Innovation through Long-distance Conversations?
Lessons from Offshoring-based Software Clusters in Bangalore

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1. Introduction

In recent years, clustering has become the focus of debates on regional economic development among scholars and policymakers. Recent literature, particularly theoretical development in economic geography and regional economics, has expanded and built on Marshall's classic theory of agglomeration economies (Fujita, Krugman and Venables, 1999; Rosenthal and Strange, 2004). The literature on agglomeration and clustering usually postulates that clustered firms and industries gain localized external benefits, such as increasing returns to scale, pooling of skilled labor, and knowledge spillovers. Other authors stress that firms and industries in clusters benefit from regional innovation systems (RIS) or local innovation systems (LIS): that is, regions develop the ability to innovate, as various institutions in clusters closely interact, network, and learn together (Cooke, 2001, 2005; Breschi & Malerba, 2001, 2005). One assumption underlying the various strands of this recent literature is that firms are more likely to innovate and create new knowledge when clustered (Porter, 2000). The reasoning is that spatial proximity between firms facilitates their creation and exchange of tacit knowledge, which has become more and more crucial as codified knowledge has become easily replicable and ubiquitous (Cumbers & MacKinnon, 2006).

On the other hand, as globalization proceeds, more and more global firms, particularly those based in developed countries, opt to outsource much of their work abroad, mostly to low-wage economies such as China and India. No longer does outsourcing apply only to low value-added labor-intensive manufacturing activities: now, highly value-added activities, in both manufacturing and services, are outsourced, including highly knowledge-intensive activities such as R&D in sectors like information and communication technologies (ICT) and pharmaceuticals.[1] As is widely known, many global technology firms outsource their work to India. Indeed, many global high-tech ICT firms have recently set up

operations there. And great many firms in developed countries, most notably in the U.S., have started "offshoring" some or all of their business processes and R&D from India.[2] The great success of the Indian software industry, and its remarkable export growth as a key driver for the country's economic development, have inspired many other developing and emerging countries. Brazil, Mexico, the Philippines, Vietnam, Pakistan and roughly 100 other countries are now making their efforts to develop export-oriented software clusters.[3]

This offshoring model, however, challenges the concept of clustering, particularly the successful experiences of knowledge-based clusters such as Silicon Valley (Saxenian, 1994), on two grounds. First, contrary to the claim in the literature on clustering, offshoring involves little intra-cluster face-to-face interaction between transacting parties, which is considered an important motive for clustering and an important enabling factor for innovation, because clustered firms' clients are largely located across distance. Second, again contrary to the claim, RIS/LIS may play only small roles as a forum to generate and exchange knowledge, because firms in clusters, though agglomerated, may establish their own external linkages to create and transfer knowledge, learning, and innovation, and to expand their markets.

Given this divergence from the theory on clustering, then, what does happen in the offshoring-based software clusters in India whose clients are predominantly foreign? How have they developed their innovative capabilities without the face-to-face interactions with their clients that are considered so important in promoting clustering among innovative firms? What local initiatives, if any, might be effective in inducing innovation, when new ideas mainly come from outside the cluster, and in fact mostly from abroad? This paper examines these questions through a detailed case study of key firms in Bangalore, India's largest software cluster, which has recently seen remarkable growth as a global hub for software development and IT services.

The phenomenal growth of the Indian software industry, especially in Bangalore's software cluster since the 1990s, and particularly since the turn of the century, is widely known and well-documented (Parthasarathy, 2000; D'Costa, 2004; Okada, 2005, 2008). This study draws on personal interviews in December 2004 and January 2005, with 30 software firms located in Bangalore, including both Indian leading software firms and subsidiaries of global IT firms.

In this paper I argue against the popular assertion regarding the links between innovation and clustering: I found that the main sources of knowledge transfer and innovation among key firms in Bangalore's software cluster are their external linkages outside the cluster

rather than face-to-face interactions between firms within the cluster. Moreover, the rich pool of skilled labor, made available through clustering has played an important role in facilitating learning, i.e., diffusing the knowledge brought in by foreign networks.

This paper is organized as follows. Section 2 reviews factors that promote innovation in knowledge-intensive clusters. Section 3 describes the nature of offshoring and outsourcing practices in Indian software clusters, with a particular focus on Bangalore. Section 4 examines intrafirm and interfirm channels and networks forged by software service firms. Section 5 summarizes the main findings and discusses some implications for developing offshoring-based knowledge-intensive clusters in developing countries.

2. Innovation and networks in knowledge-intensive clusters

Various strands of the literature on clustering have pointed to the positive relationship between clustering and innovation. First, the conventional notion of regional clustering has focused on the role of local networks of specialized firms in generating external economies. Such local networks tend to achieve economies of scale as clustered firms cooperate in producing specialized products; they often stimulate learning and innovation through their close interactions, which lead to knowledge spillovers (Breschi & Malerba, 2001, 2005). Agglomerations facilitate interfirm learning as the economy increasingly relies on the transmission of complex uncodifiable information and tacit knowledge. A notable example of this type of clusters is the "old economy" industrial clusters such as automobiles, where lead firms develop close interfirm linkages with their suppliers, which facilitate interfirm learning (Okada, 2004; Okada & Siddharthan, 2006).

Second, other scholars argue that clustering induces more innovative activities by clustered firms, through the creation/presence of the so-called regional innovation systems (RIS) or local innovation systems (LIS), which involve collective learning among various local institutions such as firms, universities, training centers, R&D centers, science parks, and government agencies, facilitating the generation and transfer of knowledge (Cooke, 2001, 2005; Breschi & Malerba, 2001, 2005). In a variant of this body of literature, Kuchiki (2005) proposes a "flowchart approach" to the formation and development of industrial clusters. He suggests the importance of having adequately sequenced policy-induced conditions in place to foster clustering. This involves a series of public policies to attract lead firms, develop related industries, and upgrade human resources and infrastructure. Another variant of this body of literature emphasizes the importance of informal personal networks among key local

entreprenuers, firm managers, engineers, and workers, based on trust, and shared norms and values; these networks facilitate learning and innovation through cooperation (Piore & Sabel, 1984; Pyke, et al. 1990). The existence of a professional community among key players who have often similar backgrounds helps develop such informal personal networks, as in the case of Silicon Valley (Saxenian, 1994).

Third, still others focus on the competitive environment within a cluster as the major stimulus for the clustered firms to innovate (Porter, 1998). Clustering may facilitate firms' learning as they observe and monitor the activities of other firms within the cluster (Isaksen, 2006). Clustered firms tend to gain access to specific information by being in a place where many other firms with related and complementary skills and knowledge operate; this may facilitate copying, learning and incremental innovation.

The literature on knowledge-intensive clusters such as software and biotechnology emphasizes the importance of close contact and interactions, often face-to-face, between firms, clients and suppliers (Isaksen, 2006; Storper & Venables, 2005). Isaksen (2006), studying a software consultancy cluster in Oslo, found that the time-bound project nature of software consultancy enhances a need for face-to-face contact with various collaborators for learning and innovation, thus encouraging consultancy firms to be closer to their client firms. This is interesting, because clustering has been considered to occur among firms that seek economies of scale, by being closer to transacting firms such as suppliers and developing long-term trust-based linkages with them.

Isaksen's study, however, implies that regardless of whether contractual relations are short- or long-term, and regardless of the sectoral differences in organizing production processes and technologies, firms do commonly benefit from direct face-to-face interactions with their clients which stimulate knowledge transfer, learning, and innovation. However, this claim draws on the case where most software firms have clients within the cluster. How relevant is this claim to cases like Bangalore, where most software firms have customers not within the cluster but in foreign markets on the other side of the globe? If close face-to-face interactions are so crucial for inducing innovation, how do offshoring-based software firms in emerging-economy clusters, such as those in Bangalore, overcome this difficulty?

In this connection, some scholars emphasize external linkages to the global economy outside the clusters, particularly clusters in knowledge-intensive industries, as they bring in new ideas, knowledge, and skills to the clusters (Saxenian & Hsu, 2001). Particularly, in the context of emerging-economy clusters, the role of foreign direct investment (FDI) may play

an important role in facilitating knowledge transfer by MNCs. Indeed, knowledge workers and entrepreneurs are known as being "among the most widely connected or mobile people, always on the move and dependent on distantiated connections" (Isaksen, 2006:190). Yet, these mobile knowledge workers tend to share similar norms, academic backgrounds, and work experience, often thus creating the professional community, which in turn facilitates social interactions and provides a network of knowledge sharing. As Isaksen (2006) puts it, flows of goods, services, people, information, knowledge and technology occur within MNCs, between firms and project teams scattered around the world, across cluster boundaries and across national borders (p. 190). Given all this, can such external linkages help overcome the absence of face-to-face contacts for firms in offshoring-based knowledge-intensive clusters? And can they promote innovation?

With respect to innovation, a recent study by Lester and Piore (2004) suggests that the ability to innovate means generating a stream of new products, improving upon old ones, and producing existing products in more efficient ways; doing this depends on the two fundamental processes of analysis and interpretation, so the key to sustaining innovativeness is finding a balance between the two processes (p.6). They say that while innovation involves analytic process, mostly in the form of problem solving, it also involves open-ended interpretive processes, especially when the possible outcomes are unknown and ambiguous. Just as consumers do not always know what they want and need, engineers do not always know what the problems they have to solve (Lester & Piore, 2004:36). Hence, innovation necessarily involves some accidental, random, and experimental elements, and a process of interpretation, during which conversations among people and organizations with different backgrounds and perspectives help identify their problems and generate new ideas, which are both ambiguous at the outset (Lester & Piore, 2004: 49).   They identify the key differences between the analytical and interpretive approaches to product development, as summarized in Table 1.

(Table 1: AROUND HERE)

Thus, following this framework, for those engaged in offshoring, it is important to ensure mechanisms that can facilitate this process of interpretation occurs across distant locations and across national borders. Managers would need to facilitate conversations among people of

different disciplines, technical backgrounds, and cultures, across organizational and national borders. This suggests the importance of having some interfaces that can solicit interpretive conversations between firms, between IT professionals with different backgrounds, and between engineers and their customers.

In this respect, Lester and Piore (2004) suggest that a key issue in innovation, and in new product development in particular, is integration. They identify two kinds of integration. One occurs among technical specialists and across the boundaries of the different firms and organizational units involved in design and production; the second occurs along the boundaries between producers and final consumers (Lester & Piore, 2004; 24). Thus, they stress the important role of boundary management in corporate integration efforts.

The above discussion suggests that we need to understand how firms manage their organizational boundaries, between different units within the organization and between firms; I focus on this process in the next sections.

3. Patterns of offshoring in Bangalore's software cluster

This section briefly describes the patterns of offshoring commonly undertaken by software firms in Bangalore, India. Several scholars have identified salient factors contributing to the formation and development of Bangalore's software cluster (Parthasarathy, 2000; Saxenien, 2001; Okada, 2005). Among them are a large pool of skilled labor and very dynamic local labor markets; the historical agglomerations of high-technology firms and research institutions; historically cosmopolitan cultural environments and pleasant year-round climates; active government interventions at both national and state levels; and the successful experience of first-mover FDI firms, which have attracted other FDI firms (see Okada, 2005 for details). Bangalore is receiving increasing attention as an outsourcing destination for global firms. In this section, I consider the nature of software development and services, and offshoring work in particular, focusing on activities that promote innovation.

Containing over 1,300 software firms by 2003/04, Bangalore's software cluster has grown remarkably since 2000, largely driven by several large Indian firms, such as Tata Consultancy Services (TCS), Infosys Technologies, Wipro Technologies, Satyan Computer Services, and HCL. These firms have transformed themselves to become global MNCs, with operations in many countries, by offering a wide range of contracted software services in outsourcing. Bangalore has also housed over 240 global technology MNCs, and over 600 Indian SMEs (see Okada, 2005, 2008 for more detailed discussions on the structure of

Bangalore's software cluster).

3.1 The Nature of software development and services

Before discussing the patterns of offshoring in Bangalore's software cluster, it may be useful to review the nature of software development and services work. The software industry encompasses a wide range of activities that may be divided into five subcategories: 1) platform suppliers; 2) product development; 3) application software development; 4) software solutions and consultancy; and 5) after-sales services (support, maintenance and training).[4] This section does not consider non-software activities such as IT-enabled services (ITES) and business process outsourcing (BPO), which include a wide range of back office activities using IT, although many software firms engage in ITES/BPO. Below, I describe each of the five types of activities. Though firms often engage in several of them simultaneously (Okada, 2005), it is useful to understand them separately, as they often determine the organizational boundaries between firms, or between divisions within a firm.

3.1.1   Global technology firms and platform suppliers

Global technology firms, particularly platform suppliers, deliver generic technology and tools that other firms use as the basis for developing software solutions (applications) by other firms (Isaksen, 2006: 195). They are mainly large, global (and mainly US-based) IT firms, like IBM, Microsoft and Oracle, with subsidiaries and branch offices in various locations, including Bangalore. Most Indian firms, including many SMEs, in Bangalore use the platform technology to develop their own products and applications.

For these global platform suppliers, the key to competitiveness is their large R&D efforts, which occur mainly in their US headquarters and increasingly in their offshore captive centers (subsidiaries) in India, most notably in Bangalore. Among software firms in the Bangalore cluster, these captive centers of the global technology firms such as Texas Instruments (TI) and Hewlett Packard (HP) carry out the most innovative software work--more innovative than giant Indian firms such as Infosys and Wipro. By developing technology and selling licenses, platform suppliers are able to engage in other activities such as consulting services, and customer support and maintenance.

3.1.2   Product development

Developing software takes time and risk; it requires considerable initial capital, a large hardware market, and extensive distribution channels. Moreover, without internationally

recognized brands, Indian software firms find it hard to export packaged software products in global markets. In addition, for their software products to be competitive, firms need to develop deep domain knowledge, coupled with strong managerial and marketing skills (Carmel & Tjia, 2005). Therefore, few Indian software firms are engaged in developing proprietary or packaged standard software products. But many allocate a small proportion of their business to product development as an investment for future expansion of their businesses; meanwhile they focus on application software development and consultancy as their main source of revenue. Product development often takes the form of continuously upgrading existing products (Isaksen, 2006: 196).

Most large Indian software firms carry out offshoring-based R&D projects for foreign firms. For example, TCS has over 700 engineers in its R&D center in Pune (in the state of Maharashtra); many work on such areas as software engineering, language processing, design, new product development, and applied research.[5] Likewise, Wipro has over 6,500 engineers in its software R&D division, which takes on R&D projects for foreign customers (Carmel & Tjia, 2005). And roughly 200 engineers in Infosys's R&D unit are grouped by their area of activity, such as software engineering technologies, e-commerce, telecommunication, and domain research.[6]

3.1.3 Application software development

Application software development entails adapting and customizing standard software developed by other firms to meet the requirements of each customer firm. This includes consulting services, such as installation, integrating new solutions in the customer firms, training employees of the customer firm, converting existing data to a new software system (Isaksen, 2006: 196). This is the largest category of activities carried out by Indian firms, both large ones and SMEs. Software development involves several phases, including identifying and analyzing client needs, prioritizing among various demands, deciding on specification of software, designing the software, programming, testing, and delivering. Of these phases, Indian firms initially focused on low-end application software development, particularly in low-end design, programming and coding.

3.1.4 Software solutions and consultancy

Consultancy projects entail the development of customized solutions, such as developing and implementing a new software system for a client firm (Isaksen, 2006: 196). Top Indian software firms, such as TCS, Infosys, and Wipro, have all achieved extraordinary

successes in offshoring-based software solutions and consultancy services; by 2003, they had captured business with more than half of the US Fortune 500 firms (NASSCOM, 2004). Consultancy projects often include advice on the purchasing and installing software products; analyzing businesses' processes, competence and business needs; organizing business activities for client firms, and preparing IT strategies (Isaksen, 2006: 196). These firms often develop new customized software solutions, building on those developed in previous projects. Firms may develop standardized programs or solutions based on successful projects, involving the process of converting tacit knowledge into codified knowledge. They serve client firms from a wide range of sectors including insurance, finance, banking, telecommunications, defense, and the public services, and increasingly many manufacturing firms. Firms that have long-term projects with certain clients send their workers to be placed on site at those firms.

Consulting firms develop their competitiveness in several ways: they continuously build on their competence and skills, their workers continuously update their knowledge, and they seek exposure to the latest technologies in the field (Isaksen, 2006: 197). Firms often assemble teams that include the different skills sets required to complete the tasks, for each project (Okada, 2005). They often hire new workers with specialized skills if they cannot find the appropriate skills internally. Some members of the project may spend time on-site at a client firm, especially at the early stage, to understand the client's requirements and ways of conducting business. At the same time, these consulting firms often provide extensive internal training to their employees to update their skills and knowledge. New knowledge is diffused internally within the firm through such training and websites.

3.1.5 After-sales services (support, maintenance, and training)

Most software firms carry out after-sales services: they provide customer support, maintain software systems, and train the client's employees to use the systems. While these after-sales services often entail fairly standardized procedures, they also serve as a feedback mechanism to provide new information from customer firms back to their product development work.

Typically, Indian software services firms, such as Infosys and TCS, organize their operations and project units in a matrix, some types of activities (product development, application development, solutions and consultancy, after-sales support) are on one axis, and various industrial domains (banking, financial services, insurance, telecommunication, manufacturing) are on the other.[7] Project teams are assembled based on this combination of

skill sets, which also determine the organizational boundaries between units and between projects.

With respect to contracts, most software development falls into one of two models: either a short-term project, often on a one-by-one basis, or an on-going contract with particular clients. One form of the latter is an offshore development center (ODC). A software service provider firm dedicates a software development center to a foreign client firm; the client may offer some specialized hardware and software, while the provider may allocate dedicated staff and other resources just for this client (Carmel & Tjia, 2005: 105).

3.2   Patterns of offshoring-based software development and services

Several factors explain the recent phenomenal growth of offshoring practices widely observed in many industries and services, especially software. First, the recent remarkable technological advances in ICT have dramatically reduced communication costs almost to zero. Second, faced with intensified global competition, firms in developed countries, most notably those in the U.S., have had to respond to growing cost pressures, making offshoring a critical strategic necessity (Carmel & Tjia, 2005). Third, on a related point, low-wage economies like India and China have large pools of English- fluent and well-trained yet low-wage scientists and engineers. Fourth, time differences between the U.S. and India make it possible for US-based global technology firms to work around the clock. Finally, in recent years, software development practices and tools have become so standardized that software tools have become nearly undifferentiated by producer (Carmel & Tjia, 2005: 4). Given the high level of standardization, can offshoring practices allow Bangalore's software cluster to develop innovative capabilities?

Indeed, in an earlier nascent phase in the 1990s, many Indian software firms were mainly engaged in low-end labor-intensive tasks such as data conversion, software customization, web site development and hosting, and reuse of codes, all of which have become increasingly standardized. Activities such as bug-fixing (in the maintenance phase) and after-sales technical support are also considered suitable for offshoring, because they are small tasks, of low complexity, and can be routinized between different sites (Carmel & Tjia, 2005: 12). Indian firms initially entered this segment in the global (mainly U.S.) market, by sending their lower-wage Indian engineers to their customers' premises onsite, in a practice dubbed "body-shopping" (Parthawsarathy, 2000). As Bangalore's software cluster grew, however, and its software firms proliferated, the practice of offshoring also expanded, not

only among subsidiaries of MNCs, including platform suppliers and large Indian software firms, but also among many Indian SMEs. Foreign clients of these offshore Indian firms are not only software end-users (such as banks, airlines, and manufacturing firms) but software firms, which in turn provide services to end-users. In the latter case, Indian firms subcontract, taking parts of a large project on a small project basis.[8] Table 2 shows the changing patterns of modes of delivery of software services exported from India.

(Table 2: AROUND HERE)

Software work is commonly divided into about ten stages: 1) conceptualization; 2) requirement analysis and specification; 3) high-level (integrated) design; 4) low-level (detailed) design; 5) coding and programming; 6) prototyping; 7) unit testing; 8) delivery and integration; 9) system testing; and 10) customer support and maintenance (see Figure 1). As Figure 1 shows, the work flow is actually a reversal of the value chain flow: The more upstream activities a firm is engaged in, the more it moves up the value chain.

(Figure 1:   AROUND HERE)

Among these stages, those most often offshored are 4) low-level (detailed) design, 5) coding and programming, 6) prototyping; 7) unit testing, and 10) customer support and maintenance. These activities are mostly standardized, can be precisely defined and specified, may be considered tedious, repetitive, and undesirable (Carmel & Tjia, 2005: 14). Indeed, many offshore activities are single projects that are contracted on a piecemeal basis, rather than the entire processes being transferred to outsider firms (Carmel & Tjia, 2005). According to a small Indian software firm in Bangalore, activities such as low-end (detailed) design, coding and programming follow the standard guidelines and procedures set by the industry such as SEI CMM.[9] These activities thus largely rely on codified knowledge; therefore, according to Lester and Piore (2004), they are analytic (see Table 1 in Section 2).

By contrast, activities that tend to stay onshore, often in the headquarters of MNCs, are 1) conceptualization (i.e., what client firms want); 2) analysis of customer requirements (i.e., what product will be needed, and what product should look like); 3) high-level (integrated) design; 8) delivery and integration; and 9) system testing. These activities require little standardization, but they do require close, and often face-to-face, interactions with

customers. They also require deep domain knowledge, and deep cultural knowledge, because of the need to meet with clients and talk to them in their own language (Carmel & Tjia, 2005: 14-15). These processes require extensive conversations between engineers who have technological knowledge and people who have solid domain knowledge, and between software development firms and their customers. Thus, according to Lester and Piore (2004), they involve interpretive processes (see Table 1 in Section 2).

As Figure 1 shows, these are also higher-end activities that add higher value, as they are more creative, innovative, and research-oriented, requiring broad knowledge (Carmel & Tjia, 2005: 15). These activities constitute an important part of the consulting work discussed in the previous subsection. Global technology firms based in developed countries tend to keep these activities at home (onshore) to maintain their competitiveness (Carmel & Tjia, 2005: 15). But some Indian software firms, and even SMEs, are taking on product development projects, however small, going through the entire process from conceptualization to final product release. And many Indian firms, including SMEs, want to expand the scope of their activities by moving up to higher-end activities.

The offshoring model poses some important challenges to both the clients in developed countries and their service provider firms in India. Carmel and Tjia (2005) identify five important challenges: 1) It is difficult to communicate over distance; to convey some ambiguous ideas and tacit knowledge using e-mail or the telephone. 2) Coordination can be difficult; software development requires a series of adjustments between the firm and its customers. People working on a software project normally coordinate with their team members on the project and their customers through numerous adjustments, which often occur through "spontaneous, face-to-face conversation" (Carmel & Tjia, 2005:12). Obviously, offshoring makes such conversations difficult, so necessary adjustments are harder. 3) Monitoring and controlling software production processes can be hard: "successful management control takes place when managers can roam around to see, observe, and dialogue with their staff" (Carmel & Tjia, 2005:12). But, with offshoring managers can hardly supervise their staff this way. 4) It is hard to develop social bonds; offshoring makes it difficult to create a sense of teamwork and build trust among project members who are so far away from each other. 5) Cultural differences interfere; offshoring inevitably places the staff in cross-cultural setting, requiring them to develop cross-cultural communication and understanding, which is hard to come by.

Given that the division of labor within the global software industry takes place along

these phases between onshore and offshore locations, and given these difficulties in offshoring operations, Indian software clusters have little scope to become innovative, unless they engage in higher-end activities and move up the value chain. Indeed, given that India's software industry has concentrated heavily on relatively low-end services, some authors even argue that the Indian software industry is not innovative, as it has a very small domestic hardware market (D'Costa, 2004). If this is true, have software clusters in India, especially in Bangalore, grown without innovation, totally challenging the notion of close links between clustering and innovation?

But if Indian software firms provide offshoring services involving little innovation, it raises a further puzzle: why have so many global technology firms agglomerated in Bangalore and why many Indian software firms have grown so remarkably to become software service firms offering contracted R&D activities to the world's top companies?

Indeed, global technology firms, mainly platform suppliers, which engage in higher-end activities, go beyond cost reduction concerns and benefit from innovation, speed, and flexibility, through offshoring from India (Carmel & Tjia, 2005). These firms engage in offshoring to increase their speed and flexibility, taking less time to complete projects, and responding quickly to rapidly changing business needs, and improving innovation capabilities by tapping highly-skilled and creative engineers. Indeed, by 2003, 77 global software product firms had established direct R&D subsidiaries in India (Carmel & Tjia, 2005: 11). A question remains: how have software firms acquired and developed their innovative capabilities? The next section addresses this question.

4. External linkages of software firms in Bangalore

This section addresses the channels and mechanisms through which knowledge for innovation is transmitted to software firms in Bangalore, with particular focus on their external linkages. The recent literature on clustering and networks points out the important role of external linkages in clustering and innovation (Saxenian & Hsu, 2001; Breschi & Malerba, 2001, 2005; Cooke, 2001; 2005). For emerging clusters such as Bangalore, external linkages may allow clustered firms access to knowledge, skills, contacts, capital, information on customer demands, technologies, and market trends.   On the other hand, for established and mature clusters such as Silicon Valley, external linkages with other regional clusters allow clustered firms to upgrade the industrial base and reduce the risk of lock-in by keeping the cluster open to new ideas and technologies (Breschi & Malerba, 2005). In other words, such external

linkages may facilitate "the conversation" among entrepreneurs and knowledge workers across different geographical locations (Lester & Piore, 2004), creating a forum for exchanging ideas and interpretations, which thus may induce innovations.

Bangalore firms are engaged in five types of external linkages: 1) intrafirm linkages between subsidiaries of MNCs (including platform suppliers); 2) interfirm linkages, including alliances with global firms; 3) international movement of highly-skilled technical and managerial workers; 4) deployment by software firms of their staff to client firms abroad on a fixed-term basis, ranging from a few weeks to a few years; and 5) the extensive use of agents, particularly for Indian firms, who serve as interfaces and interpreters, and transmit knowledge to software firms in Bangalore. In the rest of this section, I discuss the experiences of firms in Bangalore, with respect to each of these five types.

4.1   Intrafirm linkages and global division of labor within MNCs

Both Indian-based and US (or European)-based MNCs operating in Bangalore have their own global networks. For example, TCS, the largest Indian software firm, which was established in 1968 and had a total revenue of US\$ 1.56 million in 2003/04, has operations in 47 countries, with 152 offices across the globe.[10] Within India, it also has operations in seven clusters beside Bangalore: Delhi, Mumbai, Pune, Chennai, Hyderabad, Calcutta, Lucknow. Each location specializes in different types of activities, exhibiting interesting patterns of intrafirm division of labor. All its locations within India are connected through its Intranet. TCS provides mostly foreign clients with diverse IT consulting and services in the areas of IT technology and infrastructure, architecture, design and development; testing and deployment; and systems integration; and application management. In particular, by 2005, TCS had set up 33 client-dedicated offshore development centers (ODCs), spread over 10 cities in the North America, Budapest, Melbourne, Montevideo, Guildford (England), Haungzhou, and Yokohama.[11] Similarly, Infosys and Wipro have dedicated R&D centers for particular foreign clients. These ODCs and R&D centers dedicated to foreign clients clearly help facilitate close interactions between these Indian software firms and their clients including leading global technology firms. Thus they facilitate the interpretive processes described earlier, and in turn they help them develop innovative capabilities.

A large pool of highly-skilled IT professionals available in Bangalore (see Okada, 2005 for detailed discussions) has enabled these global firms to develop a well-coordinated intrafirm global division of labor, efficiently deploying the best talents to specific types of

projects even in niche areas. These talented software engineers are key to competitiveness and innovation in software R&D. For example, 7,000 to 9,000 engineers are involved in IC chip design in India; about 60% of them work in the Bangalore cluster.[12] The large supply of highly-skilled software engineers has clearly attracted many MNCs to locate in Bangalore, including their R&D centers. This has led to considerable knowledge and skill transfers to local firms in the cluster (Patibandla & Peterson, 2002). In turn the agglomeration of these leading global IT firms has led many well-trained software engineers to gather in Bangalore (Okada, 2005), creating a virtuous circle. Among software firms in the Bangalore cluster, these captive centers of global technology firms carry out most innovative software work—more innovative than activities done by Indian most successful software services firms such as Infosys and Wipro.

For example, Texas Instruments (TI), the first MNC to set up an offshore operation in Bangalore back in 1985, takes advantage of elaborate intrafirm division of labor linking its many operations across different countries. Figure 2 illustrates the pattern of its intra-firm division of labor across countries, which the firm introduced to take advantage of the "24x7" design cycle, and to reduce production costs. Within TI, however, the most innovative function—silicon research—is still carried out only in the US.[13]

(Figure 2: AROUND HERE)

It is worth mentioning here that global platform suppliers and technology firms also do forge internal linkages, within the cluster, with these local software firms that are users of their platforms. For example, Microsoft has its own certification schemes to select local software firms that depend on Microsoft platforms, and organizes seminars for these local users to diffuse knowledge related to its product.[14] Likewise, Intel has developed partnerships with its product users through the firm's "Early Access Program," which allows local users to test its new product before it goes on the market so that it can get some instant feedback from them. Intel responds to comments received from these local users by rectifying the problems they identify. This way, knowledge transfer and diffusion also occur between these global technology firms and local software firms within the cluster.

Also, these global platform suppliers and technology firms use many local firms, mainly SMEs, as subcontractors for low-end software development activities such as low-end

designs and programming. These tasks are highly standardized and routinized, and thus leave little room for local subcontractors to engage in innovation activities. In fact, Intel's software development is almost entirely carried out by local Indian firms, including large giants such as Wipro and Infosys, while Intel maintains its chip design work—higher-end activities—internally. Similarly, about 70% of Microsoft's work is subcontracted to local software firms on a project basis.[15]

In other words, global platform suppliers located in Bangalore forge vertical interfirm linkages within the cluster. But, these vertical linkages differ from those in "old economy" manufacturing clusters, where large MNCs firms play a leading role in developing their supporting industries within the cluster by forging backward linkages with local firms. Interestingly, by contrast, in Bangalore's software cluster, large global MNCs create both forward and backward linkages with local Indian firms. Internal vertical backward linkages created within the cluster between MNCs and local firms, however, do not lead the latter to develop their innovative capabilities, because the work subcontracted to local firms is so standardized, repetitive, and tedious.

4.2   Interfirm external linkages and alliances

Many firms in Bangalore forge extensive external links with firms and other institutions outside the cluster. For example, IBM, a leading global platform supplier, entered into a strategic alliance with i-flex, an Indian software product development firm, producing a banking software product on the IBM platform. IBM provides technical support for i-flex, as it does for many other software firms that use the IBM platform. These arrangements facilitate knowledge transfer from the global platform supplier to the Indian firms.

Many Indian firms, including SMEs, use another strategy to move into higher-end activities and to become more innovative: merger and acquisition (M&A). For example, Eximsoft, Ltd. a Bangalore-based Indian medium-sized firm providing relatively low-end offshore software services to foreign clients, entered into a M&A deal and was acquired in December 2004 by a US-based technology consulting firm, to grow into a high-end consulting and technology services firm with greater geographic coverage for its market.[16] This kind of alliance allows Indian SMEs to gain access to higher levels of domain knowledge, managerial skills, and markets. Moreover, it facilitates "conversations" between professionals who have different backgrounds, business cultures, and experiences; this generates more creative ideas and inspiration, and thus is conducive to innovation.

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In addition, some Indian firms have forged partnerships with foreign universities and research institutions. For example, TCS has established partnerships with over 12 universities around the world, including the University of California at Los Angeles, the University of Wisconsin, Milwaukee, and Carnegie Mellon University, for collaborative technology development (see Table 3). In addition, TCS annually sends 5 to 10 employees to these universities for study and joint research.[17] Clearly, these partnerships provide TCS with access to the latest technologies and allow the firm to engage in innovation. Interestingly, while the literature emphasizes the important role of firm-university links within the cluster as part of the local innovation systems (LIS) as discussed in Section 2, the experience of TCS shows that its links with universities outside the cluster across distance actually help the firm develop its innovative capabilities.

(Table 3: AROUND HERE)

4.3 International mobility of a highly professional workforce

Bangalore's software cluster benefits from a high level of international mobility, as highly-skilled IT professionals move between India and other nations. This mobility arises from two sources: First, as is well-known, Indian engineers who have studied and worked in foreign countries, especially the U.S. return to India. Second, Indian professionals are assigned to foreign client firms to carry out onsite work, on a short-term or long-term basis, often as a part of their projects, as discussed in the next subsection.

Returnees from the US do not yet constitute the kind of large professional community in Bangalore (Okada, 2005) that they do in Taiwan (Saxenian & Hsu, 2001). Indeed, even TCS, the largest Indian software firm, which has a staff of over 40,000 associates/ engineers, has virtually no Ph.D. holders. About 60% of its engineers hold a bachelor's degree, and 36% hold master's and MBA degrees; these are mostly graduates from India's best educational institutions. However, among the young entrepreneurs who are starting India's software SMEs, it is increasingly common to find some returnees who were educated in a foreign (mainly US) university and have worked in large technology firms in the US before they returned to India. For example, a small Indian software services firm was established in 2000 by three young entrepreneurs who are friends, including one engineer who worked with Microsoft at its Richmond headquarters for 8 years.[18]

Moreover, even at small Indian software development firms a considerable number of employees have foreign experiences. For example, of the 70 employees at a medium-sized firm established in 2003, 12 have overseas work experience, and the owner noted that their experiences are valuable to the firm.[19]

A more common practice is intrafirm transfer of Indian professionals of MNCs, Indian large firms, and even medium-sized firms, between India-based operations and their overseas operations. For example, even a medium-sized Indian software firm in Bangalore, one with 150 employees, assigns 40 of them to its office in Japan.[20]

4.4   Combination of offshoring and on-site work

Also, many firms claim that demands from their customers, often in the US market, are an important source of innovation. This means that not only supply conditions but also demand factors are important in influencing software firms' innovation activities. Clients of exporting firms are located across national borders, often on the other side of the globe, which obviously makes face-to-face interactions difficult. To overcome this problem, they send their workers to client firms for a few months, or even longer, to work with the software systems on-site; this allows them to closely interact with their clients. This is particularly effective as it facilitates cross-cultural and cross-sectoral conversations, and thus promotes the process of interpretation.

4.5   The role of external agents

Most Indian software exporting firms use some agents, as an intermediaries, in their foreign markets, such as the U.S., Europe, Japan, and sometimes in Singapore, Malaysia, and China. These agents act as an interface between the Indian software firms and their overseas clients. These agents may be firms' branches, sales offices, and subsidiaries; in other cases they are personal friends, relatives, or a few marketing staff. Virtually all the 30 firms that I interviewed had some of these overseas agents, often in multiple locations. They are often Indian, and sometimes the non-resident Indian (NRI). For example, a small Indian software firm with 40 employees, established in 1996, has an associate in Singapore and another in the U.K. These associates understand the needs of clients, monitor the projects at clients' sites, and also look for new clients.[21] Another small Indian firm has 11 associates abroad, mostly part-time independent consultants, handling 10 to 12 clients each; they provide close monitoring and customer support, and identify new clients.[22] Another firm, established in

1999, has 35 employees; it has two agents in Malaysia and the U.S., who are the owner's relatives, and also collaborates with independent associates on a contractual basis. The owner says these overseas networks help transfer technical knowledge to the firm, provide it with financial support, and help identify new clients and source materials.[23]

These agents understand not only the nature of their clients' business but also the larger business environments, market trends, and clients' languages and culture. Thus they are effective as an interface in facilitating "conversations" between the Indian firms and their clients across distance. In turn they facilitate interpretive processes, because these agents convey not only technological information and domain knowledge, but also demands and feedback from customers. They visit customers on site to discuss and understand the clients' problems, which they then convey to the Indian firms. Indeed, according to many firms that I studied, an important force that motivates Indian software firms to innovate is demands from customers.[24]

5. Conclusion

This paper, drawing on a case study of Bangalore's software cluster, has examined how firms in offshoring-based knowledge-intensive clusters in India have developed their innovative capabilities, despite having little face-to-face interaction with their predominantly foreign clients, a factor considered to promote clustering among innovative firms and to facilitates innovation. The study has first identified what types of software development and services activities are outsourced to Indian software firms in Bangalore by foreign client firms in mainly developed countries. It revealed that those offshored software development and services activities are mostly relatively low-end, labor intensive, standardized and repetitive activities such as low-end (detailed) design, programming, coding, and maintenance. Yet, in recent years, Indian software firms in Bangalore have diversified their types of activities in order to move up the value chain; more firms are now increasingly engaged in higher-end activities such as product development and R&D, and even take on the whole life cycle of software development activities.

This study found that leading software firms in Bangalore have devised various channels to engage in long-distance conversations with other divisions of the same firms, client firms, universities, and agents. Together these channels facilitate the inflow of ideas, information, and knowledge for promoting innovation, thus letting the firms move into more higher-end activities. Clustered firms in Bangalore have independently established five types

of external channels with various individuals, firms, and universities; these channels facilitate interpretive processes, and thus innovation. These are: 1) internal firm structures of MNCs (including the top Indian software services firms that themselves became MNCs) functioning across distance and across nations, and especially intrafirm linkages and global division of labor within MNCs across distance; 2) interfirm external linkages and alliances, including links with top global technology firms in the forms of dedicated ODCs and R&D centers, alliances through M&A with foreign firms that carry out higher-end activities, and partnerships with foreign leading universities around the world for collaborative research and innovation; 3) internationally mobile highly-professional workforce; Indian engineers and professionals who were educated abroad and have work experience with global IT firms abroad return to India, and Indian staff transfer to Indian firms' overseas operations; 4) organizational arrangements to combine offshoring and on-site work as a boundary management strategy; and 5) the extensive use of agents placed in foreign markets; these may be individuals (often friends and relatives), independent organizations, and their branch offices, subsidiaries, and sales offices. Acting as an interface between Indian software firms located in Bangalore and their foreign clients abroad, they facilitate "conversations" between them, transferring and diffusing new ideas, knowledge, and technologies, and thus helping the Indian firms in Bangalore improve their products, solutions, and processes. The existence of external linkages enabled technological knowledge from demanding clients to be transmitted, and market opportunities to be expanded.

On the other hand, global platform suppliers and multinational technology firms having operations in Bangalore forge both backward and forward linkages with local Indian firms, and SMEs in particular, as both end-users of their platform technologies and as subcontractors. However, the backward linkages through subcontracting involves mainly low-end, labor-intensive, and tedious activities such as programming and coding, leaving little room for these firms to develop innovative capabilities.

Therefore, contrary to the popular belief that important links exist between innovation and clustering, this study finds that external international linkages and the internal firm structures are more important in inducing innovative activities for local software clustered in Bangalore. Therefore, it challenges the notion of localized knowledge spillovers through close interfirm linkages within the cluster, which is widely cited in the literature as a critical factor that promotes innovation.

As discussed elsewhere (Okada, 2005), the development of Bangalore's software

cluster is explained at least in part by the unique and path-dependent way that it evolved; Several other factors have also been crucial: a large pool of highly skilled labor and very dynamic local labor markets within the cluster, active government interventions, the historical development of engineering and technology industries in Bangalore, and a cosmopolitan atmosphere with a large English-speaking population and relatively pleasant climate throughout the year. However, for promoting innovation, factors such as the existence of external linkages need to be considered. The findings of this study thus suggest that while the literature on clustering tends to link clustering and innovation, and focuses on the local factors within the cluster, such as the presence of local innovation systems (LIS) as important determinants, factors that explain the formation and development of clustering may differ from those that explain innovation.

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Table 1: Analytic and Interpretive Perspectives

Analysis	Interpretation
• The focus is a project, with a well-defined beginning and end, • The thrust is to solve problems; • Managers set goals, • Managers convene meetings and negotiate to resolve different viewpoints and eliminate ambiguity, • Communication is the precise exchange of chunks of information, • Designers listen to the voice of customers, • Means and ends are clearly distinguished, and linked by a causal model,	• The focus is a process, which is ongoing and open-ended, • The thrust is to discover new meanings, • Managers set directions, • Managers invite conversations and translate to encourage different viewpoints and explore ambiguity, • Communication is fluid, context-dependent, undetermined, • Designers develop an instinct for what customers want, • Means and ends cannot be clearly distinguished,

Source: Lester & Piore, 2004, p. 98.

Table 2: Modes of Delivery of Software Services Exports from India (%)

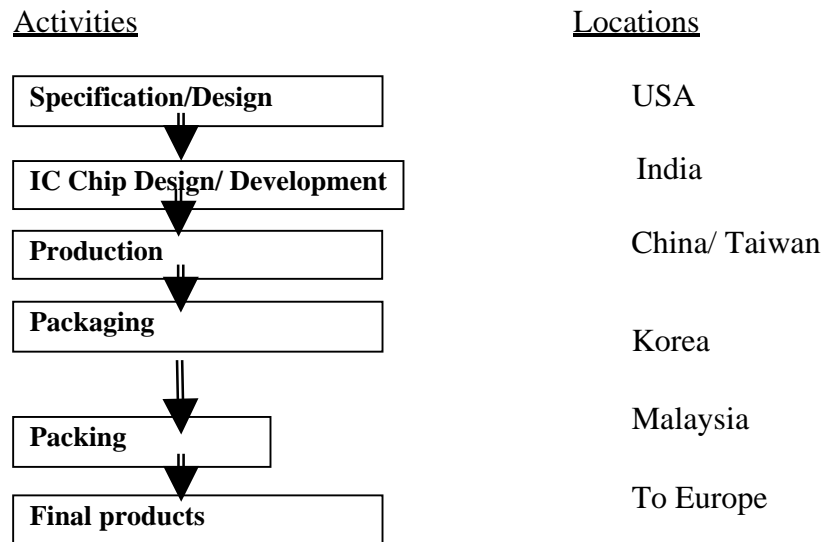|	Year					
	1994-95	1998-99	1999-00	2000-01	2001-02	2002-03
Onsite	61.0	58.18	57.43	56.08	45.21	38.95
Offshore	29.5	33.92	34.70	38.62	50.68	57.89
Products and unclassified	9.5	7.90	7.87	5.29	4.11	3.16
Total	100	100	100	100	100	100

Source: Sridharan, 2004.

Figure 1: Software Development Services Life Cycle by Location of Activities

	ONSHORE	OFFSHORE
① CONCEPTUALIZATION	X	
② REQUIREMENTS ANALYSIS & SPECIFICATION	X	
③ HIGH-LEVEL (INTEGRATED) DESIGN	X	
④ LOW-LEVEL (DETAILED) DESIGN		X
⑤ CODING/ PROGRAMMING		X
⑥ PROTOTYPING		X
⑦ UNIT TESTING		X
⑧ DELIVERY/ INTEGRATION	X	
⑨ SYSTEM TESTING	X	
⑩ CUSTOMER SUPPORT/ MAINTENANCE		X

WORK FLOW / VALUE CHAIN STREAM

Source: Personal interviews with Infosys (December 2004), Adapted from Carmel & Tjia (2005)

Figure 2: Pattern of Intra-firm International Division of Labor: The Case of TI's Semiconductor Production

Activities   Locations

| Specification/Design | USA

| IC Chip Design/ Development | India

| Production | China/ Taiwan

| Packaging | Korea

| Packing | Malaysia

| Final products | To Europe

Source: Personal interviews with a senior manager of TI (January, 2005).

Table 3: TCS's Partnerships with Universities Worldwide

Universities in Partnership	Joint R&D projects
University of Wisconsin, Milwaukee	Database technologies
University of California, Los Angeles	Multimedia
University of California, Riverside	Wireless technologies
University of Humberside, U.K.	Systems engineering & Cybemetics
Rotterdam School of Management	e-Business
IIT Chennai, Mumbai, Kharagpur	VLSI Design, Intelligent Internet
Indian Institute of Science, Bangalore	APDAP center
Carnegie Mellon University	Emerging trends in the software industry
SIMTech., Singapore	Software products in embedded systems
Aalborg University, Denmark	4G mobile technology
Simon Frazer University, Vancouver	IT research & development
State University of New York/ King's College, U.K.	Supporting real time profiles

Source: TCS's unpublished internal document (2005).

Notes

[1] Outsourcing means contracting tasks and processes to be performed outside the boundaries of the firm (Carmel & Tjia, 2005).

[2] Offshoring means the shifting of tasks to developing countries and emerging economies (Carmel & Tjia, 2005). In contrast, onsite services mean work provided locally (onsite) by foreign (developing-country) firms, often using lower-wage foreign (developing-country) workers.

[3] Carmel & Tjia (2005) classify over 100 software exporting nations into three tiers, according to their stage in exporting softare. Tier 1: mature software-exporting nations, including developed countries, Israel, Ireland, India, China, and Russia. Tier 2: emerging software-exporting nations, including Brazil, Mexico, Costa Rica, The Philippines, Malaysia, Sri Lanka, Pakistan, and many Eastern European countries. Tier 3: infant-stage software exporting nations, including El Salvador, Jordan, Egypt, Bangladesh, Indonesia, Vietnam, and many others.

[4] This classification draws on Isaksen's (2006) study, which classifies software work into four categories: 1) platform suppliers; 2) software production; 3) consultancy; and 4) after-sales services.

[5] Personal interviews with TCS, Bangalore, December, 2004.

[6] Personal interviews with Infosys, Bangalore, December 9, 2004.

[7] Personal interviews with Infosys and TCS, Bangalore, December, 2004.

[8] Many firms I interviewed stated that they have this contracting pattern (for example, Bright

Sword Technologies, Bangalore, November, 2004).

[9] Personal interviews with Metalearn, Bangalore, November, 2004.

[10] Personal interviews with TCS, Bangalore, December, 2004.

[11] Personal interviews with TCS, Bangalore, December, 2004.

[12] Personal interviews with TI, Bangalore, January, 2005.

[13] Personal interviews with TI, Bangalore, January, 2005.

[14] Personal interviews with a small Indian software firm (Company M), Bangalore, November, 2004.

[15] Personal interviews with a small Indian software firm (Company B), Bangalore, November, 2004.

[16] Personal interviews with several managers from Eximsoft and Trianz in Bangalore, December, 2004.

[17] Personal interviews with TCS, Bangalore, December, 2004.

[18] Personal interviews with a small Indian firm (Company B), Bangalore, November 2004.

[19] Personal interviews with a medium-sized firm (Company I), Bangalore, December, 2004.

[20] Personal interviews with a medium-sized Indian firm (Company F), Bangalore, December, 2004.

[21] Personal interviews with PLSPL, Bangalore, December, 2004.

[22] Personal interviews with a small Indian firm (Company S), Bangalore, December 2004.

[23] Personal interviews with a small Indian firm (Company L), Bangalore, December, 2004.

[24] For example, personal interviews with TI, Bangalore, December 2004.