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The Rise of IT Services Clusters in India: A case of growth by replication

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The rise of IT services clusters in India: A case of growth by replication

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ABSTRACT

The Indian IT services sector has grown from small beginnings at the bottom of value creation to a major player in the global information and communications technology (ICT) industry. It commands a 55% share in the global market for IT services. India's IT sector value proposition in terms of low cost with large supply of high quality talent is compelling. As a result, India has become the premier choice not only for outsourcing IT services by the developed-world's multinational corporations (MNCs) but also for locating their own Global In-house Centers (GICs), which simultaneously compete and partner with local firms. This gave rise to six additional clusters beyond the earliest, largest and robust cluster, Bangalore. The paper provides a review of relevant literature; develops a conceptual framework for evaluation of clusters; and presents data and analysis with respect to relative size, growth, specialization, MNC presence and connectivity to local firms through expatriates and returning Indians, ,innovation; and discusses adequacy of ICT infrastructure for future growth. Although there are clear signs that the Indian IT sector has been moving towards a regime of providing high-end value added services, the sector's value proposition – lower cost combined with a large supply of high quality talent – remains the single most compelling reason for the rise and growth of multiple export clusters. Thus the sector's growth appears to be a case of growth by replication rather than innovation. The paper concludes that the Indian IT sector's value proposition in terms of lower cost combined with large supply of high quality talent remains the single most compelling reason for the rise and growth of multiple IT services export clusters. While the old adage, "people follow jobs" still holds for large part of the labor force, there is little doubt that the sprawling IT services clusters in India - with more to come from Tier II and Tier III cities – indicate, in fact, that "jobs follow talent." Both local firms and the MNCs, through their GICs, are pushing the boundaries of location farther and farther to continue to leverage cost advantage and available pools of talent.

1. Introduction

Geographic concentration or agglomeration of certain industries, often referred to as clusters, has recently emerged as a key area of research in economics and business disciplines. While firms have obvious strategic interest in understanding the implications of clusters for locational decisions, it is of equal concern to policy makers who seek to understand how and why industrial clusters emerge and the implications of such agglomeration for building regional and national innovation systems for economic growth and

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development. Recent research suggests that agglomeration facilitates economic development, in the developed as well as the developing world by stimulating regional growth that benefits the nation as a whole. Indeed, analysis of clusters has become an integral part of the new trade theory. The source of comparative advantage is often local arising from a concentration of economic activity offering opportunities to improve productivity through greater access to specialized inputs and information; fostering producers of complementary products; and improving the rate and success of innovation (Marshall, 1920; Krugman, 1991; Ellison and Glaeser, 1997; Porter, 1998, for example). Key factors in the evolution of these clusters of economic activity include demand conditions, polices of local, state and national governments, transportation and communications infrastructure, institutions of higher learning, availability of skilled labor force and credit, entrepreneurial talent, the role of multinational companies (MNCs) and last but not least chance occurrences or historical accidents (such as the case of IBM setting up a large industrial research laboratory in Toronto, Canada after being denied by Cambridge, England).A detailed survey of relevant literature on clusters is provided in Section 3.

It is well established that the phenomenally rapid growth of information technology (IT) clusters over the past three decades has helped India become the world's leading exporter of IT services to the developed world in general and to the United States, in particular with important labor market implications for productivity, employment, wages, and innovation for India as well as the developed world. It is a topic of much discussion and heated debate among academics and policy makers alike in the US and other countries importing such services. A review of extant literature suggests that while there have been several case studies, focused mainly on Bangalore, few have attempted to throw light on the emergence of multiple horizontal IT services clusters - clusters separated by geography, state and local political boundaries, differences in infrastructure, educational institutions, availability of talent pool, complementary supporting industries and state and local government policies. And much of the research on IT clusters goes back to 2007 and earlier. Much has happened in the evolution of the nature, scope, and capabilities of Indian IT clusters since then, which raise a number of policy-related concerns and issues that provided the motivation for this paper. They include: the adequacy of ICT infrastructure to meet the current and future demand for IT services globally in the context of fourth Industrial revolution which, among other things, combines Internet of Things (IoT) and Internet of Services (IoS); the role of rapidly growing MNC led GICs – that compete and cooperate with the local firms - in the growth of more IT clusters in the country that go beyond being a supportive function; the role of IT clusters climbing up the value-chain through innovation to generate more and better jobs for the growing number of technical graduates in the country. Moreover, as Delgado, Porter, and Stern (2014) suggest, in the face of positive impact of clusters on regional development and industry performance, there is a growing need for cluster-based data for comparative analysis to aid policy makers and businesses alike. In addition, it is important to note at the outset that vast majority of theoretical and empirical literature on clusters has to do with *industrial clusters*. By contrast, this paper is about the growth of IT services clusters in India.

The focus of this paper is on information technology (IT) clusters—particularly the software segment—that have emerged in seven Indian cities/regions starting with Bangalore followed by the National Capital Region (NCR) comprising New Delhi and its surrounding areas in three different states, Mumbai, Pune, Hyderabad, Chennai, and Kolkata. Particular focus will be on Bangalore, the largest IT cluster within what one might refer to as super cluster of high-technology firms spanning several industries—IT hardware, aerospace, machine tools, bio technology, and pharmaceuticals—and leading educational institutions.

The rest of the paper is organized into five sections. Section 2 provides an overview of the Indian IT sector. In Section 3, we provide a survey of relevant literature and a conceptual framework to help understand the evolution of clusters. A brief profile of the seven clusters and a comparative analysis of their characteristics are provided in Section 4. Section 5 discusses the contribution of MNCs and Indian expatriates with connections to MNCs from US and other developed-countries to the development of Indian IT sector. Concluding remarks and implications of our analysis for the future of India's IT services sector are provided in Section 6.

1.1. Data and sources

For purposes of this paper, IT sector—unless otherwise specified—refers to services provided by firms under three categories: IT-enabled services (ITES), business process management (BPM), and engineering and research and development (ER & D). Major sources of data for this paper are annual reports of the National Association of Software and Services Companies (NASSCOM) and the Prowess financial data base maintained by the Center for Monitoring Indian Economy (CMIE). Company-level financial measures (sales and value-added per employee, for example) were calculated from relevant data contained in the financial statements of 76 companies for which we had consistent data from 2004–2005 to 2013–14.

2. Overview of the Indian IT services sector

A watershed event in the evolution of modern IT sector in India was a liberalized regime around the mid-1980 concerning electronic, computer, and telecom sectors. The new computer policy (NCP) under this regime allowed, among other things, import of computers meant for software development for export markets at a lower duty or no duty in certain cases, and collaborations with foreign equity participation in software development. A key element of the policy was to encourage software exports through satellite-based computers with overseas links (Sharma, 2015). Moreover, the definition of software was broadened to include consultancy services delivered by the Indian firms at the location of clients abroad spawning what has come to be labelled as “body shopping”. This work was of short duration involving lower-end jobs like coding and data conversion. The experience foreign MNCs gained working with Indian companies in body shopping combined with the availability of a large pool of low cost engineers who are fluent in English made India a very attractive destination for offshoring which became the next phase in the evolution of its IT

Table 1
Composition of Indian IT Sector, in billion US dollars.
Source: NASSCOM IT-BPM Overview and Exports, Khomiakova (2007) for 2003–04 and 2014–15.

		2003–04		2014–15	
		Dollars	**Percent**	**Dollars**	**Percent**
ITES	**Export**	7.3	70	55	81
	Domestic	3.1	30	13	19
	Total	10.4	100	68	100
BPM	**Export**	3.1	91	23	85
	Domestic	0.3	9	4	15
	Total	3.4	100	27	100
ER & D	**Export**	2.5	86	19.9	78
	Domestic	0.4	14	5.5	22
	Total	2.9[a]	100	25.4[a]	100
Total IT Sector[b]	**Export**	12.9	77	97.9	82
	Domestic	3.8	23	22.5	18
	Total	16.7	100	120.4	100

[a] Includes software products.
[b] Excludes hardware.

services sector. State-run Software Technology Parks (STPs), which allowed private companies to set up satellite data links at affordable rates, became critical for offshoring by the MNCs. Texas Instruments (TI) was the first company to set up a dedicated satellite link for internal data transmission. The TI model was soon followed by Motorola, Hewlett-Packard, and IBM. It also allowed Indian companies to undertake large projects without having to incur high cost of sending large number of engineers overseas associated with body shopping. This was particularly vital for smaller firms. In time STPs were established in multiple locations and large firms—domestic and foreign— served their overseas clients and/or parents from high-speed satellite data links on their own premises (European Commission, 2009; Government of India, 2016). In the same vein, Tata Communications, a Tata Group company like TCS, acquired Tyco Telecom's Atlantic and Pacific cable systems and to greatly increase its Internet capability/ connectivity to and from India.

One should not overlook the impetus to IT services exports came when Indian firms—large and small—found themselves at the center of fixing the so called "Y2K problem" globally and earned the reputation for quality, on-time delivery, and cost effectiveness. With competition for contracts growing, Indian companies came under pressure to aim for higher quality while holding down costs. Many companies obtained the level-5 capability maturity model integration (CMMI) certification elaborated further later in this section. Around the same period, low cost reliable nation-wide telephone connectivity was made possible through the indigenously developed digital switch suited for Indian conditions, which is essential to operate any business. We refer the reader to a recently published book, *The Outsourcer,* by Sharma (2015) for a detailed history of the evolution of Indian IT sector.

Thus, the Indian IT sector has emerged from very small beginnings with little prospect, according to some observers, of advancing from exporting highly routinized low-cost services to the developed-world to becoming a major player in the global economy through its ITES, BPM, and ER & D services (Arora, Arunashalam, Asundi, & Fernandes, 2001; D'Costa, 2003, for example). Now it is the leading global sourcing destination with 55% of market share; the largest private employer in India's organized sector with over 3 million “direct” jobs and another 7 million “indirect” jobs; and 9.5% of GDP (NASSCOM, 2015).

The IT sector, excluding hardware, has grown seven times in a decade, from USD 17 billion in 2003–04 to USD 120 billion in 2014–15 with exports accounting for 77% and 82%, respectively. The ITES services segment has been the main stay of this rapid growth, which accounted for about 56% of total IT sales, although its share relative to the other two higher-end segment – BPM and ER & D – has declined over the decade prior to 2015. Exports have been the dominant source of growth—ranging from78 to 85% in 2015—in all three segments (Table 1).

During the decade prior to 2014–15, the proportion of Indian firms relative to foreign firms has increased in all three segments (Fig. 1). The ratio of value-added – that is, the value of output produced within the firm defined as sales minus purchases of goods and services from outside vendors – to sales has increased, which indicates that the Indian firms, to whom MNCs outsource the work, themselves are doing more of the work in-house (Fig. 2). This may indicate that the average Indian firm is more into high-end projects that cannot be outsourced easily for reasons that have to do with transaction costs, expertise, proprietary nature of the work and the like.

Nominal sales per employee in the IT services sector – a measure businesses pay attention to – has increased by over 22% from INR 1.11 million in 2003-04 to INR 1.36 million in 2013-14 (Fig. 3). However, our calculation of sales per employee adjusted for inflation— by the Indian consumer price index for urban dwellers—which is a better, albeit less than perfect measure of labor productivity has *decreased* by about 28% during the same period. This may indicate that growth in the sector is occurring through replication –growth with no change in technology— rather than innovation, which involves growth through new products and processes (Jorgenson & Vu, 2016). Construction of a measure of total factor productivity (TFP) for the IT sector—which, given the

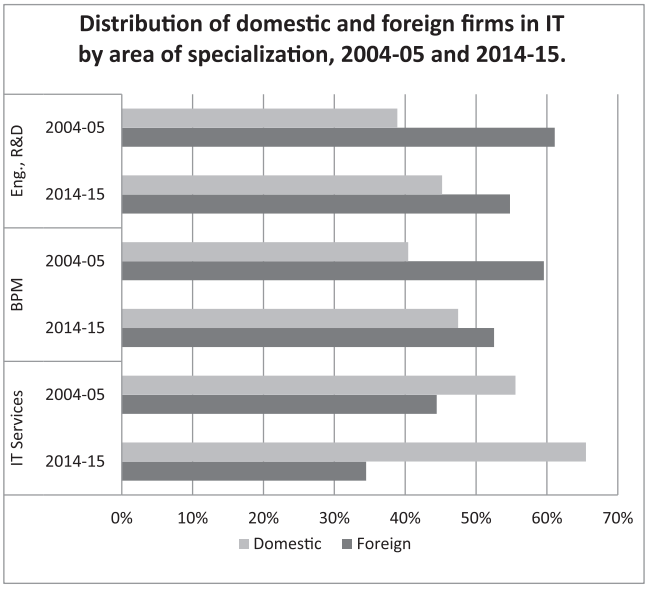

Fig. 1. Distribution of domestic and foreign firms in IT by area of specialization, 2004–05 and 2014–15.
Source: Authors' calculation based on NASSCOM Annual Report 2004–05 and 2014–15.

available data, is beyond the scope of this study – would enable us to decompose growth between replication and innovation.

Still, there are clear signs that the Indian IT sector has been moving towards a regime of providing high-end value added services, such as ER & D, for example. This trend, which has been underway in the past decade, has been well-documented (Dossani & Kenney, 2007, 2009; Lewin, Massini, & Peeters, 2009; McKinsey Global Institute, 2005). For example, sales of ER & D segment, which probably were not significant enough to be counted in the compilation of sector data by NASSCOM prior to 2004, have grown nearly nine times, from about $ 3.0 billion in 2003–04 to $25 billion in 2015. A similar trend is witnessed within the BPM segment, in which sales has increased from $3.4 billion to $27 billion during the same period (Table 1).

Another indicator of Indian IT sector moving towards high-end value added services through innovation is the number of patents granted. As shown in Table 2, top 15 domestic software firms in our 76-firm sample by sales, accumulated 602 *US patents* which (like patents from other technologically advanced countries where enforcement is strong and potential market value is high) carry a signal of greater perceived quality of research and future market value. This is especially the case in light of the fact that India still does not yet recognize software patents. Not surprisingly, the top four software firms—Infosys, TCS, Wipro, and HCL, in that order—account for 89% of total patents by the fifteen firms holding granted patents. Note, that India does not recognize software patents per se, a policy similar to the one followed by the European Union. Moreover, it appears that because of the Indian government's on-again and off-again policy with respect to recognizing software patents, many software firms have large number of Indian patent applications with no patents granted.

In terms of quality of work performed by the IT services firms, as of June 23, 2015, at least 15 firms (excluding subsidiaries of MNCs) have been awarded CMMI maturity level-5 certification, the highest level of maturity for a software firm. The focus at this level is optimization and continuous improvement of process performance through both incremental and innovative technological improvements, which subsumes achievement of all the goals assigned to levels 2, 3 and 4 after the initial level-1 where processes are

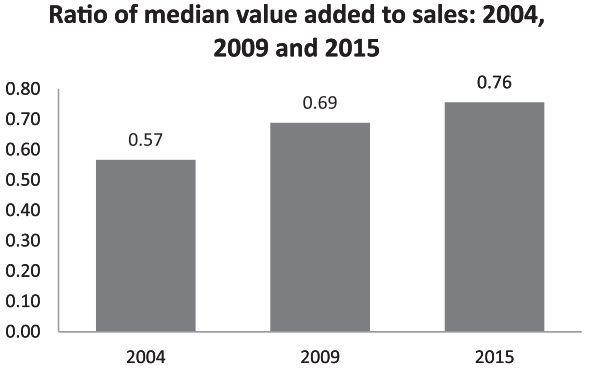

Fig. 2. Ratio of median value added to sales: 2004, 2009 and 2015. *Notes:* Authors' calculations were based on available data for 19 out of 76 sample firms.
Source: NASSCOM Annual Report 2004, 2009 and 2015.

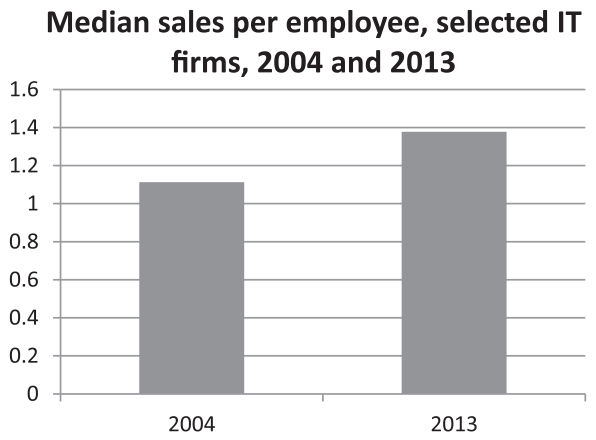

Fig. 3. Median sales per employee, selected IT firms, 2004 and 2013. *Notes*: Based on available data for 33 observations out of the 76 firm sample. Sales were unadjusted for inflation.
Source: NASSCOM Annual Report 2004–05 and 2012–13.

usually ad hoc and chaotic (Kamat, 2015).

Yet another indicator is the increasing presence of MNCs—more than 1000 in 2015—in the form of GICs engaged in high-end activities, some in competition with the local firms (NASSCOM, 2016). GICs were formerly known as wholly owned subsidiaries of MNCs. The rise of GICs in India will be further discussed in Section 4. Given the overview of Indian IT services sector, it is appropriate to ask from where these contributions have emerged, how, and in what form? To throw a light on these issues, it is pertinent to understand the role of clusters in industrial development, in terms of their influential factors, stages of development, the absorptive capacity of firm participants, and their possible economic contributions. Accordingly, we undertake a review of relevant literature to identify the core research issues, and then examine the key IT clusters of India to assess their contributions to Indian economy.

3. Survey of literature on clusters

By way of introduction to this survey we note that much of the research on Indian IT clusters predating 2008 focuses generally on the Bangalore cluster. Khomiakova (2007) was among the first to examine the development of multiple IT clusters in India; Balatchandirane (2007) provided the historical factors underlying the rise of Bangalore cluster and evaluated, comparatively, the development of Bangalore and Hyderabad clusters when the latter was in its early stage. Arora, Gambardella, and Torrisi (2001) conducted a comparative study of the development of Irish and Indian IT sectors; Parthasarathy (2004) analyzed how changing state–society relations have shaped the software industry in Bangalore; Grondeau (2007) examined the formation and development of Bangalore and Hyderabad clusters. More recently, in an important conceptual paper, Lorenzen and Mudambi (2013) examined, among other things, the role of personal relationships in the development of clusters with focus on Bangalore. More on this later, in

Table 2
US patents granted to top 15 Indian software firms.
Source: Prepared by authors from the United States Patent and Trademark Office data.

Companies	Number of patents
Infosys Ltd. (1981)	252
Tata Consultancy Services Ltd. (1995)	195
Wipro Ltd. (1945)	90
HCL Technologies Ltd. (1991)	27
Tata Communications Ltd. (1986)	9
Mindtree Ltd. (1999)	9
Larsen & Toubro Infotech Ltd. (1997)	7
Syntel Ltd. (1992)	4
NIIT Technologies Ltd. (1992)	3
KPIT Technologies Ltd. (1990)	3
Polaris Financial Technology Ltd. (1993)	2
Tech Mahindra Ltd. (1986)	1
Mphasis Ltd. (1992)	0
Vakrangee Ltd. (1996)	0
Infosys BPO Ltd.	0
Total	**602**

Notes: Top 15 by sales from our sample of 76 firms.

Section 5 when we discuss the role of Indian expatriates and their connections to MNCs in the development of Indian clusters. The discussion below summarizes the literature relevant to key issues concerning clusters such as spillover benefits, transaction costs, models of cluster formation, and absorptive capacity.

3.1. Influential factors, types, stages of development, absorptive capacity and economic performance

Industrial clusters have attracted the attention of researchers time and again, since the introduction of this concept by Marshall (1920) in the early 1920s, due to their unique contributions to economic development (Maskell, 2001; Steinle & Schiele, 2002). As a result, their origin, structure, location, role, intra-firm as well as inter-firm relations within a cluster and extra-cluster relationships have been studied in different contexts to understand the different dimensions of their contributions (Giuliani, 2005; Huggins, 2008; Ketels, 2003; Maskell, 2001; Steinle & Schiele, 2002).

Of late, researchers renewed their interest in understanding cluster contributions, particularly in the context of information and communications technology (ICT) revolution and globalization since the early 1990s. Obviously, as a result, knowledge-intensive and technology-intensive clusters have been subjected to intensive research explorations covering both developed and developing countries (Huggins, 2008; Ketels, 2003; Maskell, 2001).

For any discussion on clusters, it is important to begin with the meaning of the term. In simple words, clusters are defined as geographical agglomerations of firms operating in the same industry (Giuliani, 2005); or groups of firms and institutions co-located in a particular geographic region, which are linked by interdependencies in providing a related product/service Maskell (2001). Porter (1990) defined an industry cluster as a geographically proximate group of firms and associated institutions in related industries, linked by economic and social interdependencies. This is the most commonly used definition in the literature (Carlsson, 2010). More recently, Delgado et al. (2014) defined clusters as “geographic concentrations of industries related by knowledge, skills, inputs, demand, and/or other linkages”, which gave greater clarity to what the terms “related industries” and “social interdependencies” mean. Moreover, this definition captures the notion of high-tech industry as well with its emphasis on knowledge and skills.

Within clustering, there are two different forms of “similarity” in the clustered firms. Some clusters consist of firms that share a common underlying technology but are in different industries. For instance, industrial clusters in Boston include firms ranging from technology to material, but underlying them all is mostly the medical components industry. The current paper is concerned with *“horizontal”* clustering, which occurs when firms that essentially produce the same outputs using similar inputs locate proximately. Clusters vary, depending on the type of economic activity and the business environment that surrounds them (Carlsson, 2010; Ketels, 2003). Given this, it is important to understand what factors facilitate the origin of clusters. Clusters develop over a period of time and thus it is not an instantaneous phenomenon. Historical observation revealed that natural factors such as the availability of resources or the location at a major trading route or river, or simply by accident have facilitated the origin of clusters. Another set of factors, which facilitates cluster emergence, includes the setting up of institutions (companies and/or universities) and their inter-relationship which would have led to spin-offs within and attracted investments from outside (Ketels, 2003).

3.1.1. Benefits to member firms

As clusters emerge, member firms realize various benefits due to their close proximity which facilitate interaction of various kinds within a cluster – between firms, between suppliers and customers, between firms and institutions. This encourages mutual learning and even joint action with respect to problem solving, among others. If firms in a cluster develop a milieu, which allows for an interaction that is simultaneously co-operative and competitive, a localized value-creating system can reach its full potential by transforming it into an “innovative cluster” involving intensive knowledge exchange. In a cluster, firms can (i) become more efficient, that is, work at lower cost and (ii) simultaneously be more innovative, that is, upgrade products and performance continuously (Steinle & Schiele, 2002).

Ketels (2003) clearly identifies three types of economic benefits to the member firms in a cluster: 1. The level of efficiency with which a firm can operate will be higher as they can draw on more specialized assets and suppliers with shorter reaction times than they could if they operate in isolation, 2. The knowledge spillovers and the close interaction with customers and other firms create new ideas and put intense pressure on them to innovate while lowering the cost through experimentation, 3. New business formation tends to be higher in clusters. Clusters also reduce the cost of failure of start-ups because the failed entrepreneurs can find alternative jobs in similar companies within the cluster.

This brings out that, firms as members of a cluster stand to gain in different ways. As a result, it might attract the entry of new firms into the cluster. But without the intensive interaction that exceeds traditional market exchange, the advantages of proximity would be largely confined to lower costs of transportation and lower switching costs of employees only (Steinle & Schiele, 2002). That is why Maskell (2001) refers to two kinds of agglomeration economies emerging out of clustering. The first kind of agglomeration economies accrue from the geographical proximity of industries and services in general, referred to as ‘urbanization economies’. The second one is referred to as ‘locational economies’ that arise from the geographical agglomeration of related economic activities. It is the second category of agglomeration economies which has been attracting the attention of researchers recently.

3.1.2. Spillovers and transaction costs

As discussed at length in Chandra and Rao (2008) spillovers are a necessary but not a sufficient condition for the creation of clusters. In the absence of spillovers, clusters are either not formed at all, or tend to be small market areas. Given the existence of

some spillovers however, the magnitude of the transaction costs then determines the configuration of the emergent clusters. Bathelt (2008) identifies three factors that affect the magnitude of spatial transaction costs. The first is geographic or physical proximity to resources and infrastructure. The second factor is transactional proximity, which refers to the presence of large firm magnets that attract vertical relationships, such as those with suppliers and other partners, and horizontal specialized relationships, such as those with other similar firms for ER & D and other activities. The third and final factor is the existence of knowledge centers, including universities and dedicated research and development centers that provide the specialized labor and knowhow needed by the cluster.

3.1.3. Absorptive capacity

The dynamism of an industrial cluster that builds on access to and efficient use of knowledge is assumed to rest on three functional dimensions (Iammarino & McCann, 2006): 1. The absorption of new knowledge, technology and innovation for the adaptation to local needs; 2. The diffusion of innovations to strengthen the existing knowledge base; and 3. The generation of new knowledge, technology and innovation. It is necessary for member firms to have their own adequate knowledge base if they have to obtain benefits from external knowledge (Cohen & Levinthal, 1990) so that clusters of such firms can be sustained through several channels related to these three functional dimensions. This can provide collective learning processes through which knowledge and technology can be used, diffused and created, which are central to the evolution of clusters over a period of time (Maskell, 2001).

It is in this context that cluster absorptive capacity assumes significance. Giuliani (2005) identifies three types of absorptive capacity. The first one is basic where firms have a weak knowledge base and the cluster as a whole has very limited and weak knowledge linkages and obviously no external links. This could be the characteristic of a pure agglomeration, the initial type of clustering identified by Iammarino and McCann (2006). The second type of absorptive capacity is intermediate where firms' knowledge base is mixed where some firms will have skilled employees and perform some form of knowledge generation. The cluster has a more connected intra-cluster knowledge system but still parts of the firms may be isolated and it will have some extra-cluster connections (Giuliani, 2005). These characteristics may be associated with the industrial clusters which have grown with the emergence and dominance of a particular industry or a set of industries. The third one is advanced absorptive capacity where firms have strong knowledge bases and operate at the technological frontier with highly skilled human resources and highly innovative ER & D. The cluster will have a dense intra-cluster knowledge system and will be well connected with extra-cluster sources of knowledge. While a static cluster tends to be characterized by basic absorptive capacity, dynamic clusters will have more intermediate absorptive capacity whereas an advanced cluster absorptive capacity will represent a state in which firms operate and contribute to the evolution of technological frontier (Giuliani, 2005).

3.1.4. Models of cluster formation

Bathelt (2008) examines three models of regional development and growth that are relevant to our paper: the export-based model (Schatzl, 1981, for example), the innovative milieu approach (Crevoisier, 2001; Maillat, 1998, for example) and Scott's (1988) super-cluster model.

The export model is viewed as one that generates additional revenues to the region which in turn results in additional demand for local inputs, thus triggering a multiplier process creating further growth. Note that the model allows for growth driven by not only exports to other regions, but also to other countries. However, the model is limited with respect to innovation through interaction between economic agents within and outside the region and therefore does not assume high level of absorptive capacity.

The shortcomings of the of the export-based multiplier model— it is too macro and therefore ignores the importance of local institutions and the effects of interactive learning and knowledge creation that occurs locally—led to the innovation milieu school. Maillat (1998) suggests that what distinguishes a successful innovative milieu or a local production system from a stagnant one is the ability of actors in the region to establish linkages with economic agents in the global markets and develop the capability to acquire valuable information and resources from external sources and use them. The key to this model is the ability of the cluster to develop absorptive capacity, which keeps the cluster dynamic and viable by allowing it to not only recognize but also transfer external knowledge to networks within the cluster.

The third model—Scott's (1998) model of super clusters—focuses on the formation of industrial clusters to changes in volatile supply and demand conditions in the global markets and computer-based technologies leading to a shift to inter-firm transactions from intra-firm transactions; reconfiguration of activities in diverse locations, leading to further specialization; and the emergence of clusters of specialized activities as efficient and effective locations (Chandra & Rao, 2008). In this model what Scott calls the level of "localized external effects" and the amount of (spatial) transaction costs influence extent and type of regional clustering (Scott, 1988). Super clusters emerge when there is strong mix of interregional and international transaction networks. Similar to the innovation milieu model, super clusters require high level of absorptive capacity.

Bathelt (2008) proposes a fourth regional model called "local buzz and global pipelines". The model emphasizes "knowledge creation as being the driving force behind the establishment, growth and reproduction of industry clusters" (p. 86). Local buzz refers to a "thick web" of local interactions, processes of learning and knowledge creation. However, without global pipelines involving trans-local partnerships, local buzz in clusters would have limited effect. The firm needs to possess high level of absorptive capacity in order to access relevant knowledge from partners who are on the same "wavelength". This model differs from others in that it emphasizes "relational proximity" as a source of competitive advantage as opposed to spatial proximity.

3.2. Core issues in cluster evolution/development and economic contribution

The above discussion briefly throws light on the factors which influence the origin and growth of clusters, opportunities and

Birth or Origin	Phases of Growth or Evolution and their Characteristics				
	Phases	**Nature of Interaction**	**Learning / and or Knowledge Generation**	**Benefits for Cluster Participants**	**Economic Performance and contribution**
- National resources - Locational factors - Policy or institutional factors	Initial stage	Limited intra-cluster interaction No extra-cluster interaction	No mutual learning or knowledge generation Weak absorptive capacity	No innovation Limited economic benefits emerging from agglomeration of economic activities	Limited economic performance and limited contribution to economic growth
	Intermediate stage	Active intra-cluster interaction Limited extra-cluster interaction	Joint action and mutual learning within the cluster leading to knowledge generation Limited absorptive capacity	Limited or incremental innovation thereby enabling the participants to move towards the technological frontier	Enhanced economic performance leading to improved contribution to economic growth
	Advanced stage	Active intra-cluster interaction Active extra-cluster interaction	Joint action and mutual learning within as well as between clusters leading to knowledge creation High absorptive capacity	Radical innovation leading to extension of the technological frontier	High economic dynamism thereby directing and driving the economic growth of the nation

Fig. 4. Phases of growth or evolution and their characteristics.

benefits that can be derived from clusters by the participants, stages of development in the evolution of clusters, and the possible contributions that clusters can make through their economic performance to regional or national economic development. Keeping these issues in the backdrop, we propose to develop a conceptual framework.

One or more of several factors – natural, locational, policy related or institutional – or simply historical accidents generally lead to the birth or the origin of clusters. These clusters may be industry specific or alternatively comprise diverse industries. In the initial stage of a cluster, firms might be reaping only the benefits of agglomeration-based external economies with limited inter-firm interactions and no external interactions. At this stage, there will be no cluster level innovation and the economic benefits emerging from such a cluster may be limited. However, if cluster participants turn out to be dynamic, intra-cluster interactions would begin leading to mutual learning and knowledge generation. This is when the cluster reaches the intermediate stage of development. Limited or incremental innovations would emerge. With improvements in communication network, cluster participants would gradually start engaging themselves with firms/institutions beyond the cluster, located in other clusters across the globe. In the process the absorptive capacity of clusters would be enhanced significantly resulting in improved dynamism and maturity of the cluster as a whole, and higher economic performance of the participants. Radical innovations resulting in substantial economic benefits both for cluster participants and the nation would materialize. As a result, the overall economic contribution of such clusters to national economic growth will see a steady increase.

The possible factors involved in the origin of clusters, the phases in the evolution of clusters, their characteristics, resultant benefits to cluster participants, and their possible economic contribution to nations are shown in Fig. 4. It is in the light of literature review and identification of unique features of clusters in the process of cluster development that we examine Indian IT clusters and their economic contributions empirically.

4. IT clusters in India

India's IT services sector is deeply entrenched in the key metros of India, giving rise to seven IT clusters noted earlier. These seven clusters are embedded in and around the country's tier I cities. Together they account for a considerable proportion of products and services, employment and exports of the Indian IT services sector as well as the IT industry. There are some common factors which propelled the growth of IT industry in these cities, the most important of all being India's economic liberalization since 1991, which facilitated the setting up of back offices of IT MNCs in India. For example, international Internet bandwidth per user has increased by almost eight-fold between 2005 and 2014 (ITU, 2015). The other common factors are a large and growing educated labor force, widespread fluency in English language, comparatively low labor costs, relatively high quality of work force, acceptable level of infrastructure and the like. But at the same time, as noted earlier, these seven clusters are different in their origin and growth, resource availability, geographical size and population, level of modernity, weather conditions, infrastructure development, availability of talent in the form of skilled labor, and the role of state and local governments. Therefore, it is appropriate to examine the unique features of each of these IT clusters. A map of India with cities/regions scaled to their relative size in terms of 2014–15 revenues is shown in Fig. 5.

Fig. 5. Location of Indian IT clusters scaled to relative size of export revenues, 2014–15.
Source: Prepared by authors from data provided by NASSCOM IT-BPM Report 2015.

4.1. A profile of seven clusters

4.1.1. Bangalore

The Bangalore IT cluster occupies a unique position as it has been recognized as one of the largest and fastest growing software/knowledge clusters outside the USA (Huggins, 2008; Nadvi, 1995; Parthasarathy, 2004). We describe it at some length because Bangalore serves as a benchmark for purposes of comparison. The city has been described as the *Silicon Valley of India* as well as the *Outsourcing Capital of the World* (THOLONS, 2010). Further, Bangalore is not only a hub for software-related industries but also houses several high-tech clusters (e.g. defense, aeronautics, and biotechnology) and is considered to be the scientific and engineering center of India in terms of research and training as well as manufacturing (Jan, Cristina, & Lars, 2007). As a result, Bangalore cluster has been studied from various dimensions, with respect to its formation and emergence as an ICT cluster (Grondeau, 2007), factors contributing to its growth as an IT cluster (Balatchandirane, 2007), its growth as a biotech cluster (Ahuja, Armanious, Arnaud, D'Souza, & Kanehira, 2008), role of government policies in its promotion as an ICT cluster (Van Dijk, 2002).

The origin and growth of Bangalore as an IT industry cluster can be traced back to the late 1940s subsequent to the country's independence in 1947. The setting up of major Public Sector Undertakings (PSUs) in the 1950s and after such as Bharat Electronics Limited (BEL), Hindustan Aeronautics Limited (HAL), Hindustan Machine Tools Limited (HMT), and Indian Telephone Industries Limited (ITI), among others, laid the foundation for the growth of modern engineering industrial enterprises in the country in general, and in Bangalore in particular. The setting up of industrial estates to promote modern small scale industries, as the ancillaries to large enterprises, added another dimension to the city's industrial growth. The already established engineering institutions (both in the public and private sectors), apart from Indian Institute of Science (which was established in 1909) ensured the availability of much needed technical talent for these industries (Jan et al., 2007). The entry of Texas Instruments into Bangalore in 1984 marked another major milestone in the growth of Bangalore towards its emergence as the largest IT cluster.

In the late 1980s, some of the today's most reputed Indian origin IT MNCs such as Infosys and Wipro, among others, took birth in Bangalore (Kumar, 2014). With the onset of “economic liberalization” in 1991, more and more global IT MNCs started flowing into Bangalore. In the mid-1990s, Indian Institute of Information Technology Bangalore (IIITB) was created to address the “exclusive talent needs” of Indian IT industry. An International Tech Park was created in Whitefield, Bangalore as a result of a joint venture between India and Singapore in January 1994, followed by several other IT Parks in certain key locations of the city, providing multiple facilities for IT companies. In the process, most of the foreign software majors that have set up development centers in India preferred Bangalore (Kumar, 2014). Thus public policy and positive response of both domestic and foreign private investments together played a decisive role in the growth of IT industry in Bangalore. This led to the gradual emergence of Bangalore as an IT cluster with a primary focus on software industry. In the process, Bangalore has earned the nickname as the “Silicon Valley

of India". The setting up of affiliates of MNCs and the location of affiliates of Bangalore based Indian MNCs elsewhere have led to a steady increase in both intra-cluster interactions within Bangalore and extra-cluster interactions between Bangalore and other clusters both in India and abroad.

4.1.2. National capital region (New Delhi, Gurgaon and Noida)

New Delhi, the capital city of India, is surrounded by some of the tier II cities such as Gurgaon in the south-east and Faridabad in the south (belonging to Haryana state), NOIDA in the south-west and Ghaziabad in the north-west (belonging to Uttar Pradesh state). Together it is called the National Capital Region (NCR). Perhaps it is the largest urban agglomeration in the country. Though NCR is driven primarily by manufacturing industry, subsequent to 1991, IT industries started springing up both within New Delhi and outside, particularly in Gurgaon and NOIDA. The presence of premier educational institutions such as IIT Delhi, Delhi Engineering College, Jawaharlal Nehru University, Delhi University, among others, ensured a steady supply of talent pool for the growth of IT industry in the NCR. The cluster's strengths are primarily in hardware and ITES-BPO. It was the number one ITES-BPO destination in India (Khomiakova, 2007). New Delhi being the capital city, the infrastructure and institutional strength of the city would have favored both intra-cluster and extra cluster interactions for NCR based firms. To that extent, the absorptive capacity of the firms may be high enough, to enable their upward movement on the value-chain.

4.1.3. Chennai

The IT industry portfolio in Chennai (formerly Madras) comprised all the diverse segments of the industry such as IT services, software and ER & D, ITES-BPO, and hardware though hardware companies in Chennai accounted for the majority in the country. Chennai has both Software Technology Park and Electronic Hardware Technology Park, thus giving scope for the growth of both software and hardware industries. Chennai has also emerged as one of India's major centers for automobiles and auto parts. Reputed educational institutions such as IIT Madras, Anna University, and Madras University provided the skilled technical work force for the growth of IT industry. Both globally reputed MNCs and domestic IT firms have a significant presence in Chennai. The focus and strength of Chennai as a cluster is confined to hardware industries more than software industries, and its intra-cluster relations are likely to be stronger since it has a sizable automobile cluster located in the vicinity.

4.1.4. Hyderabad

Hyderabad is one of the largest metropolitan regions in India. The advent of globalization in India has opened the door for Hyderabad to brand itself as the popular destination for high-tech industries (Das, 2015). Hyderabad is considered the fastest growing IT cluster in India, and the second most important IT cluster in south India (after Bangalore). It is a significant player in the biopharmaceutical sector of the country. A pro-active regional government, which set up an exclusive "Hi-tech city" devoted for the growth of IT industry, played a stellar role in the emergence of Hyderabad as an IT cluster. In the process, many global IT giants entered Hyderabad giving a new dimension to the growth of the city. The relatively economical physical infrastructure, particularly the real estate also contributed to the growth of Hyderabad as an IT cluster. The establishment of educational institutions such as International Institute of Information Technology Hyderabad (IIITH) and IIT Hyderabad, apart from the traditional universities such as Central University, Hyderabad and Osmania University met the technical work force needs of the growing IT industries. Hyderabad IT cluster has a significant presence of both software and ITES-BPO industries. The newly entered MNCs and return of Telugu speaking expatriates from the USA would have contributed to cluster level interactions, learning and an improvement in the absorptive capacity of Hyderabad based firms, over a period of time.

4.1.5. Pune

The emergence of Pune (formerly Poona) as an IT cluster in India is a more recent development, and it is largely driven by several small, home-grown companies. The areas of specialization range from product development in the software sector to chip design and embedded software in the hardware sector. Pune is also India's premier center for biotech research firms. The presence of Pune University and more recently established Indian Institute of Science Education and Research (IISCER) meet the workforce needs of the IT sector locally. Although currently Pune is a small IT cluster relative to other clusters, with the exception of Kolkata, its close proximity to Mumbai (home of Tata Consulting Services – TCS – one of India's leading IT MNCs) and its vast pool of talent combined with temperate weather makes it an attractive location for IT firms. As such, Pune has a high growth potential. However, when examined as a stand-alone cluster, its level of intra-cluster and extra-cluster interactions currently may not be comparable to that of Bangalore, NCR or even Hyderabad.

4.1.6. Mumbai

Though Mumbai (formerly Bombay) is the industrial and commercial-cum-financial capital of the country, it has also attracted a significant number of IT companies both foreign and domestic. Mumbai has occupied strong positions in different segments of IT industry primarily in IT services and ITES-BPO, apart from hardware manufacturing. It is home to the oldest and most successful IT Park in the country, namely, Santacruz Electronics Export Processing Zone, and as noted above, it is the home for TCS; one of India's leading IT services MNCs. The presence of reputed institutions such as IIT Bombay and Bombay University play a crucial role in the supply of technical talent to the IT industries. Like other leading IT clusters, it has affiliates of several global IT giants. The sheer size and magnitude of Mumbai comprising a wide variety of industrial clusters with a significant presence of MNCs for decades together now, would have given adequate scope for both intra-cluster and extra-cluster interactions. The manufacturing hub of Bombay along with the thriving film world is another positive factor for an intensive interaction between IT industries and the former. Given this,

the absorptive capacity of Bombay IT cluster can be anticipated to be on the higher side. However, IT industry does not really occupy a prominent space in the industrial scenario of Mumbai as it does in Bangalore.

4.1.7. Kolkata

Kolkata (formerly Calcutta), which was the traditional manufacturing hub of the country, is a late comer to the IT sector and has made only a slow progress in terms of its growth. Kolkata can boast of several reputed institutions like Calcutta University, Jadavpur University, Indian Institute of Science Education and Research (IISCER), among others which enabled the city to provide technical work force for the growth of IT sector. It has both large domestic large IT firms as well as foreign IT MNCs, apart from several SMEs. However, over a period of time, the city has lost much of its traditional manufacturing industry base and new manufacturing industries have hardly emerged to make their presence felt. Given this, the level of intra-cluster interactions may be said to be the minimum. The extra-cluster interactions are also not likely to be high. Therefore, its absorptive capacity has yet to develop on a considerable scale. Clearly, Kolkata's IT cluster is in its nascent stage.

4.2. Comparative analysis of cluster data

Drawing upon CMIE's Prowess database supplemented by other secondary sources, we have been able to examine, empirically, characteristics of clusters, which in combination with qualitative factors noted above, to help us evaluate the relative strengths and weaknesses of each cluster, the phase of development a cluster is in and its potential contribution to regional and national economic development. A summary of comparative characteristics from the available data for the seven clusters is provided below:

1. Size (sales, employment, and number of firms in 2014–15): Bangalore remains the largest and ranks first in size by all three measures followed by NCR, which experienced a decline in its share of firms along with Mumbai, while Hyderabad gained significantly along with Pune and Kolkata, the last from a small base (Tables 3 and 4).
2. Growth, 2004–05 to 2014–15 (number of firms): Hyderabad ranks first followed by Kolkata—a late comer starting with a small base of only 7 firms in 2004–05—and Pune (Table 3).
3. Presence of MNCs (number of firms): Bangalore ranks first followed by NCR and Hyderabad (Table 5).
4. Growth of MNCs, 2004–05 to 2012–13 (number of firms): Kolkata ranks first—starting with a small base of only 2 MNCs in 2004–05– followed by Pune and Hyderabad
5. Cluster specialization: Not surprisingly, Bangalore ranks first in the proportion of firms in ER & D followed by Pune and Hyderabad in 2014–15. Note that MNCs have consistently higher proportion of firms in ER & D in all locations except Kolkata (Table 5)
6. Global In-house Centers (GICs): As noted earlier, GICs are what used to be referred to as captive subsidiaries of MNCs. According to selected slides from Everest Group's September 2014 Market Report made available for this paper, vast majority of GICs (82%) are located in Tier I cities serving ER & D function (65%). As shown in Table 6, of the 739 GICs in India, 38% are located in Bangalore followed by Hyderabad (13 per cent); NCR (12%); Chennai and Pune (11% each); Mumbai (7%); and none in Kolkata (Everest Group, 2014).
7. An examination of the presence of firms with headquarters in Bangalore in other clusters by ITES, BPM, and ER & D categories—shows that vast majority of these firms are confined to Bangalore only (Table 7). This is consistent with the benefits of being in a large and a closely knit cluster. When some firms do have multiple locations, they appear to prefer Mumbai/Pune as first choice and Mumbai, Pune, Hyderabad as a second choice.

To sum up, a variety of data we examined by cluster suggests that Bangalore not surprisingly remains at the top, not least because of its historical advantage in terms of institutions, related industries, and prominent educational and research institutes. Moreover, the evolution of any cluster, by its nature, is expected to be path dependent. On the other hand, Hyderabad and Pune are growing not only faster, but they also seem to be attractive destinations for the high-end ER & D segment of the IT services sector as well as MNC

Table 3
Geographical distribution of IT firms for selected cities/regions.
Source: Prepared by authors from data provided by NASSCOM Annual reports 2004–05 and 2014–15.

Location	2004–05		2014–15	
	Number	Percent	Number	Percent
Bangalore	92	26.82	424	26.21
Delhi NCR	95	27.70	336	20.77
Chennai	42	12.24	234	14.46
Hyderabad	27	7.87	179	11.06
Pune	22	6.41	121	7.48
Kolkata	7	2.46	71	4.39
Mumbai	58	16.9	253[a]	15.64
Total	**343**	**100**	**1618**	**100**

[a] Estimates based on average annual growth rate between 2004–05 and 2012–13.

Table 4
Export revenues and employment of IT services by cluster, 2014–15 (US dollars in billions).
Source: Prepared by authors from data provided by NASSCOM IT-BPM Report 2015.

	Revenue	Employment
Bangalore	$37.24	960,000
Chennai	11.76	320,000
Hyderabad	9.8	320,000
Mumbai–Pune	24.5	640,000
NCR	9.8	800,000
Kolkata	4.9	160,000
Total	**98**	**3,200,000**

global In-house centers (GICs) serving ER & D function. Hyderabad and Pune are also experiencing rapid growth in terms of MNC location. Thus, if we were to classify the clusters in terms of their respective stage of development (see Fig. 4) based on the qualitative and quantitative profile of the seven clusters presented above, we get a mixed picture. Bangalore would be at the threshold level of entering into the advanced stage in the evolution of an IT services cluster, albeit at a slower rate of growth, but by no means at the advanced stage. Although relatively small in terms of size, Hyderabad and Pune may be classified at the next level—intermediate stage – as they are growing rapidly and becoming attractive destinations for the MNCs in the ER & D segment; and Mumbai as well, given the vast diversity as a multi-dimensional cluster. On the other hand, while NCR is second in size, it appears there is nothing substantial occurring in this cluster. Clearly, Kolkata is in the initial stage of cluster development.

On the other hand, in terms of models of cluster formation discussed earlier (see Section 3.1.4), all seven clusters fit the export

Table 5
Distribution of domestic firms and MNC's in IT sector by area of specialization and geographical location for 2004–05 and 2012–13.
Source: Prepared by authors from data provided by NASSCOM Annual Report for the years 2004–05 and 2012–13.

		2004–05				**2014–15**			
		Domestic Firms		**MNCs**		**Domestic Firms**		**MNCs**	
		Number	*Percentage*	*Number*	*Percentage*	*Number*	*Percentage*	*Number*	*Percentage*
BANGALORE	IT Services	19	61.3	27	44.2	155	74.88	84	50.3
	BPM	5	16.1	20	32.8	26	12.56	43	25.75
	Eng, R & D	7	22.6	14	23	26	12.56	40	23.95
	Total	31	100	61	100	207	100	167	100
DELHI NCR	IT Services	32	61.5	22	51.2	149	75.25	79	57.25
	BPM	14	27	12	27.9	38	19.19	45	32.6
	Eng, R & D	6	11.5	9	20.9	11	5.55	14	10.15
	Total	52	100	43	100	198	100	138	100
CHENNAI	IT Services	14	53.9	6	37.5	119	74.38	45	60.81
	BPM	6	23.1	8	50	29	18.13	22	29.73
	Eng, R & D	6	23.1	2	12.5	12	7.5	7	9.45
	Total	26	100	16	100	160	100	74	100
HYDERABAD	IT Services	6	66.7	11	61.1	71	79.78	57	63.33
	BPM	2	22.2	5	27.8	11	12.36	23	25.56
	Eng, R & D	1	11.1	2	11.1	7	7.87	10	11.11
	Total	9	100	18	100	89	100	90	100
PUNE	IT Services	7	53.9	5	55.6	50	69.44	30	61.23
	BPM	3	23.1	2	22.2	14	19.44	10	20.5
	Eng, R & D	3	23.1	2	22.2	8	11.11	9	18.36
	Total	13	100.1	9	100	72	100	49	100
KOLKATA	IT Services	4	80	2	100	41	73.21	13	86.67
	BPM	1	20	0	0	13	23.21	2	13.33
	Eng, R & D	0	0	0	0	2	3.57	0	0
	Total	5	100	2	100	56	100	15	100
MUMBAI	IT Services	23	65.71	11	47.82	117	69.64	82	71.3
	BPM	7	20	9	39.13	36	21.43	29	25.22
	Eng, R & D	5	14.29	3	13.04	15	8.93	4	3.48
	Total	35	100	23	100	168[a]	100	115[a]	100

[a] Estimates based on average annual growth rate between 2004–05 and 2012–13.

Table 6
Global In-house centers (GICs) in India by location.
Source: Prepared by authors from data provided by Everest Group 2014, Global In-house Centers landscaping India, Market Report: September 2014.

Location	Number	Percent
Bangalore	281	38
Hyderabad	96	13
NCR	89	12
Chennai	81	11
Pune	81	11
Other	59	8
Mumbai	52	7
Total	**739**	**100**

Notes: The data came from complimentary slides made available by the Everest group.

model with varying degrees of absorptive capacity and interaction within and outside the cluster. Because they are export-driven clusters, all of them, with varying degrees, interact with economic agents in the volatile global markets and acquire valuable information and resources suggested by the innovation milieu school (Maillat, 1998, for example) and the super cluster model proposed by Scott (1998). However, none of them appear to rise to the level of knowledge creation and/ or the absorptive capacity required by the two models, much less Bathelt (2008) "local buzz and global pipelines" model in which knowledge creation is central.

5. The role of MNC-expatriate nexus and global linkages

The role of MNCs in the development of Bangalore IT cluster has been well-documented starting with the arrival of Texas Instruments in 1985 and cannot be overstated. However, a serious examination of the role of Indian expatriates and returning Indians – with education and experience in the West and connections to MNCs – to the development of Indian IT clusters is more recent. Lorenzen and Mudambi (2012) provide the conceptual framework based on a broader theory of connectivity for examining the role of personal connections between the MNCs and the "returning" Indian expatriates in the development of Indian IT clusters. The authors illustrate their theoretical propositions by contrasting the Bangalore software cluster with Bollywood, the filmed entertainment cluster in Mumbai. The essence of their argument, in the emerging economy context, is that while clusters linked through decentralized pipelines to global value chain (e.g. MNC subsidiaries in the Bangalore cluster) could lead to "in-depth catch-up" in terms of industry and technology scope, those linked through decentralized personal relationships has the potential to "in-breadth" catch-up in several related industries and technologies. Subsidiaries of MNCs that have located in Bangalore to take advantage of local talent pool are an example of decentralized pipelines. An example of decentralized personal relationships is global Argonauts or independent diaspora members or returning expatriates with contacts to MNCs. In terms of spillover effects, in a decentralized network structure knowledge has a strong public goods element, so spillovers are likely to be substantial with significant potential for catch-up. By contrast, in a centralized network structure knowledge tends to be proprietary and spillovers are limited with limited opportunity to catch-up. These are untested propositions. However, based on anecdotal evidence and case studies, the authors argue that while Bangalore's IT sector initially fit the description of a centralized pipeline model driven by the MNCs, overtime with the proliferation of MNC subsidiaries and competition among them for local talent helped increase connectivity with the Indian firms, a degree of MNC decentralization took hold. As a result, Indian firms enjoyed some spillover benefits, which increased their potential for catch-up through innovation and foreign direct investment through acquisitions.

Personal connections of Indian expatriates and/or returning Indians from the west have also played a significant role in the development of Indian IT sector. As might be expected, our search of the websites of our sample of 76 IT-firms revealed that a vast majority of the firms (81%) have either a joint venture or a collaboration with an MNC; over 50% of the executives listed on the website had worked for an MNC; and about 30% had education abroad (Table 8). The dominance of Indian expatriates in the Silicon Valley and other locations in the US is well documented. According to a research study by Wadhwa, Saxenian, and Siciliano (2012), of the total immigrant-founded engineering and technology companies in the Silicon Valley, 33% had Indian founders, a figure more than the next top seven immigrant-founder-sending countries combined. Taeube and Sonderegger (2009), using Bangalore cluster as a case study, show how local and non-local factors connected through Diaspora networks can accelerate growth by bridging

Table 7
Location of firms with head-quarters in Bangalore in other clusters, number of firms.
Source: Authors' calculations based on 2013 data from NASSCOM Annual Report.

Locations	ITES	BPM	ER & D
Only Bangalore	127	37	28
Bangalore and Mumbai or Pune	19	9	2
Bangalore,(Mumbai or Pune), Hyderabad	4	4	2
All others combinations with Bangalore	38	12	16
Total	188	62	48

Table 8
Indicators of top managements global linkages, selected Indian owned firms.
Source: Authors' calculations based on information available on the websites of sample of 75 IT firms.

	Percent
JV/Collaboration with foreign owned MNC	81.58%
Work experience with foreign owned MNC	52.63
Overseas education	30.26

weaknesses in the local cluster.

6. Concluding remarks and policy implications

6.1. Concluding remarks

The story of the rise of Indian IT sector can be attributed, among other factors, to local entrepreneurship with connections to MNCs, compelling needs of the MNCs propelled by the ICT revolution that placed software at the helm of technological change, global competition that led to vertical disintegration in many a large firm in the developed-world and outsourcing of work to firms in countries with supply of high quality talent at a fraction of what it costs in the MNC home country. That convergence and unbundling of R & D has placed software development at the helm of innovation in the ICT sector was discussed at length by Rao (1999).

The Indian IT sector has grown from small beginnings in the already grown industrial cities of the country, at the bottom of value creation to a major player in the IT services segment of the global ICT industry. It commands a 55% share in the global market for IT services. Indian IT sector's value proposition in terms of low cost with large supply of high quality talent is compelling. It is a sector that is highly human capital intensive. Presence of premier educational and research institutions, historical concentration of high-tech firms, and temperate climate, connections between locally born entrepreneurs and MNCs, and strongly supportive state and local governments culminated in Bangalore becoming the largest cluster of IT services export firms. The data we have analyzed, by cluster, suggests that over the past decade, Bangalore remains the largest with greater depth and breadth. Hyderabad and Pune are growing more rapidly in terms of number of firms located including MNCs. There is some indication of specialization. Bangalore ranks first in terms of the proportion of firms in ER & D followed by Hyderabad and Pune. Not surprisingly, innovation by Indian software firms measured in terms of patents is confined to a few large firms and less than robust. While there are clear signs that the Indian IT sector has been moving towards a regime of providing high-end value added services, evidence of innovation as opposed to replication is weak at best. MNCs have higher proportion of firms in ER & D in virtually all locations except Kolkata. Meanwhile, global In-house centers (GICs) are aggressively focusing on ER & D. The question arises as to why six more clusters engaged in exporting the same services with varying degrees of depth and breadth compared to Bangalore? There are some characteristics that are common to all. They are all located in and around large cities. On the surface, all possess educational and research base, supply of talent, diverse set of industries, acceptable physical infrastructure and minimally expected amenities in the form of hospitals, schools and the like expected of any large city, although we do not know their relative strengths. A comprehensive evaluation of relative strengths and weaknesses of the seven clusters with Bangalore as the benchmark is important for business decisions, for individual decisions concerning attractiveness of the city as a place to work and raise a family, and for public policy concerning regional and national economic development. Note that most cities in India—large and small—suffer from traffic congestion, power outages, unaffordable housing and more. This is a topic for future research. That said, while the old adage “people follow jobs” is still holds for large part of the labor force, there is little doubt that the sprawling IT clusters in India with more to come from Tier II and Tier III cities indicates that “jobs follow talent” may be more true in that local firms as well as the MNCs through their GICs are pushing the boundaries of location farther and farther to continue to leverage cost advantage and supply of talent.

6.1.1. Policy implications

First, the development of IT services with the involvement of MNCs and their GICs would eventually lead to the entry of ER & D centers which would result in the diversity of a cluster and enable the cluster-based firms to gradually move up the value-chain, thereby resulting in a more significant economic contribution from that cluster. This brings out the importance of two key issues: (i) liberalized foreign investment policy to suit the entry and growth of IT service based MNCs and their GICs, and (ii) development of appropriate infrastructure for the promotion of IT services sector across the country, particularly in Tier II and Tier III cities to facilitate the emergence of more IT clusters in the country.

This brings us to the issue of ICT infrastructure that exists currently in the country and its adequacy for future growth. India's ICT application indicators are startling, to say the least, for a country that leads in IT services exports. Bandwidth per Internet user in India in 2014 was 5677 bps compared with 27,688 bps in Philippines, the latter which has become a strong competitor in the export market for IT services; and annual telecom investment as a percent of GDP in India was half of Philippines’ (0.3% vs. 0.6% in 2014). Data on usage reflects this relatively low level of investment in infrastructure; internet users per 100 people in 2014 was 18 – just above Nicaragua and well below low and middle income countries at 32.2 (ITU, 2015; World Bank, 2015). It is important to note that the usage data reflect not only on the state of ICT infrastructure in terms of ease of access at affordable price and convenience, but also on such factors as level of education, income, and willingness to adopt new technologies which are not necessarily

independent of ICT infrastructure.

What is interesting about the evolution of multiple horizontal IT clusters is that they are all export-driven and therefore the needs of domestic customers in terms of ICT infrastructure were not a priority to the firms or to the governmental bodies like the Department of Electronics, a strong force behind the push for exports and the creation of STPs.

The relatively poor picture of ICT indicators noted above raises questions about the adequacy of infrastructure for future growth of IT services sector. Newer versions of mobile communications standards are emerging all over the world. India is still trying to cope with the implementation of 3G and Wireless Broadband Access. It is expected that 3G will provide high-speed connectivity to a third of wireless subscribers within four years from now. However, the concern is today's networks are not equipped to provide quality service for the traffic it generates, especially given exponential growth in demand for exchange of data. Moreover, with phone subscriptions around a billion (of which, 96% is mobile) the country needs very large quantities of quality and affordable spectrum, which is scarce. For every million customers in India, there is only 0.1 MHz of spectrum available, while in most European countries corresponding number is 3–6 MHz. On an average, Indian telecom companies hold 13–15 MHz of spectrum vs. Chinese firms with 60–100 Mhz (Bhupta, 2015). So, more 3G sites are required to provide adequate capacity across technologies. New customers including GICs will further increase the need for additional sites. Data growth will not be limited to Tier I cities. It will come from Tier II and Tier III cities, introducing the “last mile problem”—the final leg of communication networks delivering connectivity to customers. Last but not least is the concern regarding the adequacy of ICT infrastructure for the IoT revolution—connection of physical devices with the digital realm—which is underway (Greengard, 2015). Gartner Group estimates that India will begin to adopt IoT in about ten years (Gartner, 2016). Wireless connectivity—which requires lot of spectrum and compression—is central to IoT. It is not clear whether the ICT infrastructure will be able to support IoT adoption at this stage given the scarcity of spectrum in India.

Second, the increased entry of MNCs and their GICs into a cluster facilitates the return of MNC trained Indian expatriates who can play a crucial role in the promotion of global linkages of clusters leading to further strengthening of the cluster for its growth and diversification. This brings out the role and importance of Indian expatriates in cluster development for IT services sector growth.

Third, the growth and diversification of IT clusters leading to climbing up of the value chain by the cluster-based IT firms has significant policy implications for employment generation as well. India being one of the largest generators of engineering graduates in the world annually, how to generate productive employment to the large and growing technical graduates is a growing concern for the policy makers. If due efforts are made to promote more and more number of IT clusters across the country, which can grow horizontally as well as vertically taking advantage of the entry of MNC- led GICs, including Indian expatriates, such clusters will be able to steadily generate employment to absorb a growing share of technical graduates.

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