets and were heavily protected under the decades-long Indian government policies on small-scale industries (SSI).

Given this context, what challenges do these newly-established small firms face to compete in the global market? How do these small firms develop their capabilities to innovate and build their competitiveness in both the domestic and global markets? What linkages do they form with other firms, including global firms, within and outside the clusters? Are these firms forging horizontal inter-firm linkages within the clusters, as in small-firm-dominant industrial clusters in developed countries, unlike the manufacturing industries that had vertical supply chains? If a small number of domestic large firms and MNCs are so dominant, what roles, do domestic small firms play in the global division of labor? This paper addresses these questions.

In knowledge-based industries such as software, as the sources of competitiveness largely depend on the creation, transmission, and sharing of knowledge, it becomes critically important to build mechanisms that can be used to create, transmit, and share that knowledge. Thus, if small domestic firms are to promote innovation and become more competitive, and shift to higher value-added activities in the global division of labor, it is important to build such internal mechanisms within the firm as well as within the cluster, for skills and technological upgrading.

The objective of this study is thus twofold. First, the study analyzes the internal structure of the Indian software clusters and investigates the relative importance of domestic firms in promoting the development of regional clusters. Second, it examines the patterns of inter-firm linkages that small firms forge within the cluster, between clusters, and across countries in order to

expand their businesses, upgrade their skills and promote innovation.

These are important questions for several reasons. First, many recent studies have focused on the leading firms within the Indian software industry, but the existing literature has paid little attention to the role and performance of smaller domestic firms within the Indian software industry. Second, while there is a growing body of literature on knowledge-based industrial clusters in the context of developed countries, few studies focus on developing countries. Third, many recent studies have focused on the Indian software industry, but few have studied the internal dynamics of the Indian software clusters. Finally, as the development of global linkages is critical for inducing innovation which is important for promoting regional economic growth, the micro-level analyses of the ways small domestic firms in clusters cope with this challenge will help us consider the viability of cluster-based economic development for India and other developing countries.

To examine these questions, I use a case study of the Indian software industry, and especially of Bangalore, the oldest and largest software cluster in India. This paper draws on extensive interviews with about 40 software firms of different sizes in Bangalore (in the state of Karnataka), Delhi, NOIDA (in Uttar Pradesh) that I carried out during three rounds of fieldwork in India between 2001 and early 2005. During these visits, I also interviewed with and collected information from government institutions both at the center and of the state government of Karnataka, and industrial organizations such as the National Association of Software and Service Companies (NASSCOM) and the Electronics and Computer Software Export Promotion Council (ESC).

This paper is organized as follows. Section 2, drawing on the existing literature, conceptually discusses the sources and nature of competitiveness of firms clustered in knowledge-based industries, and the challenges that small firms face in building this competitiveness. Section 3 briefly discusses recent growth trends in the Indian software industry. Section 4 identifies the patterns of geographical distribution of software firms and clusters in the Indian software industry. Section 5 analyzes the strategies that domestic firms in software clusters have adopted to build their competitiveness, with focus on the patterns of their capability development, and of inter-firm linkages between small domestic firms and their affiliates and clients both within India and abroad. Section 6 concludes with a summary of findings and some discussion of their implications for policy.

2. Building the Competitiveness of Firms in Knowledge-based Clusters

Since the 1990s, with globalization and technological change that have gone through at an unprecedented speed, and with increased importance of technological progress embodied in manufactured goods as well as in services, competition has intensified in the global market. Thus, competitiveness has become an important policy concern for both developed and developing countries.[1] Meanwhile, the key determinants of competitiveness are also changing rapidly. As the global economy increasingly becomes knowledge-based, the economic performance of countries and regions depends on a series of relatively immobile resources such as knowledge, technologies and skills, and institutional and organizational structures (Breschi & Malerba, 2001:817). The development of information and communication technologies (ICT), and the diffusion of the internet in particular, have made it easier to network, collaborate and share knowledge, among firms across national boundaries. This has reduced the costs of transportation, communication, affiliations with foreign firms, and outsourcing from overseas clients.

In turn, a new pattern of competition has emerged, based on knowledge and technological advantages, rather than on traditional competitive advantages based on inherent factor endowments. Innovation has become more and more important as a determinant of competitiveness, for developed and developing countries alike. Indeed, OECD observes that "innovation has become more market-driven, more rapid and intense, more closely linked to scientific research, more widely spread throughout the economy" (OECD, 2000: 8).

In order to build competitiveness, therefore, firms, and industries, need to develop their capabilities to innovate. To do so, they must accumulate a set of adequate knowledge and skills that allows them to innovate, and to develop markets for goods and services as well as for finance. Thus, for developing countries to shift towards knowledge-based economies, and for developing-country firms to promote innovation, active public policies may be necessary to ensure the conditions conducive to innovation. In particular, in knowledge-intensive industries such as software, human resources are the main inputs, and thus the knowledge and skills embodied in these

[1] Within the literature, there is no single accepted definition of competitiveness. According to OECD, competitiveness refers to "the ability of companies, industries, regions, nations and supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis" (OECD, 2000).

human resources are an important source of innovation. For all these reasons, it is important to generate, transfer, and diffuse adequate knowledge and skills among firms, and to upgrade them at national, regional (cluster), and firm levels. Porter (1990) argues that continuous improvement and technological upgrading are the most important conditions to keep firms competitive. Thus, building firms' competitiveness must necessarily involve the process of technological learning within and between the firms.

Indeed, challenging the conventional neo-classical thinking that undermines the processes of becoming efficient and of learning to use technologies, evolutionary theorists argue that the vital process of learning to become efficient entails considerable skills development and institutional arrangements (Nelson & Winter, 1982). They also stress that it is not just formal R&D that brings firms to promote innovation, but informal activity at every level in a firm (Nelson & Winter, 1982).

Firms can promote innovation by finding new interpretations for existing information, by adopting new ideas that modify the existing knowledge, and by bringing new people from other industries to the team (Porter, 1990). Moreover, firms do not learn on their own; they often draw on other firms for new information, knowledge, and skills. Especially in developing countries, firms often bring such new interpretations and ideas from abroad. Foreign direct investment (FDI) is clearly an important channel for doing so. Also, experiences in developing countries suggest that start-up firms are important generators of new ideas and innovation, and may have an advantage over large established firms in emerging areas where demand is uncertain and risks are high (OECD, 2000: 9).

Thus, it is important to develop a "forum" for firms to create, share, transmit, and adopt new sets of information, insights, interpretations, and ideas and develop global linkages that would entail inter-firm cooperation. Some argue that the creation of such a forum, or what some scholars call the "regional innovation system (RIS)" (Cooke 2001; Breschi & Malerba, 2001), involving the linkages, networking, and mutual learning among various local organizations such as firms, universities, research institutes, science parks, and technological transfer centers, is a key factor contributing to the development of industrial clusters.

It is well-known that knowledge spillovers and externalities play very important roles in the growth of knowledge-intensive industrial clusters (Breschi & Malerba, 2001; 2005). In order to promote them, it is critically important to develop the internal mechanisms that will let firms and

other organizations create, share, transmit, and adopt the information and knowledge. Industries with international competitiveness facilitate the development of suppliers and other supporting industries by transferring skills and spillovers (Porter, 1990). As firms from other industries enter a cluster, they are all more likely to diversify their R&D, develop new strategies, form new sets of skills, and share information; in turn they create new ideas and upgrade skills, all of which further induces innovation (Porter, 1990).

In the literature, earlier constructs of industrial clusters, or industrial districts focused on dynamic, innovative small firms, which typically forged cooperative horizontal networks among themselves, and played a considerable role in promoting regional growth (Piore and Sabel, 1984; Pyke et al, 1990). Others identified alternative models of industrial clusters, which depict the dominance of the state and/or MNCs in shaping and leading these clusters (Markusen, 1996). In these alternative models, MNCs provide "the glue that makes it difficult for smaller firms to leave, encouraging them to stay and expand, and attracting newcomers into the region" (Markusen, 1996: 294). We might see this phenomenon in the industrial clusters in many developing countries, which are currently absorbing growing amounts of FDI.

Markusen (1996) and her colleagues conducted a study of largely developed-country industrial clusters; she classified industrial clusters into four categories. They are: 1) Marshallian industrial districts, with small, locally-owned firms transacting from one another to produce products for eventual export from the region; 2) hub-and-spoke industrial districts, characterized by the dominance of a number of key firms and/or facilities that act as anchors or hubs to the regional economy with suppliers and related activities spread around them; 3) satellite platform industrial districts, which are "congregation[s] of branch facilities of externally-based multi-plant firms" with the predominance of links to the parent firm and other branch plants elsewhere, and without much connections or networks within the cluster; and 4) state-anchored industrial districts, which are anchored by a public or nonprofit entities, such as military base, a university, or a concentration of government offices (Markusen, 1996: 304). It is interesting to see how adequately these classifications capture the structure of clusters in developing countries.

However, few studies have focused on the role of SMEs within FDI-driven knowledge-intensive clusters in developing countries. SMEs tend to face more constraints than large firms, especially in gaining access to the global markets, responding to the market demands,

and providing services. To overcome these constraints, many export-oriented SMEs use export agents as in Italy, or general trading companies and sales offices as in Japan; others use industry-wide associations and intermediary organizations, organize trade fairs, and conduct market surveys (Porter, 1990). But, in developing-county clusters, SMEs face greater constraints as they try to develop such overseas channels, develop innovative capabilities, and acquire the right set of skills. Moreover, SMEs may be linked to MNCs within the clusters, and to other firms and institutions outside the clusters. These channels may help them not only to become more involved in global value chains but also to upgrade their skills. But so far we know little about how SMEs operate in knowledge-intensive industrial clusters in developing countries: what measures do they actually adopt to build their competitiveness and foster linkages with global markets?

3. The Recent Performance of the Indian Software Industry

This section reviews recent trends in the performance of the Indian software industry, to provide some background for the discussions that follow. The Indian software industry has grown remarkably since the mid-1990s, making the country one of the most promising global IT powers. It is widely known that one source of the industry's competitiveness is an abundant supply of relatively low-cost and English-speaking IT workers (Heeks, 1996; Patibandla & Petersen, 2002; Okada, 2005). As the U.S. software market has expanded, the Indian software and services industry has grown at a rate of 50% annually, with total export earnings reaching US$ 175 million in 1989/90, to US$ 5.7 billion, and further to US$10.01 billion in 2002/03 (NASSCOM, 2004). Also, the share of the IT industry in India's GDP increased from 0.59% in 1994/95 to 2.87% in 2000/01.

As India became increasingly recognized as a destination for global outsourcing, the agglomeration of software and related firms has intensified further in various software industry clusters in India. In more recent years, IT-enabled services (ITES) and business process outsourcing (BPO) have grown remarkably, covering a wide range of areas such as customer services, finance and accounting, and human resource development. Many global firms in a wide range of industries—airlines, insurance, banks, medicine, communications, and media—outsource their businesses to India, taking advantage of India's abundant low-wage semi-skilled workers and the time differences between the U.S. (or Europe) and India. In 2003, the total output of the software and service industry reached 733.5 billion rupees (or US$15.94 billion), accounting for

5.2% of that year's GDP . The average annual growth rate was as high as 33.3% (or 30.6% in dollar terms) (ESC, 2005). In 2003/04, revenues from exports of the Indian ITES/BPO reached US$36 billion, a 46% increase from the year before (NASSCOM, 2004).

The Indian software and services industry relies heavily on the exports, with 580 billion rupees (US$12.6 billion) in 2003/04, accounting for 79% of the total sales of software products and services (ESC, 2005). This is a remarkable increase compared to the export performance a decade ago: in 1993/94, exports accounted for only about one third of total sales. The share of the software sector in India's total exports rose rapidly, from 3.28% in 1996/97 to 10.5% in 1999/2000 (NASSCOM, 2001). Figure 1 shows the exports of software and services from India by category in 2003/04: more than 50% of software and services exports are in the form of customized software application. On the other hand, more knowledge-intensive work, such as turnkey projects and IT consulting, accounts for only 3% and 19% respectively. Moreover, few products have global brand (Government of India, 2001), as Indian software products account for only 0.2% of the global software product market (NASSCOM, 2002). Also, many global IT firms, especially MNCs, have accelerated the outsourcing of their R&D operations to India in recent years. Leading IT firms such as IBM, Intel, Sun Microsystems, and Texas Instruments (TI) have all located some of their operations, especially their R&D, in India.

(Figure 1 AROUND HERE)

As the Indian software industry is gradually moving up the value chain, sub-sectors with higher value added—such as embedded software/ technologies, chip design, and telecommunication—are growing. Moreover, not only IT firms but also global manufacturing firms such as those producing electrical goods and auto components, are increasingly moving to India to outsource their R&D operations. For example, Robert Bosch India, which is a 100% subsidiary of its parent firm in Germany, and one of the largest global auto component manufacturers, established in India its second largest plant after its headquarters in Germany,

developing embedded software for auto components such as control units, tools, and anti-locking brake systems (ABS). It also serves as a service center for Bosch's plants across the world (CMIE, 2004; 101).

The main destination of the Indian software and services exports has been the U.S., accounting for 60% of total exports, followed by the U.K., which accounts for 13.5%. Since 2001, when the U.S. economy stagnated after the IT bubble burst, India has tried to diversify its export markets, focusing increasingly on Asian countries, and Japan in particular; still, Japan accounted for only 4.4% of its export markets in 2004 (ESC, 2005).

4. The Structure of the Indian Software Clusters and the Patterns of Agglomeration

4.1 The Structure of Software Clusters

Not only well-known Bangalore, which is the largest and oldest software cluster in the country, but also several other software clusters have emerged in various parts of the country. These clusters include: Delhi and NCR (national capital region, which includes Gurgaon in Haryana, and NOIDA in U.P.); Hyderabad (Andra Pradesh); Ahmedabad and Gandinagar (Gujarat); Kochi and Thiruvananthapuram (Kerala); Mumbai, Navi-Mumbai, and Pune (Maharashtra); Chandigarh (Punjab); Jaipur (Rajasthan); Chennai (Tamil Nadu); and Kolkota (West Bengal).

The Indian software industry estimated that over 6,000 software firms exist in various locations; of these, about 4,400 are members of the Software Technology Park of India (STPI).[2] Table 1 shows the size distribution of software firms in India as a whole in 2000/01. The table clearly shows the pyramidal structure of the Indian software industry. The majority of firms are small in size, earning only less than Rs. 100 million (approx. $2.2 million) as annual turnover. In recent years, only this category of smaller firms grew in number, while the number of larger firms—those earning more than Rs. 1 billion (approx. $22 million)—remained largely unchanged.

(Table 1 AROUND HERE)

[2] In 1991, the Indian government set up the Software Technology Park of India (STPI) in 29 cities, as an autonomous body under the central government. STPI provides new start-up firms that are registered with STPI with a range of services such as infrastructure and communications on a priority basis, tax breaks for the first five years, and provision of new technologies. In return, these firms are mandated to export their products. For detailed discussions on the role of STPI in the growth of the Indian software industry, see Heeks (1996), Parthasarathy (2000), and Saxenian (2001). At present, STPI is established in 35 cities and the central government plans to set it up in every state.

But, this small number of large firms is playing a leading role in promoting software exports, as well as in developing software clusters in different regions, as they typically have operations in multiple locations. Table 2 shows the export performance of the top 10 software and services firms in India. The top five firms have sales of over Rs. 10 billion (approx. $220 million); interestingly, these are all Indian firms, rather than MNCs. They account for nearly a third of the total software exports from India, and 45% of largely low-tech IT-enabled services (ITES) (Sridharan, 2004). Thus, interestingly, the same firms often undertake both high-end services involving sophisticated systems integration and low-end ITES such as call centers. While many Indian firms achieved their growth based on their global or offshore service delivery model, these top firms and a few others, like Ramco and Iflex, are moving up the value chain by developing proprietary software products and offering high-end consulting services (CMIE, 2004: 3).

(Table 2 AROUND HERE)

In addition, some firms are captive ITES/BPO operations that work only for their affiliates abroad; these include GE Capital International Services, Standard Chartered Bank's Scope International, and American Express. Moreover, many MNCs have operations in India that exclusively service their own plants in other countries, using them as cost centers.

Looking at the cost structure of the software industry, it is apparent that software is a knowledge-intensive industry, with wages and salaries accounting for a high proportion of firms' total operating expenses. The total cost of wages and salaries amounts to nearly 30% of the total sales of the industry as a whole, and that proportion has been growing over the years (see Table 3), reflecting a large demand for IT engineers and a rise in compensation packages for them (Okada, 2005 for detailed discussions on this point). Transport also accounts for an increasing proportion of travel and communication expenses (indicated as "miscellaneous expenses" in Table 3), reflecting the export growth mentioned earlier.

(Table 3 AROUND HERE)

With regard to the geographic location of these software firms, interestingly, the larger firms have multiple operations, with offices in various software clusters, while the smaller ones mostly undertake single or multiple operations within a cluster. For example, Tata Consultancy Services (TCS), the largest IT firm in India, has offices in seven main software clusters: Bangalore, Delhi, Mumbai, Pune, Kolkota, Chennai, and Hyderabad. Each specializes in different line of activities.[3] Table 4 shows the patterns of location-specific division of labor within TCS. Likewise, Infosys, the second largest firm, has offices in 11 locations; four are in Karnataka, including its head office in Bangalore. Similarly, Wipro Technologies, the third largest, has operations in five clusters within India: Bangalore, Chennai, Gurgaon, Hyderabad, and Pune. Thus, the patterns these firms choose in locating their operations clearly differ from those of manufacturing firms such as automobile assemblers,[4] which tend to locate their plants in a single or at most in a few regions. Unlike automotive firms, these large software firms are present in every major software cluster across the country.

(Table 4 AROUND HERE)

Table 5 shows the size and recent export performance of these clusters: overall, India's software clusters have experienced rapid growth in exports in recent years, especially in the last few years. As the Indian software industry caters mainly to the export market, and virtually all exporting firms are members of STPI, the figures for STPI members presented in Table 5 provide a fairly accurate picture of the economic performance of major software clusters in terms of export earnings for the last five years. In recent years, the export market for Indian software clusters has

[3] TCS internal presentation material, December 2004.
[4] For detailed discussions of the geographical distribution of the Indian automobile firms, see Humphrey et al. (1998), Okada (2004).

grown much more quickly than the domestic market.

(Table 5 AROUND HERE)

Table 5 clearly shows that a rising number of firms is located in newly emerging software clusters like Hyderabad and NOIDA, but Bangalore has kept its dominant position as the largest software cluster, in terms of the export performance. Its export earnings reached at Rs. 181 billion (US $39 million) in 2003/04, accounting for nearly one third of India's total software exports. It also suggests that the spatial concentration of economic activities, as measured by export performance, has been intensified in selected clusters such as Bangalore and Hyderabad, rather than in other regions.

Furthermore, Table 6, using the data available from the Prowess database, a firm-level database of the Bombay Stock Exchange (BSE) listed software firms, including some MNCs, provided by the Centre for Monitoring Indian Economy (CMIE), compares the aggregate performance of firms agglomerated in four main software clusters in India: Bangalore, Chennai, Hyderabad, and Pune.[5] While NOIDA in U.P. ranks as the second largest software cluster in terms of export performance in Table 6, the data constraints exclude it here. The firms covered under each cluster are those with a corporate office in that location; therefore the table may not reflect the real volume of economic activities carried out in each cluster, since many firms have multiple offices across different clusters. Pune is quite small as a software cluster remains small, but over the last few years it has had one of the fastest export growth rates among all software clusters in India (see Table 5).

Although this data includes only on the upper echelon of software firms, it still provides a snapshot of the cluster-wise performance, as these firms are likely to contribute more to the cluster's development than non-listed ones. The table also confirms that Bangalore outperforms the other three clusters in terms of sales, profits, export values and R&D expenditures, even though it has fewer BSE-listed firms than other three. This is because many top firms have their registered (and

main) offices in Bangalore, including two of the three top firms, i.e., Infosys and Wipro Technologies, as well as other large firms, such as HP and Global Soft. For these reasons, the rest of this paper focuses on Bangalore cluster in more depth.

(Table 6 AROUND HERE)

4.2 The Structure of Bangalore's Software Cluster

Bangalore, the state capital of Karnataka, is the country's oldest and largest software cluster.[6] As of 2004, more than 1,322 software firms were located there.[7] As of 2003/04, Bangalore housed 110 MNCs, many based in the U.S. and Europe, including major global players (STPI, 2004). The Karnataka IT Directory 2001/02 listed 951 software and services firms in Bangalore; more than 60% were domestic SMEs (see Table 7). Although this total number of firms does not match with the STPI figure, it still helps us grasp the distribution of firms in the Bangalore cluster by firm size.

(Table 7 AROUND HERE)

MNCs have become even more dominant in Bangalore in the last few years, with rapidly growing move among many U.S. firms (and some European firms) to outsource their R&D, as well as their ITES and BPO to Bangalore. MNCs had invested Rs. 197 billion (US$ 4.1 billion) as of 2003/04, while Indian firms of all sizes had invested Rs. 4.37 billion (US$ 92 million) (STPI, 2004). Despite a rapid growth in new startups, particularly among SMEs, the top 10 firms account for 50%

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6 For the historical evolution of Bangalore's software cluster and the detailed analysis of factors contributing to the development of the cluster, see Heeks (1996), Parthasarathy (2000), Okada (2005). For the analysis of software policies that influenced the development of Bangalore's software cluster, see Parthasarathy (2000), Saxenian (2001).

7 The Software Technology Park of India (STPI) -Bangalore (2004). Figure represents the number of registered firms under STPI, Bangalore. Thus, the actual total number of software firms should be larger than this figure.

of exports from Bangalore, whereas SME accounts for only 20%. Of Bangalore's firms, 35% have close ties with those in foreign locations through non-resident Indians (NRI).[8] Clearly, apart from the presence of Infosys and Wipro, the two leading Indian software firms, Bangalore's software cluster has also been driven by its close connection with the global market through MNCs and NRIs.

Figure 2 shows the rapid export growth of Bangalore's cluster in the software and services industry between 1991/92 and 2003/04. With the remarkable growth of the software and service industry, the number of firms in the industry in Bangalore (and neighboring cities) increased from 13 in 1991/92 to 728 in 1999/00, and further to 1,322 in 2003/04. The value of exports increased from US $1.3 million to US $3.2 billion during this period, accounting for 36% of India's exports in this industry (STPI, 2004). US customers account for 54% of Bangalore's software and services exports, while Europe and Japan accounts for 24% and 4% respectively. Clearly, as in the case of Hsinchu in Taiwan (Saxenian & Hsu, 2001), these close links with the US market have contributed to the cluster's rapid growth.

(Figure 2 AROUND HERE)

Especially in the last few years, Bangalore's ITES/BPO segment, which includes banking and financial services, call centers, technical support, and insurance claims processing, has grown rapidly, with the growth rate of 135% in 2003/4 over the previous year, generating more than 60,000 jobs in Karnataka. Indeed, out of 168 firms that started up newly in Bangalore in 2003/04, 26% were in ITES/BPO services, while 49% were in enterprise application services (STPI, 2004).

On the other hand, in recent years, MNCs have rapidly increased their R&D outsourcing. For example, Sun Microsystems and IBM created R&D centers in several locations in India, including Bangalore, and Motorola shifted 90% of the R&D functions for its mobile phone operation to Bangalore. Similarly, Hewlett Packard India (HPI) has a large R&D operation as part of its International Software Operation Department, mainly developing embedded software for HP's hardware products. Accordingly, Bangalore firms have shifted their interest toward high-end

[8] Interview with Joint Manager, STPI, Bangalore, in December 2001.

services such as embedded systems, design and manufacturing chips, and embedded communications (Okada, 2005). Thus, while enterprise software applications development continues to dominate, activities have diversified in Bangalore, requiring a wide range of skills.

Table 8 shows the distribution of software and services exports from Karnataka by segment. While ITES/ BPO currently accounts for only 13% of Karnataka's exports in the software and services industry, the share is likely to increase further in the coming years. However, despite the rapid recent growth in R&D services, under 1% of all software firms are engaged in R&D services for exports, and the value of R&D services in the total sales is only 2% to 7 % (Sridharan, 2004). Although large firms exported almost US $1 billion in R&D services exports (Sridharan, 2004), these services are carried out only by a small number of leading Indian firms such as Infosys, Wipro Technologies, and HCL.

(Table 8 AROUND HERE)

Rapid growth of the software cluster has, however, posed two major challenges to Bangalore: infrastructure and human resources. First, the rapid agglomeration of software firms in Bangalore has caused great congestion on the city's roads, rapid population growth, and a sharp rise in land prices. To relieve the infrastructure pressure on Bangalore, STPI (Bangalore) now plans to promote a centrifugal move of firms away from Bangalore to other satellite cities in the state, such as Mysore, Mangapole and Hubli, by encouraging new investors to set up in these cities instead of in Bangalore. This has resulted in a recent growth of secondary cities as new clusters. Second, the rapid growth of the cluster has resulted in an acute growth in demand for IT manpower, leading to fierce competition among firms in Bangalore to recruit, retain, and continue to train IT workers (Okada, 2005). These over concentration and infrastructure pressure in Bangalore are likely to affect SMEs' performance negatively in terms of rising land prices and increased commuting time required by their employees.

5. Bangalore's Small Firms: Building Competitiveness

In this section, I analyze the role of small firms in Bangalore's cluster: how have they helped the cluster develop, and what are the patterns in their process of building competitiveness? Based on the discussion in Section 2, I consider firm-level capabilities to examine the patterns in domestic SMEs' process of building competitiveness. In particular, this section focuses on three key types of capabilities: 1) technological skills and capabilities;[9] 2) organizational capabilities; and 3) linkages with other firms and institutions both within and outside the cluster. Before analyzing the innovative capabilities of domestic SMEs, however, a brief discussion on the division of labor within Bangalore's cluster is in order.

5.1 The Division of Labor within the Cluster

The Indian software industry incorporates three general business models: a) turnkey projects; b) medium- to long-term contracts for largely offshore-based fixed-term consulting services; c) body-shopping contracts based on time and labor. The Indian software industry has rapidly grown since the late 1980s, mainly undertaking tasks such as coding and programming, mainly for U.S. clients, while taking advantage of the abundant supply of low-cost IT manpower. In the early 1990s, firms used the body-shopping business model, but since the mid-1990s, they have gradually shifted to the model of offshore outsourcing, where most work is carried out in India (Parthasarathy, 2000; Patibandla & Pertersen, 2002). Indian firms still perform a small proportion of turnkey projects, as those require a higher level of integration and higher levels of both technical and managerial skills. Many large firms combine fixed-term consulting services and body shopping; recently, however, they have been increasingly shifting their focus from body shopping to offshore-based fixed-term consulting services.

What activities, then, are SMEs in Bangalore's software clusters engaged in? As I discussed elsewhere, we can see a skill-based hierarchical structure among different lines of activities within the industry (Okada, 2005). However, firm size does not determine the type of activities the firm undertakes. Indeed, leading large firms such as Infosys and Wipro engage in all

[9] Amsden (2001) distinguishes the technological capabilities into three types: 1) production capabilities (the skills necessary to transform inputs into outputs); 2) project execution capabilities (the skills necessary to expand capacity); and 3) innovation capabilities (the skills necessary to design entirely new products and processes) (for details, see Amsden 2001: 3-4, Table 1.2). While this paper largely adopts this definition of technological capabilities, it does not follow it entirely. As Amsden mainly focuses on the manufacturing sector, some skills she discusses may not apply to the software industry.

the levels of activities, ranging from low-end BPO to high-end R&D, although the largest chunk of their work is still in the category of customized software application. Likewise, small firms engage in activities in all the tiers. But unlike the large firms, which practically do all kinds of activities by themselves, however, each small firm tends to specialize in a relatively narrow range of activities. While some small firms are engaged in highly specialized high-end activities such as embedded software and IC chip design, including highly-specialized niche activities, such as VSI design, many others are engaged in relatively simple tasks such as application, data conversion and coding. However, small firms spend far less on R&D than large firms. Also, very small firms rarely engage in BPO activities like call centers which require a relatively large initial capital investment.

On the other hand, global IT firms like IBM and HP carry out a wide range of activities, from high-end R&D to low-end software application services, as well as to ITES/BPO. Other global IT firms like Oracle, Microsoft, SAP, and Adobe largely use their R&D functions for intra-firm exports of software services to their operations elsewhere. Moreover, by 2003, about 100 MNCs had established R&D centers in India as their 100% subsidiaries. Firms like TI and Intel have set up R&D centers in Bangalore, which is the largest R&D center outside the U.S., to design IC chips. Including these, a total of 230 MNCs have established R&D service centers in Bangalore, employing 25,000 Indian engineers, mainly developing telecommunication applications and chip design (Kriparalani, 2004, as cited in Sridharan, 2004). The large presence of these MNC subsidiaries that are mainly engaged in intra-firm software services for other branches of their own firms abroad suggests that Bangalore is a “satellite platform industrial cluster” according to Markusen’s (1996) classification, as discussed in Section 2.

The process of software development typically involves the following flow of value chains: 1) conceptualization; 2) requirement analysis and decisions on specification; 3) high-level integrated design; 4) low-level design; 5) coding and programming; 6) prototyping; 7) testing; 8) delivery, installation, and operationalization; 9) module test; and 10) customer support and maintenance. In the upper stream of the value chains are higher value-added activities. Since the late 1990s, more firms have been trying to move up the value chain by starting such activities as requirement analysis and design.

Within Bangalore’s software cluster, a division of labor occurs among the firms engaged in various steps in the above-mentioned flow. MNCs located in Bangalore subcontract low-end R&D,

including requirement analysis, as well as relatively low-end activities such as programming and coding to local small firms, developing vertical supplier relations (Patibandla & Peterson, 2002; Sridharan, 2004). For instance, MNCs such as Iflex and Motorola have developed long-term, stable contractual relationships with local software firms, including many SMEs. Some MNCs have selected designated subcontractors. For example, Intel subcontracts about 60% of its software development to 20 to 25 local SMEs, although it carries out IC chip design 100% by itself.[10] For high-end core R&D activities, however, MNCs carry out the work internally by themselves or send it to their R&D centers elsewhere. Similarly, Microsoft subcontracts about 70% of work to local SMEs.[11]

These global IT firms offer various opportunities to transfer the latest knowledge and technologies to their local suppliers and users. For example, Microsoft organizes seminars and workshops for local software firms in Bangalore that use the Windows platform, even before new Microsoft versions or products are released to the market, and it provides technical support for problem solving. Moreover, Microsoft has developed "key skill networks," so as to select the right local firms with the right skill sets when subcontracting its work. Likewise, Intel has set up its "Early Access Program." Through this program, the firm provides local software firms in contractual relations, including its suppliers, with new products for trial before they come out on the market. This helps Intel quickly rectify any problems that the local firms identify, before the products go to market, and that local firms also benefit from these trials by learning new features, knowledge, and technologies. Thus, the program brings benefits to both Intel and its local subcontractors, in terms of transferring and sharing information and knowledge, as well as in reducing costs.[12]

The existence of these vertical inter-firm linkages suggests that Bangalore's pattern of agglomeration differs from the Marshallian model of industrial clusters, as in Sillicon Valley and Emilia-Romagna. Rather, it exhibits a pattern similar to that of manufacturing clusters such as automobiles (Okada, 2004). In this sense, Bangalore's cluster also falls into Markuesen's (1996) category of "Hub-and-spoke industrial districts" as discussed in Section 2.

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10 Interview with a software firm in Bangalore (Nov. 29, 2004, Bangalore).
11 Interviews with a software firm in Bangalore (Nov. 29, 2004, Bangalore).
12 Interview with a domestic software firm (Dec. 2004, Bangalore).

Interestingly, however, domestic large firms like Infosys and Wipro Technologies do not use local small firms as suppliers, because they carry out all levels of activities essentially in-house.[13] When these firms experience an increase in demand, they respond by hiring more employees, rather than subcontracting out the work that they cannot handle. These top players in the Indian software industry are export-oriented firms with few inter-firm linkages within the clusters; this suggests a new model of industrial clusters, different from all four categories of industrial clusters classified by Markusen (1996).

In India, few small firms are engaged in developing software products, because the entry risk is high, involving high development costs and a considerable waiting period before they profits appear. In addition, without an internationally recognized brand, it is hard for Indian firms to export software products and packages. Small firms may be interested in product development in the long run, but only a small proportion of them are actually engaged in such activities for revenues, mainly for the domestic market, particularly targeting SMEs as clients. Some small firms do engage in product development in a long-term strategy to diversify their scope of activities, while mainly performing the more profitable application services to guarantee a revenue stream.

On the other hand, horizontal inter-firm linkages also do exist among domestic SMEs that work on product development. For example, a local small firm that I interviewed, which specializes in media-related hardware development, engages internally in upper-stream activities such as conceptualization, specification, and design as well as the final stage of testing/adaptation, but it subcontracts to other local firms the lower-stream activities such as coding and manufacturing/assembling.

Indeed, many firms that I interviewed in Bangalore maintain that they have close social networks among themselves like “friends,” characterized by reciprocal relationships of cooperation.[14] Given the more or less exclusive focus on the export market, and as each firm has exclusive contractual relationships with foreign firms within the cluster or abroad, domestic firms in Bangalore do not directly compete against each other, because they are serving to the U.S. customers. In this sense, Bangalore fits in the pattern of the Marshallian industrial cluster (Markusen, 1996; see also Section 2), like Emilia-Romagna (Piore & Sabel, 1984; Pyke et al, 1990).

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[13] Infosys has set up a subsidiary firm within the same premises which looks after its BPO operation.

[14] Interview with a small software firm in Bangalore (Nov. 29, 2004).

Thus, Bangalore's software cluster shows a mix of patterns of industrial clusters, combining elements of all four categories in Markusen's (1996) classification of industrial clusters: namely, 1) Marshallian, 2) "Hub-and-spoke"; 3) "satellite platform," and 4) the state-anchored industrial districts (see Section 2). Bangalore originally developed in the last form, i.e., the state-anchored industrial cluster. Since the 1950s, many state-owned research institutes, universities, and R&D facilities related to the defense and aerospace industries have been concentrated in Bangalore. This concentration in turn helped Bangalore accumulate industrial engineering skills decades before it emerged as a leading software cluster (Heeks, 1996; Parthasarathy, 2000; Okada, 2005). This suggests that over time a given cluster can be transformed from one form to another as it faces changing external economic environments.

In addition to these four categories of industrial clusters, Bangalore shows another unique pattern, one not captured by existing studies. This is because large Indian private firms, including Infosys, Wipro, and HCL, played such dominant roles in the growth of Bangalore cluster.

5.2 Technological and Organizational Capabilities of Domestic SMEs

In this subsection, I discuss various dimensions of firm-level technological and organizational capabilities among small- and medium-sized software firms in the Bangalore cluster. I focus on four dimensions: 1) individual technical skills; 2) business models and strategies; 3) technology and innovation capabilities; and 4) marketing skills.[15]

1) Individual Technical Skills

Preliminary observations of about 20 small- and medium-sized software firms that I interviewed in Bangalore suggest that the level of individual technical skills of their employees, particularly in programming, is generally good, but lower than that of their counterparts in large Indian firms and MNCs. Due to the fierce competition among software firms in Bangalore to hire the "best talents," from leading engineering colleges such as the Indian Institute of Technology (IIT),

[15] These dimensions of firm-level capabilities build on six dimensions that Veloso et al. (2003) identified in their analysis of firm-level capabilities in the software industries in India, China and Brazil: a) individual technical skills; b) revenue model; c) technology; d) marketing skills; e) process maturity; and f) management. Discussions in Veloso et al. (2003), however, are general and largely refer to leading software firms in these countries.

smaller firms end up attracting the second-tier talents (for a detailed discussion on hiring practices among large software firms, see Okada, 2005).

The skill profiles of employees differ depending on their business models and types of activities. Those SMEs specializing in software application services and ITES rarely employ engineers with doctorates. Instead, many of their technical employees hold bachelor of engineering degrees in computer science and related disciplines. Quite a few of the small firms specializing in web development services commented that for such work, academic backgrounds do not matter much, suggesting that relatively low skill levels are required in software services.

On the other hand, owners of some new start-ups hold doctorates in engineering from well-recognized engineering universities such as IIT; they also have a strong sense of entrepreneurship and a keen interest in technological development. For example, a small firm with 30 employees, which specializes in embedded software for multimedia products (similar to iPod), was set up by a team of three engineers who hold doctorates from IIT. Their highly specialized technical skills have led them to start up this business, often specializing in higher value-added activities than low-end application services. Some had worked with multinational firms, before starting their business as a spin-off. Many of their employees hold master's degrees, such as the three-year Master's in Computer Application (MCA) or a Master's of Science (MSc.) in computer science. These firms easily find suitable employees, as over 100 engineering colleges are located in Bangalore and its surrounding areas.

Software SMEs also invest in a good deal of in-house skills training for their employees, particularly in terms of technical and process skills. These training opportunities also help them retain their employees. As firms try to move up the value chain by moving from simple application work to more complex software solutions and consulting, they require their workers to develop domain knowledge and skills. Thus, they offer training opportunities to their staff, often when they form a new project in a particular subsector (such as finance, banking, healthcare, and telecommunication). Indeed, a medium-sized firm specializing in telecommunications stated that competence in domain knowledge is a key to solving business problems through innovation and to improving product quality.[16] Some firms said they send their employees to training institutions to acquire and develop particular skills.

[16] Interview with a medium-sized firm (350 employees) specializing in telecommunications.

On the other hand, firms that carry out BPO/ITES activities provide extensive training to their staff with more focus on soft skills and attitude training.

2) Business Models and Strategies

Various business models co-exist among the SMEs in the Bangalore software cluster. As discussed earlier, many SMEs rely for their primary revenues on services outsourced from abroad, particularly offshore software application work. They carry out offshore application services projects for individual clients on a fixed-term basis. For on-site services, they tend to bill on the basis of staff time spent at clients' firms; when they engage in offshore services, they usually fixed amounts, which they set out in advance in contracts. Thus these two kinds of services have provided them with relatively secure sources of revenues and ensured sustained growth, given the growing worldwide recognition of India as a major destination for outsourcing work. As many firms are still young, often only a few years old, their scope of activities is limited. Unlike large firms such as Infosys and TCS, small firms often focus on only one or two particular niche areas of specialization such as embedded software, communication software, and multimedia, and niche domains in services that are familiar to them. Interestingly, however, many small firms I interviewed noted that they follow the successful business model of Indian software giants such as Infosys and Wipro. While these two giants have no contractual relationship with domestic software SMEs, they do play a mentoring role for local SMEs, directly or indirectly. This is particularly important for Infosys, which itself began as a small firm.

Firms often find it hard to differentiate their services and to grow beyond a certain level due to decreasing returns to scale (Veloso et al., 2003), but small software firms still enjoy growing opportunities in the global market. In particular, they often see BPO as a strategy to ensure quick revenues and easy success, because they can easily staff their programs by scaling up easily replicable work (except call centers). While many firms have recently enjoyed rapid growth in BPO, the more technology-driven firms deliberately stay away from BPO services. This is partly because the BPO business model is very different from that of software development, partly because BPO services have a lower profit margin (US $12 per hour in BPO, compared to US $24 per hour in software development), and partly because BPO requires a high level of initial investment. Indeed, a BPO firm noted that its infrastructure and utility costs are generally three times higher than those

of software firms, due to its 24-hour operation.[17]

Some SMEs do engage in product development, not so much for the revenues but as a long-term investment. While some of their offshore software services are targeted entirely for exports, they develop software products both for domestic and export markets. Few firms rely on product development as their primary revenue source. They cite several reasons for their difficulties in developing their own products. First, they lack an internationally recognized brand. Second, it takes time to develop their own products, and this kind of investment in product development leaves them at risk, with an uncertain potential on the markets. Third, the sale of products requires their continuous physical presence in the market to provide after-sale support to their customers, which is very costly, indeed beyond the reach of many small producers.[18] Finally, many software SMEs are self-financed firms, making them risk-averse; few are financed by venture capital, which still plays a very limited role in the Indian software industry.

However, many SME owners are aware that the current services-oriented business model will not last very long for Indian firms, as the nature of competition in services, particularly for relatively simple application work, is essentially price-driven. That is, when wages go up in India, these firms will lose their competitiveness in the global market as the work moves to companies in lower-wage economies. They are acutely aware that they need to move up the value chain, to higher value-added activities.

Thus, some owners of new start-up firms began to develop their own products after first developing software solutions services for multiple customers, gradually extending their services as packaged products. Some other SMEs that had focused on applications development have recently started opting to merge with foreign (mainly the U.S.) business consulting firms to offer more consolidated offshore services in business and software solutions.[19]

3) Technology and Innovation Capability

In India, the level of technology penetration is generally low, compared to more advanced markets. The exception is software development, which firms conduct for the U.S. customers.

[17] Interview with a manager of a BPO firm in Bangalore (December 6, 2004).
[18] Interview with a small domestic Bangalore firm specializing in web technologies (December 2, 2004, Bangalore).
[19] For example, Eximsoft (with 130 employees) merged with Trianz (U.S. consulting firm, with 140 employees) in 2005.

Among small- and medium-sized software firms, those that are more technologically oriented (often those interested in product development) tend to invest in applied research as part of their research and development (R&D) activities, albeit small, in order to promote innovation and expand the features of their future products. These R&D activities include prototyping, requirement analysis, and product conceptualization. In some cases, domestic SMEs are engaged in R&D activities subcontracted from MNCs located in Bangalore, such as Motorola and TI, in terms of design, prototyping and testing. Some firms are even involved in pure research, though on a small scale.[20] In addition to in-house R&D activities, software SMEs acquire new knowledge and technologies in many ways: through their foreign clients, through joint work with local universities (e.g., their former academic advisors) and research institutions, and through internet (working on opensource software). They also learn as they work with local institutions such as STPI and ESC, large MNCs such as Microsoft and IBM, and component suppliers, and through mergers with foreign firms, as discussed earlier.

On the other hand, more service-oriented firms, particularly those focusing on BPO, invest less in technological development. They mainly use Microsoft or Oracle platforms, and thus their own technological upgrading efforts are less intense. However, even these service-oriented software firms must themselves keep up with the latest technologies so they can add more complex features in application work to meet customers' demand. Thus, they carry out applied research mainly for process innovation that will improve their efficiency in business processes; they engage in requirement analysis, solutions development, implementation and integration, prototyping, and learning new technologies. Just like larger firms (Veloso, et al., 2003), they want to ensure that their process capability is acceptable to foreign customers, so they are keen to obtain internationally recognized certifications of process maturity such as such as the Software Engineering Institute (SEI)'s Capability Maturity Model (CMM)-Level 5, which is the highest level.

They mainly acquire new knowledge and technologies from their customers, from the open market, from employees who have worked abroad, and by paying licenses and technical fees. They also learn new ideas from published reports and professional papers. Much of their learning entails their understanding both the latest technologies and what their competitors do in the market.

[20] Interview with a small Bangalore firm with 33 employees, which specializes in software applications and product development (November 30, 2004, in Bangalore).

Thus, they largely develop their innovation capability though a daily process of learning and experience. Their foreign customers' requirements are an important motivation to develop their capability.

4) Marketing Skills

As discussed earlier, SMEs face difficulties in marketing their products, partly because they lack an internationally recognized brand. Service-oriented firms often market their services through their own marketing offices, agents and affiliates located in their main markets (notably, the U.S., Europe, and to a lesser extent Japan, Australia and Singapore). These SMEs tend to expand their business through these intermediaries, and through references and personal networks (friends and relatives abroad, who are often NRIs), suggesting that social capital plays an important role in marketing and expanding business opportunities. As I discuss further in the next subsection, these intermediaries also serve as an interface; they translate customers' requirements and transfer technological and domain knowledge as well as information on the market to Indian SMEs.

Like the Indian software giants, even the software SMEs are keenly interested in diversifying their export markets, which are currently highly concentrated in the U.S. Thus, these firms are promoting training for their staff in language skills (particularly in Japanese and German) and skills related to business cultures and business practices in these countries.

5.3 Small Firms and Their Global Linkages

To build global competitiveness, global linkages are critical. Software SMEs are linked with the global market and to the global value chain in various ways. First, many firms undertake subcontracting work from MNCs located in India (Patibandla & Peterson, 2002). As discussed in Section 4, many firms that I interviewed undertake some subcontracting work in applied research, design, programming, and testing, for global players located in Bangalore, such as Intel, TI, and Motorola. This suggests the existence of intra-cluster vertical inter-firm linkages, as in the Hub-and-Spoke" type of industrial clusters identified by Markusen (1996) as discussed in Section 2. Most MNCs in Bangalore have such local subcontractors. Interestingly, however, the Indian software service giants, including TCS, Infosys and Wipro, do not use these local smaller firms as subcontractors. For them, it is more profitable to expand their own operations internally than to

subcontract some processes or some projects.

Second, in recent years, the ITES/BPO sectors in Bangalore's cluster grew rapidly: Bangalore has become known worldwide as a destination for outsourcing various kinds of software and services across many sectors. Global software firms located in the U.S., and Europe increasingly outsource part of their work to smaller firms in Bangalore. That is, these small firms in Bangalore do not work directly for the final users of software applications. Instead, the U.S. or European firms give the work to these firms on a rather piece-meal basis. In order to build global competitiveness, however, SMEs would need to move up the value chain from developing simple software applications to providing more complex consulting services.

Third, like large Indian firms, some SMEs use direct methods to find their overseas clients, mainly in the U.S., and to a lesser extent in Europe and Japan. They have their own overseas agents and affiliates, regardless of whether they work on projects or on long-term consulting. In fact, in the 1990s, more than 250 of the leading Indian software firms established their subsidiaries and branch offices in the U.S.(NASSCOM, 2001). Small firms are now taking the same step. These overseas partners can be private agents, or branch offices of their own firm, or related firms, which are often managed by friends or relatives, often the so-called non-resident Indians (NRIs). These firms are interested in developing their own brand in foreign markets, rather than continuing as subcontractors to overseas clients. These partners not only engage in marketing but also serve as an interface between customers and firms in Bangalore. As discussed earlier, these overseas partners are familiar with market demands and the trends in latest technologies, as well as the quality standards that customers expect, so they can play an important role in translating the requirements and particular requests from customers to Indian firms and in transferring knowledge and technologies to them.

Finally, not only in Bangalore, but also in other software clusters, owners of new start-up firms are relatively young people, often under 30, who graduated from local engineering colleges and have worked for several years at large Indian software firms or global IT firms, particularly in the U.S.. They often set up new firms with a few classmates from engineering college. The knowledge, skills and networks that they brought from their work experience abroad are important assets for these new start-ups. Moreover, Bangalore's software cluster enjoys very close social networks among these former classmates from engineering colleges and their friends, who often

exchange and share information and knowledge, and help each other when they encounter problems. Again, the software industry's almost exclusive focus on the exports prevents the domestic firms from competing directly within the cluster. As a result, these social networks promote cooperation, rather than competition, among local firms.

As seen above, small firms in Bangalore find various avenues to link themselves with the global market. These linkages are established not only through MNCs located in Bangalore but also through their own links with foreign firms and agents. These linkages help them not only expand their exports but also acquire new technologies and upgrade their technological capabilities.

6. Conclusion

In this paper I have examined the role of SMEs in the development of India's software clusters, especially in Bangalore, and the strategies they use to develop capabilities to innovate and build their global competitiveness.

In recent years, the Indian software clusters have grown remarkably as a favored destination for global outsourcing, since many MNCs have entered India; their growth is due largely to the successful growth of large Indian software firms. While a handful of large domestic firms and MNCs have played a key role in driving the growth of both the industry and its exports, many small start-up firms emerged in these clusters. These large domestic firms operate in multiple clusters, in contrast with manufacturing firms such as auto makers that operate in single clusters; still, the smaller firms are usually located in single or multiple operations in a single cluster.

Many Indian software firms are engaged in relatively low-end software application development, while some large firms are moving rapidly into higher-end activities. Moreover, leading MNCs—not only IT firms but also global manufacturing firms—have located their operations, particularly their R&D, in India. As the largest and oldest software cluster in India, Bangalore houses these MNCs, and contributes to the industry's exports, particularly to the U.S. market. On the other hand, the number of software SMEs has increased in recent years, and the BPO/ITES sector has grown very rapidly.

Software clusters have emerged in several locations around the country, but Bangalore remains the country's largest software cluster. In Bangalore, domestic SMEs account for more than 60% of the 951 software and services firms registered in the cluster.

With regard to the type of activities, large domestic service firms undertake all kinds of service activities by themselves, while small firms tend to specialize in a relatively narrow range of activities. Some small firms specialize in high-end activities such as embedded software and IC chip design, including highly-specialized niche areas, but many SMEs are engaged in relatively simple software application development.

This study finds that software SMEs in Bangalore undertake a wide range of activities with different institutional forms. First, through subcontracting, they form some vertical inter-firm linkages with MNCs located in Bangalore. Large firms, including Microsoft and Intel, extensively use local small firms as designated subcontractors. These MNCs offer their designated subcontractorsvarious opportunities, including seminars and training, and the subcontracting firms remain loyal users of these global players' products. Thus, although such subcontracting work does not require these SMEs to have high technological capability, it does provide them access to the new set of knowledge, skills, and information that these MNCs provided. Interestingly, however, large domestic firms such as Infosys and Wipro do not take local small firms as subcontractors.

To assess the competitiveness of domestic software SMEs in Bangalore, I examined various dimensions of firm-level technological and organizational capabilities. First, with regard to individual technical skills, while domestic SMEs have no problem recruiting employees with skills necessary to do the work, their employees' level of individual technical skills is generally lower than that of employees in large domestic firms and MNCs. At service-oriented SMEs, the majority of their technical staff have bachelor of engineering degrees in computer science and other related fields and a few hold doctoral degrees. However, the more technologically oriented SMEs, which were often new start-ups established by a team of engineers, have employees with higher technical skill profiles.

Second, with respect to business models and strategies, I found that domestic SMEs follow various business models. Although few firms carry out product development as a central source of revenue, some SMEs use a combined strategy: they engage in product development as a long-term investment, and meanwhile ensure their short-term revenue stream by providing application development. So far, because the demand for software applications has expanded so rapidly, smaller software firms have grown by tapping this growing demand. Moreover, the recent rapid growth of BPO/ITES has led some of them to shift to BPO, which generates revenues. The more

technologically oriented SMEs tend to deliberately avoid entering into BPO/ITES. However, many firms are aware of the risks in depending on software application work; therefore they use diversification strategies, moving into product development for future investment. Still others deliberately concentrate on a narrow range of niche specialties. Some firms have recently started opting to merge with foreign business consulting firms to offer more consolidated offshore consulting services offering including business and IT solutions.

Third, with respect to technology and innovation capability, while the level of technology penetration is generally low in the Indian software industry, technologically-oriented SMEs tend to invest in applied research as part of their R&D, to promote innovation and expand the product features they can offer in the future. On the other hand, more service-oriented firms tend to invest less in technological development. To gain international recognition, even some SMEs are keen on obtaining internationally recognized certification of process maturity such as CMM (especially Level 5, the highest). In order for SMEs to build global competitiveness, it will be critical to enhance their technological and innovation capabilities.

Finally, with regard to marketing skills, SMEs generally face difficulties in marketing their products, due partly to the lack of an internationally recognized brand. However, service-oriented SMEs often market their services through their own marketing offices, agents and affiliates located in their main foreign markets. These SMEs expand their business opportunities through these intermediaries, and through references and personal networks. As part of their efforts to diversify their export destinations, service-oriented SMEs increasingly prepare their staff with foreign language skills such as Japanese and German, and knowledge of business cultures.

In addition, to build global competitiveness, it is critical to forge global linkages. Many software SMEs are linked with the global market in various ways, i.e., through subcontracting work for MNCs located in Bangalore, through their foreign branch offices and agents, and through alliances with foreign consulting firms. However, Indian SMEs generally subcontract their outsourcing work through these agents, making it difficult to directly communicate with end users. Therefore, if SMEs want to move up the value chain, they will have to offer a complete package of consulting services, which allows higher value addition, rather than offering only a part of such services. SMEs will also need to improve the capabilities of those branches and agents, so they can negotiate directly with end users.

To sum up, Indian software SMEs have great potential to compete in the global market and play an important role in promoting both regional and national economic development. However, in order to expand their business opportunities, they will need to develop both their technological and organizational capabilities to build their global competitiveness. There is much room for public policy to support these small firms' efforts to build competitiveness, in terms of developing technical and marketing skills, and fostering technological and innovation capabilities.

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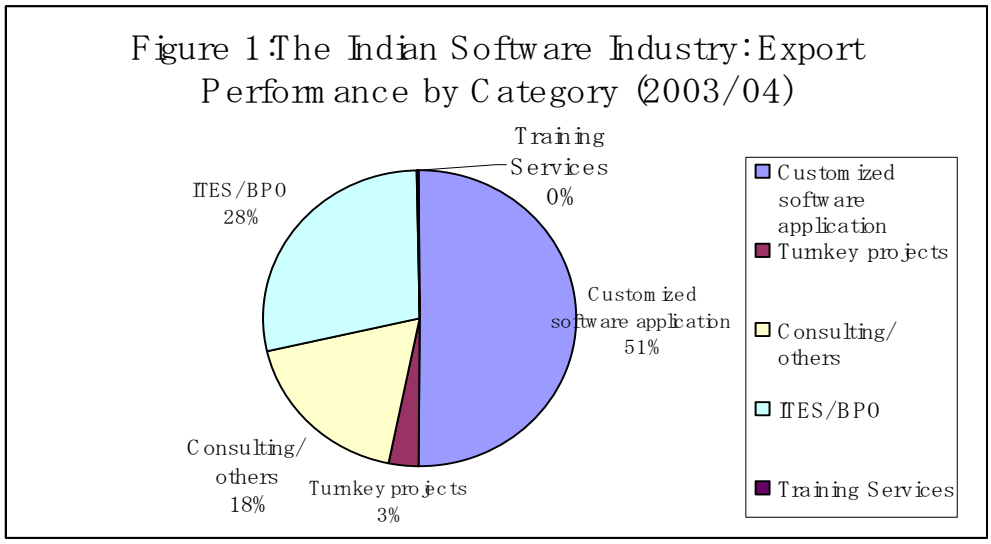

Source: ESC (forthcoming).

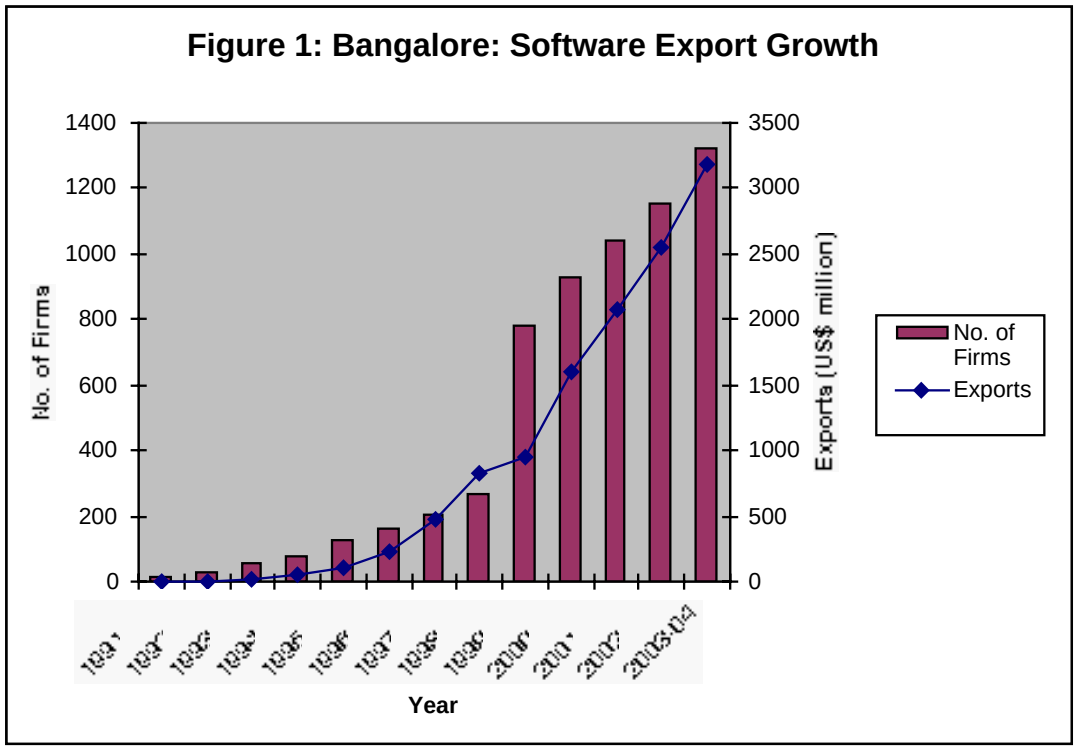

Table 1: Structure of the Indian Software Exports Industry

Annual Turnover (Rs in million)	No. of Firms (2000/01)	No. of Firms (2001/02)
Above 10,000	5	5
5,000 – 10,000	7	5
2,500 – 5,000	14	15
1,000 – 2,500	28	27
500 – 1,000	25	55
100 – 500	193	220
Below 100	544	2,483

Note: Rs. 48 = approximately US$ 1 for the year concerned.
Source: NASSCOM 2003.

Table 2. Top 10 Software and Services Exporters from India

(in US $ million)

Rank	Firm	Annual Sales (2000/01)
1	Tata Consultancy Services	813
2	Infosys Technologies Ltd.	535
3	Wipro Technologies Ltd.	481
4	Satyan Computer Services Ltd.	357
5	HCL Technologies Ltd.	277
6	IBM Global Services India Pvt. Ltd.	160
7	Patni Computer Systems	153
8	Silverline Technologies	126
9	Mahindra- British Telecom Ltd.	113
10	Pentasoft Technologies Ltd.	96

Source: NASSCOM, 2003.

Table 3: The Indian Software Industry: Cost Structure (as % of gross sales)

	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Raw materials	1.73	1.36	1.68	1.02	3.64	2.18	2.06	1.41
Stores & spares	0.21	0.21	0.16	0.14	0.30	0.20	0.21	0.19
Packaging expenses	-	0.00	-	0.00	0.04	0.01	0.03	0.03
Purchase of finished goods	32.04	27.21	18.16	10.51	9.87	8.03	6.54	5.38
Energy (power & fuel)	0.46	0.58	0.45	0.50	0.60	0.59	0.67	0.63
Wages & salaries	13.54	16.70	17.50	19.43	20.32	22.16	27.41	29.78
Plant & machinery repairs	0.38	0.28	0.39	0.37	0.29	0.25	0.25	0.38
Other operating expenses	15.03	14.45	22.98	23.85	19.50	19.74	18.73	18.37
Indirect taxes	0.21	0.23	0.30	0.32	1.52	1.20	0.45	0.43
Change in stock of finished goods	-4.99	-1.53	-0.55	-0.03	0.55	-0.01	-0.04	-0.07
Promotion expenses	4.14	4.07	2.57	2.34	2.42	2.65	1.42	1.29
Distribution expenses	0.07	0.09	0.06	0.04	0.18	0.13	0.09	0.04
Miscellaneous expenses *	11.36	12.65	8.39	8.30	12.74	12.90	12.77	15.09
PBDIT (NOI, NNRT) **	25.11	25.12	28.37	32.18	26.54	28.19	27.34	24.98
Depreciation	4.39	4.58	5.36	5.76	5.32	5.14	5.88	5.98
Financial charges	4.76	5.92	5.26	4.12	2.97	2.18	2.40	2.51
Tax provision	1.57	1.63	2.40	2.81	1.88	2.06	3.21	3.45
PAT (NOI, NNRT) ***	14.39	12.99	15.34	19.48	16.37	18.82	15.85	13.04

Source: CMIE, 2004.

Notes: * Miscellaneous expenses include travel and communication expenses

** PBDIT(NOI, NNRT)= Profit before depreciation, interest, and tax (both net of other income and non-recurring transactions)

*** PAT (NOI, NNRT) = Profit after tax (both net of other income and non-recurring transactions)

Table 4: Location-Specific Division of Labor: The Case of Tata Consultancy Services (TCS)

Location	Activities
Delhi	AS400 Center; Internet & Intranet Groups; OS/2; Netware; Data Communications; Quartz (International Banking Product); AS/400 & RISC 6000; Tools
Mumbai	Corporate Office; E-commerce; Client Server; Tandem; Sequent; SGI; HP; Oracle Group; Multimedia; Visual Computing Lab; Apple Competency Center
Pune	Dedicated Software Research & Development Center; Microsoft Excellence Center; Y2 (International Product for Garment Industry);
Bangalore	IBM 9672-R25; MVS & Open MVS; Networking; LAN/WAN; Communications; HP; Unix; CAD/CAM
Hyderabad	Windows NT, Sun; Unix; Client Server; PeopleSoft
Chennai	IBM 9672-R44 & R35s; ES9000; MVS & Open MVS; Year 2000 Factory; Tools Development; CASE Tools – CASE Pac; IEF; ADW
Kolkota	DEC; Vax/VMS; DEC Alpha; Oracle Financials;

Source: Adopted from TCS internal presentation material.

Table 5: Software Clusters in India: Distribution of Exporting Firms and Recent Export Performance (Rs in billion)

Software Clusters	# of Exporting Firms* (as of Dec. 2004)	Export Earnings in 1999/00	Export Earnings in 2000/01	Export Earnings in 2001/02	Export Earnings in 2002/03	Export Earnings in 2003/04	Growth Rate 2002/03 to 2003/04
Bangalore	705	43.2 (25.0%)	74.8 (27.2%)	99.0 (27.1%)	123.5 (26.6%)	181.0 (31.2%)	47%
Bhubaneshwar	46	0.9 (0.5%)	2.0 (0.7%)	2.1 (0.6%)	2.6 (0.6%)	3.2 (0.6%)	23%
Chennai	535	18.9 (10.9%)	29.6 (10.7%	50.2 (13.8%)	63.2 (13.6%)	76.4 (13.2%)	21%
Gandhinagar	89	0.3 (0.2%)	1.0 (0.4%)	1.2 (0.3%)	1.1 (0.2%)	1.4 (0.2%)	34%
Hyderabad	785	10.6 (6.1%)	19.9 (7.2%)	28.1 (7.7%)	36.7 (7.9%)	50.3 (8.7%)	37%
Kolkota	103	1.5 (0.9%)	2.5 (0.9%)	6.0 (1.7%)	12.0 (2.6%)	16.0 (2.8%)	33%
Mumbai	445	9.6 (5.6%)	16.1 (5.9%)	26.0 (7.1%)	27.1 (5.8%)	43.2 (7.4%)	59%
NOIDA	782	24.8 (14.3%)	44.2 (16.1%)	60.9 (16.7%)	76.0 (16.3%)	99.0 (17.1%)	30%
Pune	306	5.7 (3.3%)	9.6 (3.5%)	20.0 (5.5%)	28.0 (6.0%)	42.0 (7.2%)	50%
Thiruvananthapuram	114	0.6 (0.3%)	0.9 (0.3%)	1.6 (0.4%)	1.7 (0.4%)	2.1 (0.4%)	28%
Sub-total (STPI members in the clusters above)	3,910	116.7 (67.1%)	200.5 (72.9%)	295.2 (80.9%)	371.7 (79.9%)	514.6 (88.7%)	38%
STPI members in other locations and non-STPI members	n/a	56.9 (32.9%)	74.5 (27.1%)	69.8 (19.1%)	93.2 (20.1%)	65.4 (11.3%)	-30%
All India	n/a	173.0 (100%)	275.0 (100%)	365.0 (100%)	465.0 (100%)	580.0 (100%)	20%

Source: The author's calculation using data from STPI internal documents and ESC (forthcoming,).
Notes: As the figures are rounded, the sum does not necessarily match the figures for the subtotal and the total.
* The number of exporting firms in each location refers to STPI members in that cluster. Exports are mandatory for

STPI member firms.

Table 6: Four Main Software Clusters in India: Comparison of Performance

(US$. Millions)

	Indian software industry(n=411)	Bangalore cluster (n= 34)	Chennai cluster (n= 45)	Hyderabad cluster (n= 77)	Pune cluster (n= 8)
Sales	7,492	2,622	511	840	184
Total costs	6,458	2,151	547	74	147
Operating profit	1,340	564	25	131	44
Profit after tax	1,239	528	-41	134	43
Total exports	5,966	2,224	305	624	174
Total imports	2,773	993	167	373	30
R&D exp.	36	11	0	4	1

Source: The author's calculation using data from CMIE Prowess database (2004).
Note: n refers to the number of firms listed for Bombay Stock Exchange (BSE) that have registered offices in the location. Thus, even though many firms have multiple offices in various locations, a firm's performance is captured only in the location where its registered office is located. Activities of those firms that are not listed for BSE are not reflected here, regardless of the size and volume of their activities.

Table 7： Distribution of Software Firms in Bangalore by Size and Ownership

Size	Ownership	Number of Firms	Subtotal
Large	MNC	217 （22.8%）	
	Indian	36 （3.8%）	253
SME	MNC	26 （2.7%）	
	Indian	622 （65.4%）	648
Not known		50 （5.3%）	50
Total		951 （100%）	951

Source: Computed by Author from *Karnataka IT Directory 2001/02.*

Table 8: Software Exports by Segment: Karnataka (2003/04)

Segment	Distribution
Enterprise Application Software	36%
Telecom	16%
System Software	14%
IT Enabled Services (ITES)/ BPO	13%
Embedded Software	10%
IC Design	9%
Others	2%

Total	100%

Source: STPI (2004)