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Abstract

The role of industrial clusters in the industrialization of many emerging economies continues to dominate the debate among policy makers and researchers worldwide. While recent discussions on this debate have focused on knowledge spillovers among participants within clusters, knowledge flows between non local networks and the cluster actors have not been accorded due attention in the literature. Further, the literature does not compare the relative impact of knowledge flows among firms within clusters and firms outside clusters. In this study, we attempt a comparative analysis of the role of knowledge flows in capability formation among firms in the Indian Information Technology sector (IT sector) across cluster and non-cluster locations. The empirical results suggest that at the firm level, leveraging of capabilities to enhance performance and networks to build capabilities is not automatic; structural features of the firms' location enable this transformation. Moreover, while capabilities affect performance of firms positively only in clusters, economies of scale and some strategies like quality certification used by firms impact performance of firms outside clusters. Interestingly, although economies of scale do not impact the performance of firms within clusters, they do, however affect the capability formation of firms within clusters only. Further, we found that local and national non-customer networks affect capability formation of firms within and outside clusters whereas international customer networks affect capability formation of firms within clusters only. These have implications for how firms can develop appropriate strategies to enhance their performance.

Keywords: Industrial Clustering, Information Technology industry, Networks, Capabilities

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1. Introduction

The role of industrial clusters in economic performance of firms and regions has been a topic of research for several years. Several studies have highlighted the importance of local knowledge spillovers (facilitated through a variety of interactive networks) as the primary driver for innovation and economic performance of firms in clusters. A number of theoretical and empirical contributions have shown that firms tend to cluster in order to take advantage of knowledge available with other firms in the region.[4] The primary explanations for knowledge spillovers within a cluster were the nature of knowledge (tacit) and face to face interactions between firms that enable the transfer of such knowledge. Researchers even in the developing country contexts emphasized the importance of geographical proximity (Nadvi, 1996; Rabellotti, 1995; Schmitz, 1995; Visser, 1999) despite the emphasis on international linkages in knowledge transfer to firms in technology transfer studies (Evenson and Westphal, 1995; Szirmai, 2005)

These studies, however, assumed that firms within the region or clusters have equal access to knowledge spillovers. Besides, firm characteristics (such as R&D investments) do not impact the ability of firms to absorb these knowledge spillovers within a region. Additionally, networks that aid spillovers (the non-pecuniary type) and those that aid knowledge flows (the pecuniary type) were not differentiated by most studies. Further, studies in this stream typically focused on customer innovation or innovation that helps in creating or improving products for customers. Other kinds of innovation were largely ignored. Moreover, the studies were either restricted to case studies or primary survey of firms in one cluster or region. Empirical studies using multiple cluster data as well as comparison of knowledge flows between firms in clusters vis-à-vis firms outside clusters do not exist. In this paper, we focus on innovation across products, processes and practices. Additionally, this paper also undertakes an empirical exploration of processes of capability building in cluster and non-cluster locations that would provide useful insights on the relative role of different drivers of capability development. All this is done in the context of the Indian Information Technology (hereafter called as IT industry) which is highly clustered and successful. The Indian IT industry is the fastest growing industry in the country and the growth has been largely export oriented. Moreover, the industry is currently clustered around seven locations and recent studies have identified 15 additional cities as possible clustering destinations for IT firms where the industry is growing well (NASSCOM, 2010).[5] The locational concentration of IT firms and the success of IT industry in the Indian context have once again highlighted the possible role of clusters in influencing firm performance. While developing an analytical

[4] Saxenian (1994) provided on of the early analyses of these issues and cluster specific advantages.

[5] Bangalore, Mumbai, Pune, the National Capital Region (NCR) around Delhi, Chennai, Hyderabad and Kolkata have been the main IT clusters in India. About 43 new tier II/III cities are emerging as IT locations with concentration of firms. During 2009, 60 per cent of the new delivery centers were located in 15 of these cities (NASSCOM, 2010: 194).

framework and implementing it empirically using primary survey data, we also hope to highlight some issues relating to the measurement of firm networks, knowledge flows and firm capability.

The remainder of the paper is structured as follows. The next section undertakes a brief review of the available literature in order to build an analytical framework to explore the processes of capability building and securing competitive advantage by firms in cluster locations. While section 3 provides details of the survey, relevant variables and measures used in this study, section 4 presents the empirical results. In the final section, we summarize how our study adds to the current literature and draws implications for policy and future research.

2. Analytical Framework and Research Questions

Literature has identified a large number of advantages that clustering firms in specific geographical locations can enjoy. These advantages are used to explain why firms in clusters are likely to do better than stand-alone firms in terms of capability building, innovativeness and performance. Earlier explanations focused on advantages relating to cost and resource availability arising out of agglomeration economies. Co-location of producers and suppliers (of labour, raw material, other specialized inputs and complementary services) results in economies of scale and scope, improve efficiency and increase speed to market (Krugman, 1991; Marshall, 1890; Rosenthal and Strange, 2003). As cluster specific linkages across enterprises and other entities develop, transaction costs fall contributing to the cost advantages of firms located in clusters. Moreover, if clusters have better infrastructural facilities – power, telecommunications, roads, transport, education, R&D facilities etc. – the advantages multiply manifold (Basant, 2002).

Recent studies have highlighted the advantages that arise from the better knowledge base and associated knowledge spillovers in cluster locations that enhance the capability of firms. Higher capabilities in turn result in better performance. Co-location of interlinked and/or competing entities enhances the possibilities of learning from each other and of transmission of new ideas. Firms build capabilities due to relatively easier access to knowledge sources and through knowledge spillovers (Audretsch and Feldman, 1996; Jaffe et al., 1993). Proximity of entities facilitates knowledge flows to take place as significant parts of relevant knowledge are complex, tacit and often specific to the context (Basant, 2002; Cowan et al., 2000; Lundvall and Johnson, 2001).[6]

Focus on knowledge flows and firm capabilities in cluster studies has led to the exploration of sources of knowledge and learning in firm agglomerations. In this context scholars have explored

[6]Studies have also highlighted the importance of institutional context (including shared language, communication and culture) for knowledge spillovers within the geographically bound regions (Breschi and Lissoni, 2001; Cooke and Morgan, 1998; Cowan et al., 2000; Maskell and Malmberg, 1999).

the contribution of several institutions that facilitate knowledge flows and learning. These include dense social, professional & commercial relationships that often evolve into vibrant local networks of innovation, local trade associations and research institutions (Saxenian, 1990; Schmitz and Nadvi, 1999). However, most of these studies have essentially relied on analytical descriptions of available evidence (often anecdotal). Moreover, studies in the industrial district literature largely focused on spatial proximity rather than firm networks. Torre and Rallet (2005), however, highlight that firm networks do not have to be localized or co-location is not essential for knowledge flows to take place. Even infrequent face to face interactions between entities can facilitate knowledge flows. This literature also assumes that knowledge spillovers which occur in regions are equally absorbed by firms in the industrial district. However, some of the recent studies question this assumption. In fact, it is argued that the role of cluster based firm networks and their differential impact on knowledge flows has not been adequately explored (Kesidou and Romijn, 2008; Weterings and Boschma, 2009). Thus, a shift is seen from the focus on co-location and spatial proximity to knowledge networks (local and non-local) in explaining the performance of industrial clusters and regions. Some studies on clusters from developing countries emphasize the importance of non-local networks for knowledge flows and thus capability formation for firms in clusters (Bell and Albu, 1999; Effie, K. and Romijn, 2008; Schmitz and Nadvi, 1999). According to some studies, the interactions between firms within a location may also limit learning and innovation (Boschma, 2005; Boschma and Weterings, 2005; Torre and Rallet, 2005). This may happen as firms in a region (with no connections outside a region) may suffer from over embeddedness (Uzzi, 1997) resulting in some kind of path dependence or lock-in to a specific trajectory. The presence of non-local relationships may help firms become aware of new technological and market related developments and facilitate their growth along with that of the region where they are located (Asheim and Isaksen, 2002; Camagni, 1991). However, there has been no conclusive evidence on the relative importance of local knowledge spillovers vis-à-vis non-local knowledge flows.[7]

Broadly then, the available literature suggests that any empirical exploration of the capability building processes in cluster locations and the associated advantages of clusters would require an exploration of the nexus between firm networks, knowledge flows and firm capabilities. Since all possible knowledge flows, irrespective of their source, need to be captured both local and non-local networks would need be covered (Basant, 2002; Effie, K. and Romijn, 2008). In what follows we discuss in detail the role of networks, knowledge flows and firm capabilities.

[7] For example, the empirical work of Kesidou and Romijn (2008) has shown local knowledge spillovers to be more important than international knowledge flows in building innovative capabilities of firms in Uruguay's software cluster. However, Wettering and Boschma (2009) show that spatial proximity does not affect innovative performance of software firms in any significant manner.

2.1 Networks, Knowledge Flows and Capability Formation

A number of anecdotal studies on clusters have identified a variety of *sources* such as customers, suppliers, technology support organizations, universities, government institutions, employees, research institutions and competitors that enable knowledge flows and knowledge spillovers to firms in clusters (Basant, 1997; Breschi and Lissoni, 2001; Nadvi, 1999; Rabellotti, 1999; Saxenian, 1990). All these entities, which may or may not be located in *geographical proximity* of the firm, constitute the network of a firm. Several studies have suggested that geographical proximity is important for transfer of *tacit* knowledge to firms which may require face-to-face interaction (Cowan et al., 2000; Lundvall and Johnson, 2001). It has also been argued that tacit knowledge is best shared through face to face interaction in situations where the communicating entities share common codes of communication, shared conventions, norms and trust (Cooke and Morgan, 1998; Maskell and Malmberg, 1999). Given such arguments, the idea of 'proximity' has been enlarged in several studies (Amin and Cohendet, 2000).[8] 'Proximity' ensures contextual relevance of the shared knowledge as well as ease of communication which facilitates transfer of complex and tacit knowledge.

As discussed above, formal and informal networks that a firm builds (with different degrees of proximity) contribute to flows of knowledge and consequently capability building among these firms, which may in turn contribute positively to firm performance. These networks has been given a number of labels such as 'social capital' (Maskell, 2001), 'untraded interdependencies' (Stroper, 1995) and 'industrial atmosphere' (Marshall, 1890). And cluster firms are expected to be richer in 'social capital' than non-cluster firms. The contribution of these networks in building capabilities can take place *both* through *pecuniary advantages* arising out of efficiency of *transactions* within this network (similar to agglomeration economies in a geographically bound clusters) and through *spillovers* of knowledge that such networks facilitate. In one of the recent studies, Kesidou et al (2009) point out that the spillovers and transactions represent a continuum rather than two distinct categories. Insofar as social capital incorporates both local and non-local linkages that a firm has, it can include networks that a firm has *within* and *outside* a cluster location. However, the concept of social capital encompasses the socio-cultural aspects of the network and any empirical implementation of such a concept would be very information intensive, requiring data on a variety of socio-psychological variables. We shall revert to this issue in a subsequent section when we discuss measurement of variables.

[8] While most studies have highlighted *geographical proximity* to be critical for knowledge flows, Breschi and Lissoni (2001) suggested that *cultural proximity* is more important than spatial proximity for knowledge transfer to firms. In the same vein, Lundvall and Johnson (2001) have also suggested that tacit knowledge can only be transferred effectively between two people when they share a common social context, language and culture. Amin and Cohendet (2000) have additionally suggested that *organizational proximity* is more important in transfer of tacit knowledge.

While the empirical explorations of the linkages between firms' network and capability building have been largely restricted to case-studies and anecdotal evidence, a few recent studies have undertaken an econometric estimation of these relationships. Wetering and Boschma (2009) focus on the role of spatial proximity and user-producer interactions on innovativeness of firms in a cluster of Dutch software firms. In the context of our earlier discussion, they focus only on the impact of *customer related networks* on firms' innovative capability; the role of *other (non-customer) networks* is not analyzed. Their results show that spatial proximity does facilitate face-to-face user-producer interaction but the impact of such interactions on innovative performance of firms is limited; while interactions and collaborations with customers increase the probability of software firms developing new products but have no significant impact on the innovative output. They also find that collaborative networks (including face to face interactions with customers) do have a positive impact on the performance of firms. In another study by the same authors (Boschma and Wetering, 2005), a non-parametric exploration (due to the small sample size) of the relationship between networks and innovative performance shows that knowledge on market and technology derived from local networks affect process innovations (i.e., number of machines introduced over last three years). Besides, non-local networks (including market knowledge and technical knowledge networks) affect share of new product sales and new product introductions. Further, they found that geographically open and locally embedded firms were able to significantly perform better in terms of innovation. However, the study considers machinery introduced over last years as a measure of process innovation whereas smaller improvements in processes are not captured.

Kesidou and Romijn (2008) focus on the role of *spillovers* on the innovativeness of software firms in the Uruguay cluster. They not only distinguish between *knowledge transactions* and *knowledge spillovers* but also separate *local* (cluster) transactions/spillovers from *international* ones. Local knowledge spillovers are further divided into those arising out of *spin-offs, labour mobility and interactions.* However, local or international transactions/spillovers are not further sub-divided into those arising out of customer and non-customer networks (interactions). Their results show that while *local knowledge spillovers* have a positive impact on *technology innovation*, *international knowledge transactions* positively influence *organizational innovation*.[9] Kesidou, et al (2009) found that local knowledge spillovers (non-pecuniary) affect the number of innovations that are new to the market as well as the firm whereas local knowledge transactions (pecuniary) affect the certification of firms (which they term as organizational process innovation).

[9] For some reason, the authors do not emphasize the second finding and the fact that cumulative R&D expenditure of firms also has a significant impact on *organizational* innovation performance and not on *technological* innovation performance.

Broadly then, some recent studies have begun to econometrically explore the impact of firm's networks (and associated interactions) on firm (essentially innovation) capabilities in geographically bound clusters. These studies typically focus on one aspect of innovation i.e., product innovation. Most studies do not capture innovation in the processes and practices of firms. For example, Weterings and Boschma (2009) focuses on the impact of *user-producer interaction* on *product development capability* of software firms in the cluster. They do not focus on other aspects of firm's technological capabilities. This study also does not distinguish between the roles of spillovers and agglomeration (pecuniary) economies; the focus is on the role of local customer networks (interactions) on innovativeness. Even the study by Kesidou and Romijn (2008) measure innovative performance by introduction or changes to the product or service to the market, sales from the new product or changed product or service, number of product or service innovations and presence or absence of quality certification. A principal component analysis of the above shows two factors i.e., *technological innovation* (measured primarily in terms of new or modified product/service and sales derived from new product / service innovations) and *organizational innovation* (measured primarily in terms of quality certification and number of product or service innovations).[10]

Studies do not also distinguish between customer and non-customer networks while estimating their impact on capabilities; either the focus is only on customer interaction or the two types of links are lumped together. As noted above, a wide variety of network partners have been identified as sources of knowledge. Except in the non-parametric study by Weterings and Boschma (2009), while local (cluster specific) networks are distinguished from international networks, other domestic (national) networks are not considered. This may not be as relevant in the case of small countries covered in the studies referred to above but can be quite important for large countries and countries which have several clusters in the same or related industries. Non-inclusion of non-cluster domestic networks might bias the estimated coefficients of the included networks. The studies do not explore if the same type of processes are at work in non-cluster locations. For example, if the results obtained in the studies above are also found in cases of firms which are located in areas where there is no agglomeration of firms, the interpretation of these results would become somewhat problematic. The basic premise for exploring the role of interactions and networks on firm innovativeness/capabilities is that it is dominant in clusters and not elsewhere. Only then it can be seen as an explanation of better performance of firms in clusters vis-à-vis others. In this paper, we attempt to overcome these limitations. However, our study also does not distinguish between knowledge spillovers and knowledge transactions and lumps the same as knowledge flows to firms in clusters or outside clusters.

[10] These two innovation performance measures are derived on the basis of Principal Component Analysis. However, the interpretation of these measures is not entirely clear. We shall revert to this when we discuss data and measurement issues.

2.2 Structural Differences between Cluster and Non-Cluster Locations

As mentioned, studies have suggested that significant differences can exist between cluster and non-cluster locations in terms of advantages derived by firms (Krumme, 1969). These include proximity to customers, availability of skilled labour, presence of suppliers, access to support services, access to training facilities and R&D institutions, availability of maintenance/repair services, better access to information from/about competitors, availability of information on marketing fairs and exhibitions. Among these, availability of skilled labour, better access to training facilities, R&D institutions and information from/about competitors, can potentially be important sources of knowledge or capability formation. Certain location characteristics (both in and outside clusters) may facilitate absorption of knowledge. For example, easy availability of skilled labour, R&D institutions, consultants, etc. may facilitate identification and absorption of available knowledge within clusters (Athreye, 2004; Cooke et al., 1997; Dahl and Pedersen, 2004).

Earlier, we have already discussed that spatial proximity and geographic location may impact knowledge flows differentially. In this context, location of a firm in a cluster can potentially affect capability building processes and performance of firms in the following inter-related ways:

- Agglomeration economies provide efficiency advantages to firms through availability of requisite resources and lower transaction costs. Availability of requisite resources may also help firms to absorb knowledge flows more effectively.
- Facilitate building of networks due to co-location of firms. Both cluster specific and external networks can get build through such agglomeration. Physical co-location of inter-related entities enhances the chances of such networks locally. At the same time external agents may view clustered firms more positively for building links, given the advantages identified in the point above. Besides, local network partners can also create opportunities to access external entities.

2.3 Research Framework and Design

The literature suggests that firm networks help build capabilities in clusters which might affect their performance positively. Capability building is affected both by the efficiency of transactions as well as spillovers facilitated through the networks and these are likely to be superior in a cluster as compared to non-cluster locations resulting in better performance of cluster firms. As mentioned, studies reviewed above focus on innovative performance but one can also view performance in terms of labour productivity and financial performance that reflect competitiveness of firms. Besides, firm capabilities can be viewed more broadly to include other technological capabilities relating to processes and organizational practices. Empirical exploration of these relationships can be undertaken by asking three inter-related but analytically separate questions:

1. What is the impact of networks on firm capabilities (broadly defined)?
2. How do firm capabilities influence firm performance?
3. Does the nature of these two sets of relationships differ in cluster and non-cluster situations? If so, what are the structural differences between cluster and non-cluster locations that aid in knowledge flows, capability building and performance of firms within and outside clusters?

We hope to derive insights on the advantages of clustering by answering the third question. The studies reviewed above have essentially focused on answering a question which is a combination of questions 1 and 2 namely, how do networks influence firm innovation capability/performance in a cluster. One can posit that clustering facilitates network building and may also be useful for converting networks into capabilities. Similarly, clustering may also provide advantages in the translation of firm capabilities into superior performance. In other words, 'structural' features of a cluster enumerated above may provide advantages to local firms in leveraging networks for building capabilities and in effectively exploiting capabilities for superior performance. In a dynamic sense, the persistence of these advantages would partly depend on how the cluster and the sectors in the cluster evolve and how the associated policy framework undergoes changes. Figure 1 provides a pictorial overview of this broad analytical framework that we use in the paper to explore these questions and examine the propositions. Admittedly, it is very difficult to empirically explore the dynamic elements of the relationships mentioned above. Even the exploration of the static relationships poses significant data and measurement related challenges. It is to the discussion of these issues that we now turn.

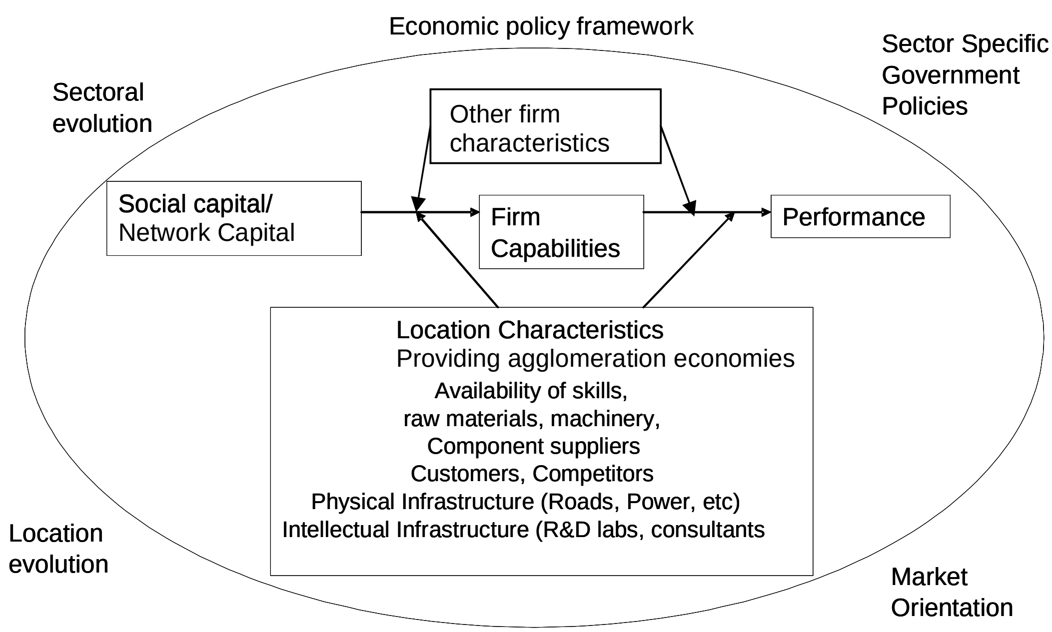


Figure 1: An Analytical Framework

3. Data Description and Measurement

As the brief review of literature above showed, empirical exploration needs to meaningfully measure *networks*, *firm capability* and *performance*. Such data is not available from secondary sources and needs to be collected through primary surveys as was done in the studies mentioned above. Our paper is also based on surveys of IT firms in cluster and non-cluster locations in India, undertaken in 2004-05.

3.1 Data Description

The Indian IT industry has seen tremendous growth in recent years from about USD 5.7 billion in 2000 to USD 73 billion in 2010. The contribution of IT industry to GDP grew five times during the period 1998-2010 to reach 6.1%. IT-Business Process Outsourcing (BPO) exports have trebled over the last five years to reach USD 50 billion in 2010 and this constitutes about 25% of total exports of the Indian economy. The industry provides direct employment to 2.3 million with an estimated indirect employment of 8 million (NASSCOM 2010). The industry is highly clustered around a few cities. Currently, 94% of exports are from seven Tier-1 cities i.e., Bangalore, Mumbai, Pune, National Capital Region (constituted by adjoining regions of Noida, Gurgaon and Delhi), Hyderabad, Chennai and Kolkata. As mentioned, 15 more centers are slowly emerging as important clusters but that process has started only recently. Thus, not only the IT industry is very important for India's growth, the clustering phenomenon also seems to be critical for the growth of the industry.

In order to understand if the processes of capability building differ across cluster and non-cluster locations, a survey of IT firms was done in cluster and non-cluster areas. There is no single widely accepted definition of clusters. Besides, it is also equally difficult to identify and develop a sampling frame for clusters and non cluster locations (Martin and Sunley, 2003). For the purposes of this study, a city wise analysis of membership profile of National Association of Software and Service Companies (NASSCOM) has shown that Bangalore, NCR, Mumbai, Chennai, Pune and Hyderabad as agglomerations of IT firms. Accordingly, the survey of firms was conducted in Bangalore, Pune and NCR. Since the study involved comparison of processes at work between cluster and non-cluster locations, firms in non-cluster locations like Chandigarh, Bhubaneswar and Jaipur were also surveyed. Table 1 below shows that data was collected from a sufficiently large number of firms (243 firms) across cluster and non cluster locations. A list of firms was compiled from the NASSCOM directory for IT industry. An analysis of revenues of firms shows that the sample is representative of the population of the firms in the NASSCOM directory.

Table 1: Distribution of Firms

S. No.	Name of City	Number of Firms
1	Bangalore	86
2	NCR	73
3	Pune	24
4	Other cities	60
	Total	**243**

As part of the survey, a structured questionnaire was administered to the senior managers of firms in clusters and non-cluster locations. The process of measuring various constructs including capabilities was developed on the basis of discussions with a large of number of senior managers across IT firms. Subsequently, the questionnaire was also pre-tested and modified on the basis of those responses.

3.2 Measurement

A rigorous analysis of the type described above would require measures of *capability*, *network* and *knowledge flows* that are conceptually meaningful and empirically implementable at the same time.

3.2.1 Technological Capabilities

Knowledge flows are associated with interactions among network partners and they help build a firm's technological capabilities. Earlier econometric studies on clusters have used extent of patenting and citations as proxies for technological capability and knowledge flows/spillovers (Almeida and Kogut, 1997; Jaffe et al., 1993). These are inadequate as few firms in developing countries are engaged in patenting activity. Besides, many types of knowledge are not patentable (or are not patented for strategic reasons) and economic entities use a variety of mechanisms to learn from each other and patents is only one of them (Breschi and Lissoni, 2001). More recent studies have measured knowledge spillovers through labour mobility, trade patterns, (i.e., movement of goods) and spinoffs (Feldman, 1999).

Technology has been categorized as knowledge embodied in products, processes and practices (Chandra, 1995; Basant and Chandra, 2002). Bell and Albu (1999) has highlighted that technological change within firms can be captured through changes in products, processes, materials or production organization. Similarly, Lipsey (2002) has suggested that technological change can be captured through products, processes and organizational routines. A significant amount of overlap can be seen in these three conceptualizations. Using the conceptualization by Chandra (1995)[11], we suggest that *knowledge flows* can relate to products, processes or practices

[11] To save space a detailed comparison of these conceptualizations is not attempted here. Basant and Chandra (2002) provide additional details.

and capabilities can also measured through accumulated stock of knowledge on these 3 Ps. Consequently, *technological capability* of a firm is conceptualized as the *knowledge embodied in products that a firm makes and the processes & practices it employs to make these products*. In order to measure a firm's technological capabilities, we collected information on the *products* made by the firm and the *processes* and *practices adopted (deployed)* by them. The initial idea was to use the knowledge of the industry experts to categorize products, processes and practices according to their technological complexity and/or capability requirements for production and adoption. Unfortunately, products could not be categorized according to their degree of complexity and the views of the knowledgeable persons on the hierarchy of processes and practices did not converge. Consequently, product capability could not be captured and the capability measure that we use in this paper was based on the simple aggregation of the number of processes and practices adopted by the firm (see Appendix 1 for computation of process and practice capabilities); inadequate information on the hierarchy of these processes and practices did not allow us to use any weights in the aggregation process. However, since the list of processes and practices compiled with the help of senior managers in the industry and secondary sources was quite exhaustive, the adoption variable does provide a reasonably objective measure of capabilities. Besides, being a continuous variable that can take a large range of values, it captures variability in capabilities across firms somewhat better than a dichotomous variable. Admittedly, since all processes and practices have been given equal weight in the construction of this measure, it is not able to capture the hierarchy of capabilities implicit in them. Some of the processes and practices can be more critical for performance in clusters than others whereas critical processes and practices for firms outside clusters may be different. In our analysis, we have distinguished between *process* and *practice* capabilities. Whether these capabilities complement each other or are substitutes is an open question. Similarly, it is difficult to assess the role of linkages between components within each type of capability. We shall revert to this issue as it has interesting implications for interpreting our results. Given all the constraints mentioned above, it needs to be emphasized that our measure of capability is different from the 'performance based' measure of innovation capability used in earlier studies (Kesidou and Romijn, 2008; Weterings and Boschma, 2009).

In addition to the capability measures referred to above, we have used two other variables as proxies for firm capabilities. A firm with *quality certification* is considered as more capable than ones without any such certification. This, however, is a dichotomous variable and is not able to capture gradations of capability that firms with or without quality certification may have. The other measure is the *number of engineers as a proportion of all workers in the firm*. Presence of well qualified personnel who are trained in technology areas enhances the availability of tacit knowledge that may result in better utilization of existing capabilities and creating new ones. Presence of better trained people may also increase the possibility of adopting new products, processes and practices. While this is a continuous variable, we have not been able to capture the quality of engineers.

To what extent different measures of capability overlap is an interesting conceptual issue. Insofar as adoption of some of the processes and practices (especially the latter) is required for quality certification, *ceteris paribus*, firms with such certification may have higher adoption rates of processes and practices. However, all the processes and practices covered in the two measures (quality certification and our capability measure) are not the same and therefore, each capture some extra information on firm capabilities. Of course, while quality certification is a dichotomous variable, the process/practice capability measures that we have developed are continuous and should be preferred under normal circumstances. Similarly, adoption of certain technologies (processes and practices) may require engineers. But as mentioned above, the knowledge levels of engineers, especially the tacit component may help exploit the adopted technologies in a better fashion. In fact, the extent, intensity and efficiency of use of these technologies may be higher in firms which have a higher proportion of skilled labour (i.e., engineers). In other words, the three measures of capability can be substitutes as well as complements. For the purposes of analysis in this paper, the degree of substitutability/complementarity is an empirical issue which we will revert to later.

3.2.2 Network Capital

Our earlier discussion suggested that social capital includes all networks built through a variety of inter-organizational linkages (local – cluster specific, national and international) of firms within and outside clusters. Any meaningful empirical implementation of this concept would not only involve measurement of linkages a firm has with different entities but also the socio-cultural dimensions of these linkages. Although many dimensions of social capital affect knowledge flows and capability formation of firms, our study only captures the number of linkages and the importance of these networks to firms (see below). In some sense, therefore, we are measuring "network capital" rather than the social capital in its entirety which includes the social and cultural context of linkages.

Network capital of a firm is measured here on the basis of linkages that a firm has with entities outside the firm. Data on the number of linkages with customers, suppliers, competitors and other entities (consultants, R&D institutions etc.) was collected thereby distinguishing between different types of networks based on these linkages that the firm has. *Within* each category of network, the links (and therefore the network) were further subdivided into *local* (cluster specific linkages), *national* (outside the cluster but within the country linkages) and *international* networks. For example, customer links are further divided into local, national and international customers. Apart from the information on links, information was also collected on the perception of respondents regarding the importance/criticality (in the range of 1 to 5) of each network (customer, supplier etc.) with respect to knowledge flows. Information on criticality was used to weigh the number of links (product of number of networks and importance) to get a measure of network capital of different types. For each type of network (*local, national and international*) we have distinguished between *customer* and *other* (all linkages other than customer) networks.

Once again, the measures used in our study to some extent overlap with the measures used in earlier studies. Weterings and Boschma (2009) collected information on proximity to customers in the vicinity and the extent of face-to-face interaction whereas Kesidou and Romijn (2008) on the other hand asked direct questions to develop a scale of knowledge transactions and spillovers (both local and international) measuring the importance or criticality of local and non-local knowledge transactions and spillovers. In some sense our measure is a combination of these two measures. We capture all types of linkages (not only customer) and get a scaled measure of the importance of these linkages for knowledge flows. We do not, however, distinguish if the knowledge flow was due to a more efficient transaction or spillovers. In that sense we are not able to capture the relative importance of pecuniary vs. externalities based advantages of networks. Therefore, we can only measure the role of network capital in its entirety and not separate out the network induced knowledge flows due to agglomeration economies and through spillovers.

3.2.3 Cluster Characteristics

Cluster characteristics (advantages) were measured in multiple ways. As mentioned, cluster locations can provide a variety of advantages to firms: facilitate formation of useful networks; provide access to specific sources of knowledge and provide better access to information, intellectual & other infrastructure and skilled labour. Besides, cluster specific policies can also add to the advantages of firms located there. To capture these potential advantages, we collected *perception based* information if firms benefited from their location in terms of infrastructure availability (both physical and intellectual), government policy, and availability of labour, information and R&D facilities etc. In addition to the data on perceptions on such advantages, we also collected information on the *sources of knowledge* (local, national and international) of processes and practices for each firm surveyed in cluster and non-cluster locations.

3.2.4 Firm Performance

Unlike in the earlier studies *firm performance* is measured through employee productivity. It is computed as sales divided by total number of employees. We feel that this is a more appropriate measure of performance in the context of the Indian IT industry which has essentially grown as a service industry and only recently has shown some signs of 'product development'.

Following Figure 1, broadly, two types of relationships are analyzed to examine the questions posited above:

1. Impact of *firm capabilities* and *firm location* (cluster/non-cluster representing structural features of location) on *firm performance* controlling for firm size; and the
2. Impact of *network capital* and *firm location* (cluster/non-cluster representing structural features of location) on *firm capabilities* controlling for firm size.

While analyzing these relationships, an effort is made to ascertain if specific categories of firm capabilities (e.g., process, practice), network capital (e.g., customer and others) and structural characteristics of locations (e.g., infrastructure, skilled labour etc.) play significant roles in determining firm performance and capabilities.

4. Results

Table 2 shows that firms located in clusters have higher firm size and labour productivity. However, while the adoption rates of processes and practices are also generally higher but *not for all* processes and practices.

Table 2: Performance of IT firms across cluster and non-cluster locations

Performance Variables	Cluster Firms			Non-cluster Firms			Means are Significan-tly different
	Mean	Standard deviation	No. of firms	Mean	Standard deviation	No. of firms	
Sales (Rs. In Lakhs)	8743.20	57220.15	159	532.73	1611.00	53	Y*
Employee Productivity	52.82	139.35	156	9.96	21.15	53	Y**
Total Number of Employees	138.12	295.79	179	48.6	155.44	60	Y**

**- $p<0.05$, *-$P<0.1$; Y- means are significantly different;

A significantly larger proportion of firms in cluster locations (50% of firms within cluster compared to 21% of firms outside clusters) had quality certification. On average, firms with quality certifications were also larger in size. But interestingly, Table 3 and Table 4 show that both in cluster and non-cluster locations, firms with quality certification neither have higher percentage of engineers nor consistently higher capability scores than firms without quality certification. Irrespective of where the firms are located (cluster/non-cluster), there is no significant relationship between the proportions of engineers in a firm with the capability scores. Finally, with very few exceptions the number of networks and network capital of all types is also higher for cluster firms than for non-cluster firms.

Table 3: Differences in capability of firms with and without quality certifications in clusters

Percentage of firms with quality certification in cluster					50%
Cluster	Without Quality		With Quality		Significance
Variable	N	Mean	N	Mean	
Capability	81	2.98	80	3.10	N
Process	81	2.02	80	2.09	N
Practice	81	2.48	80	2.62	N
Percentage BECS	75	3.47	70	3.45	N
Total employees	81	3.45	76	4.60	Y

Table 4: Differences in capability of firms with and without quality certifications outside clusters

Percentage of firms with quality certification in non cluster locations					21%
Variable	N	Mean	N	Mean	Significance
Capability	45	2.80	12	3.06	Y
Process	45	1.93	12	2.13	Y
Practice	45	2.18	12	2.44	N
Percentage BECS	34	3.14	9	2.99	N
Total employees	45	2.53	12	4.02	Y

Does this imply that firms in cluster locations are able to grow bigger in size, get quality certifications, hire more engineers and accumulate large network capital? Is the advantage of the cluster restricted to these dimensions? The impact of clustering on capability building and performance when network capital, firm size and other variables are controlled was investigated and the key findings of the econometric analyses are described next.

4.1 Determinants of Firm Performance in IT Industry

Table 5 provides results of the relationship between capabilities and performance. If one takes all firms together (cluster as well as non-cluster), cluster location *does* emerge as a positive and significant influence on performance even after other factors are controlled for. Both process and practice capabilities also have significant positive impact on performance. However, firm size does not have an impact on performance. If the analysis is done separately for cluster and non-cluster firms, some interesting patterns emerge. Process and practice capabilities significantly determine performance *only in* clusters while firm size matters *only outside* clusters.

Table 5: Performance Determinants of IT firms – Process Capabilities, Practice Capabilities and Location

Variable	Combined Sample	Cluster	Non-Cluster
Constant	-0.334 (0.674)	-1.664 (0.105)	0.237 (0.789)
Ln (Process Capabilities)	0.700 (0.051)*	0.971 (0.028)**	-0.334 (0.493)
Ln (Practice Capabilities)	0.452 (0.039)**	0.905 (0.005)***	0.314 (0.264)
Location	-1.281 (0.000)***	-	-
Ln (Total number of employees)	0.066 (0.470)	-0.060 (0.556)	0.324 (0.030)**
F-Statistic	15.43 (0.000)***	7.68 (0.000)***	2.25 (0.096)*
R^2	0.264	0.159	0.1355
Adjusted R^2	0.246	0.139	0.0752
Chow (Test for homogeneity)	2.32 (0.045)**	-	-

***, **, and * indicate significance at 1, 5 and 10 percent levels respectively

Table 6: Performance Determinants of IT firms – Capabilities, Skills, Quality certification and Location

Variable	Combined Sample	Cluster	Non-Cluster
Constant	0.637 (0.346)	-1.170 (0.216)	1.637 (0.041)**
Ln (Process Capabilities)	0.472 (0.094)*	0.932 (0.019)**	-0.896 (0.039)**
Ln (Practice Capabilities)	0.237 (0.192)	0.275 (0.333)	0.435 (0.071)*
Ln (Percentage of engineers)	0.081 (0.411)	0.358 (0.002)***	0.023 (0.815)
Quality dummy	0.002 (0.990)	-0.297 (0.215)	1.321 (0.004)***
Location dummy	-1.421 (0.000)***	-	-
Ln (Total number of employees)	0.023 (0.794)	-0.058 (0.596)	0.026 (0.851)
F-Statistic	12.33 (0.000)***	6.940 (0.000)***	3.40 (0.011)**
R^2	0.3071	0.1730	0.2981
Adjusted R^2	0.2822	0.1391	0.2104
Chow Test (Test for homogeneity)	3.10 (0.004)***	-	-

***, **, and * indicate significance at 1, 5 and 10 percent levels respectively

Table 6 provides empirical results of the relationship between capabilities and performance after controlling for share of skilled labour and quality certification. The impact of firm size becomes insignificant even in non-cluster locations once we control for share of skilled labour and quality certification. Percentage of skilled employees (engineers) in a firm turn out to be a significant determinant of performance *only in* clusters but the inclusion of this and the quality certification variable makes the impact of practice capabilities insignificant. The other measure of capability, quality certification is important for performance *only outside* clusters. Finally, once we include variables to control for skill and quality certification, both practice and process capabilities become significant determinants of performance in *non-cluster* firms. But while the impact of practices capabilities is positive, process capabilities surprisingly have a negative influence on firm performance. The interpretation of these results is somewhat difficult as the relationship between the three measures of capability is complex. The discussion in the section on measurement would suggest that they can be part complements and part substitutes at the same time.

The role of firm size that emerges from these results is quite interesting but before we discuss it a few other insights are worth noting. The fact that the share of engineers is able to make a significant positive impact only in cluster firms seems to suggest that the quality of engineers available to cluster firms is better than of those available in non-cluster locations. This may also partly explain the fact that inclusion of share of engineers in the model makes the role of practice capabilities insignificant. The absence of any significant role of quality certification in cluster locations may be due to the fact that virtually every firm in clusters has such a certification and it is no more a distinguishing feature to affect performance; such a situation apparently does not exist in non-cluster areas.

The change of signs for process and practice capabilities in non-cluster regions is surprising and needs to be explored further. The other interesting result is that firm size does not matter as far as performance of firms in clusters is concerned. Besides, firms are able to benefit from capabilities more in cluster than in non-cluster locations. Why are firms (even small) in clusters able to leverage capabilities for better performance? Are firms in clusters able to build capabilities that reduce the scale and other benefits that large firms typically enjoy? At one level, adoption of new technologies may not be possible for small firms and therefore capabilities and firm size may be positively correlated. But if firms (large as well as small) in cluster locations are able to have much higher adoption of various processes and practices than non-cluster firms, they may cross the 'threshold of adoption' that is critical to provide performance benefits. As adoption rates cross a threshold for firms of all sizes, the 'economies of scale' of capabilities might kick-in while the role of conventional benefits related to size may become somewhat less important. However, analysis of adoption rates of practices and processes by firm size in cluster and non-cluster locations did not show any clear patterns (data not reported here).

Apart from the scale of adoption, the other possibility is that cluster firms are able to identify the more *critical* processes/practices and adopt them for performance benefits while non-cluster firms are not able to do so. Table 7 shows that cluster firms have higher adoption of the following processes: high-level design, low-level design and functional requirement specification. As compared to non-cluster firms, cluster firms also have significantly higher adoption of some practices that include code readability, code reusability, benchmarking, informal KM, mentoring, system downtime, physical security and cross-functional teams (Table 8). It is very difficult to ascertain if these are the most critical processes and practices but it is important to re-iterate that the aggregate adoption measures hide these compositional differences which we have not been able to explicitly account for.

Table 7: Differences in adoption of processes by IT firms across cluster and non-cluster locations

Processes Adopted	Cluster Firms	Non-Cluster Firms	Test for difference in Proportions
Application Development			
Requirement Analysis	90	88	N (C)
High Level Design	90	72	Y (C)*
Low Level Design	83	67	Y(C)
System Requirement Specification	87	83	N(C)
Functional Requirement Specification	90	73	Y(C)
Coding	95	92	N(C)
Testing	95	92	N(C)
Installation	91	93	N(NC)
Post Production Support	87	90	N(NC)

*-p<0.05; Y( ): proportions are significantly different; N( ): proportions are not significantly different; NC-Non-cluster firms have higher proportion; C-Cluster firms have higher proportion.

Table 8: Differences in adoption of practices by IT firms across cluster and non-cluster locations

Practices Adopted	Cluster Firms	Non-Cluster Firms	Test for difference in Proportions
Coding Practices			
Code Readability	84	60	Y (C)*
Code Reusability	87	65	Y(C)
Error Reduction	85	77	N(C)
Speed of coding	62	62	N
Code Execution	78	68	N(C)
Knowledge Management (KM) Practices			
Testing	91	83	N(C)
Benchmarking	66	48	Y(C)
Formal Knowledge Management	56	45	N(C)
Acquiring new tools	84	85	N(C)
Informal KM practices	61	23	Y(C)
Security Practices			
Hardware maintenance	67	57	N(C)
Data Security	83	73	N(C)
Disaster Management	71	57	N(C)
Physical Security	74	52	Y(C)
System downtime	72	50	Y(C)
Human Resources (HR) Practices			
Training Practices	84	83	N(C)
Job rotation	69	60	N(C)
Mentoring	71	43	Y(C)
Cross functional teams	73	43	Y(C)

*-p<0.05; Y( )- proportions are significantly different; N( )- proportions are not significantly different; NC-Non-cluster firms have higher proportion; C-Cluster firms have higher proportion.

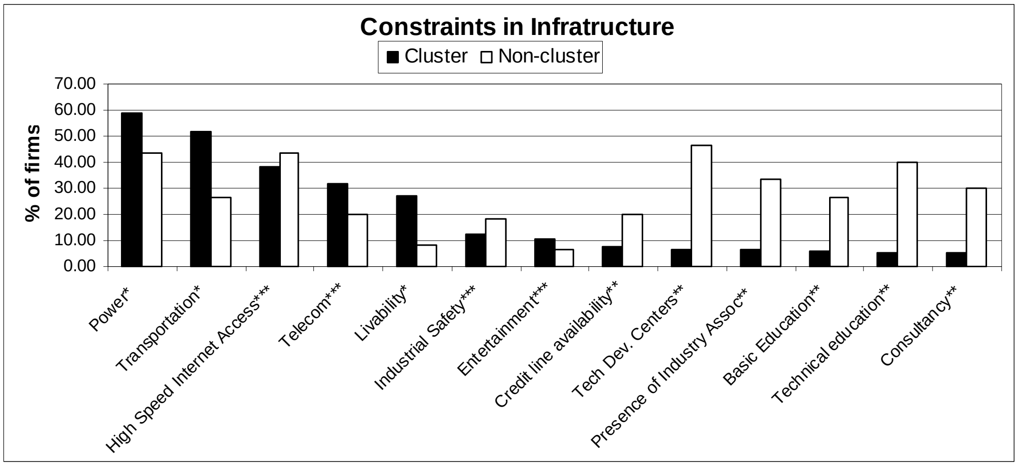
Ability of firms to leverage capabilities in clusters can also arise out of advantages that are available to all firms in clusters. Table 9 shows that firms in cluster have better access to skilled labour, hardware/software suppliers, R&D facilities, training facilities and support services (including for maintenance/repair). All these can potentially influence the efficacy of the adopted processes and practices.

Table 9: Comparison of Locational Advantages for IT Firms in Clusters vis-à-vis those Outside Clusters

Advantages of locating in a cluster (IT industry)	Type	No. of Firms	Mean	Significance
Proximity to customers	Cluster	176	2.94	N
	Non-cluster	59	3.12	
Information from competitors	Cluster	173	2.91	N
	Non-cluster	59	2.61	
Information about competitors	Cluster	172	3.03	Y*
	Non-cluster	59	2.63	
Availability of skilled labour from competitors	Cluster	175	3.15	Y*
	Non-cluster	58	2.64	
Access to skilled labour	Cluster	180	3.92	Y
	Non-cluster	59	3.12	
Presence of hardware & software suppliers	Cluster	180	3.76	Y
	Non-cluster	59	3.17	
Better access to support services	Cluster	177	3.67	Y
	Non-cluster	57	3.05	
Better access to training facilities	Cluster	177	3.63	Y
	Non-cluster	57	3.05	
Better access to R&D Institutions	Cluster	165	3.25	Y
	Non-cluster	57	2.61	
Better access to information on fairs & exhibitions	Cluster	174	3.57	Y
	Non-cluster	59	2.69	
Availability of maintenance / repair services	Cluster	179	3.79	Y
	Non-cluster	59	3.39	
Availability of better infrastructure	Cluster	181	3.55	N
	Non-cluster	59	3.64	

*-5% level of significance; others are significant at 1% level; Y-means are significantly different; N- means are not significantly different

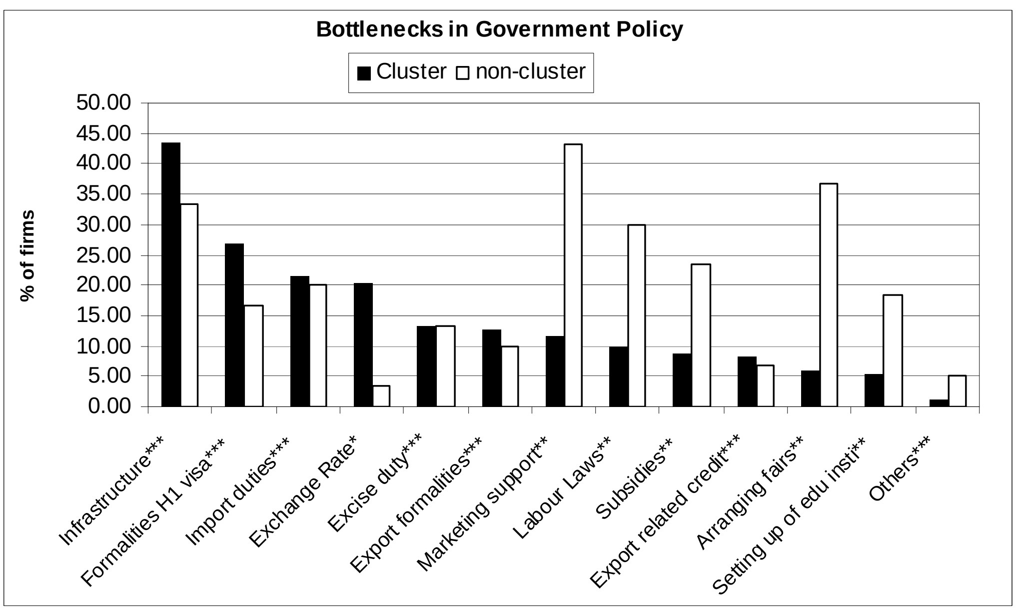
In the same vein, infrastructural constraints can also reduce the effect of capabilities on firm performance. Do cluster firms face fewer infrastructure constraints? Figure 2 and Figure 3 show that all firms (in clusters as well as in non-cluster locations face problems due to power, transportation, high-speed internet access and telecom across locations. However, non-cluster firms also have to contend with problems due to absence of technology development centers, industry associations, basic education and technical education facilities and consultancy / support services. Once again, both the adoption level and the subsequent implementation of technologies can get adversely affected by these problems.



*-Significantly higher proportion of cluster firms face problems
**-Significantly higher proportion of firms outside clusters face problems
***-Firms in clusters and outside clusters are not significantly different from each other

Figure 2: Constraints in Infrastructure faced by IT Firms in Clusters and Outside Clusters

Moreover, unlike cluster firms, non-cluster firms also report constraints arising out of absence of marketing support, appropriate labour laws and subsidies apart from limited exposure to fairs and exhibitions. All these can also have an indirect effect on adoption decisions.



*-Significantly higher proportion of cluster firms face problems
**-Significantly higher proportion of firms outside clusters face problems
***-Firms in clusters and outside clusters are not significantly different from each other

Figure 3: Constraints due to Government policy faced by IT Firms In and Outside Clusters

4.2 Determinants of Capability in IT Firms

It is hypothesized that technological capability of the firm is influenced by its size and location (cluster/non-cluster) and the access to network capital. While estimating this relationship, the following types of networks were distinguished: *local* (city specific) *customer* network; *other* (competitors, suppliers, consultants, R&D institutions etc.) *local* networks; *national customer* network; *other national* network; *international customer* network; and *other international* network.

Table 10: Determinants of Capabilities of IT firms

Variable	Combined Sample		Cluster Firms		Non-Cluster Firms	
Constant	2.836 (0.000)***	2.788 (0.000)***	2.951 (0.000)***	2.809 (0.000)***	2.381 (0.000)***	2.361 (0.000)***
Ln (local customer network capital)	0.003 (0.703)	-0.003 (0.698)	-0.001 (0.898)	-0.012 (0.127)	0.008 (0.719)	0.004 (0.848)
Ln (other local network capital)	0.031 (0.015)**	0.024 (0.025)**	0.011 (0.219)	0.018 (0.044)**	0.070 (0.084)*	0.082 (0.046)**
Ln (national customer network capital)	0.001 (0.999)	0.006 (0.423)	-0.007 (0.379)	0.002 (0.736)	0.040 (0.097)*	0.050 (0.041)**
Ln (other national network capital)	0.018 (0.074)*	0.013 (0.145)	0.022 (0.005)***	0.022 (0.003)***	0.047 (0.100)*	0.030 (0.324)
Ln (international customer network capital)	-0.003 (0.721)	0.003 (0.685)	0.019 (0.002)***	0.015 (0.011)**	-0.124 (0.000)***	-0.133 (0.000)***
Ln (other international network capital)	-0.012 (0.225)	-0.014 (0.159)	-0.024 (0.000)***	-0.028 (0.000)***	0.171 (0.009)***	0.180 (0.009)***
Ln (total employees)	0.049 (0.001)***	-	0.034 (0.004)***	-	0.035 (0.402)	-
Ln (Sales)	-	0.039 (0.000)***	-	0.042 (0.000)***	-	0.035 (0.182)
Location dummy	-0.145 (0.006)***	-0.038 (0.463)	-	-	-	-
F-Statistic	4.97 (0.000)***	7.62 (0.000)***	5.83 (0.000)***	10.63 (0.000)***	5.20 (0.000)***	4.74 (0.000)***
R-Square	0.2069	0.2592	0.1895	0.3907	0.4702	0.4941
Adjusted R-Square	0.1714	0.2221	0.1452	0.3542	0.3797	0.3899
Chow test (Test for homogeneity)	2.96 (0.002)***	2.99 (0.002)***	-	-	-	-

***, **, and * indicate significance at 1, 5 and 10 percent levels respectively

If we analyze the determinants of technological capability across firms for all firms taken together (Table 10), we find that, as in the case of performance, cluster location affects capability building positively. *Other local* and *other national* network capital emerges as an important determinant of capabilities. And size also affected capability building positively. However, if the analysis of determinants of capabilities is done separately for cluster and non-cluster firms, some interesting differences emerge. *International customer* capital turns out to be a positive and significant determinant of capabilities *only* in clusters. Surprisingly, in non-cluster locations such capital affects capability of IT firms negatively. One possible explanation could be that nature of linkages that non-cluster firms have with international customers is different from those that the cluster firms are able to establish. Besides, the number of such linkages may be much smaller for non-cluster firms. If there is a threshold effect for international customer capital, that may not have kicked in for non-cluster firms, but a negative impact is counter-intuitive. *Other local and other national* network capital have a significant and positive effect on firm capabilities both *in and outside* clusters, while *National customer* network capital has a positive impact on firm capabilities *only in non-cluster* locations. It is likely that national customer networks of non-cluster firms may essentially be with *IT firms located in clusters*. Thus, the role of national customer capital for non-cluster firms essentially captures linkages between cluster and non-cluster firms. Interestingly, Size has a positive impact on capabilities *only* in clusters. Thus, while size does not affect performance significantly in cluster locations, it does affect capability building. We have not been able to explicitly explore economies of scale and scope in networks. But the data clearly shows that firms in clusters have higher number and greater diversity of networks (Table 11).

Table 11: Average number of Networks of IT firms within and Outside Clusters

Type of networks	**Local Networks**		**National Networks**		**International Networks**	
Location	**Cluster Firms**	**Non-cluster Firms**	**Cluster Firms**	**Non-cluster Firms**	**Cluster Firms**	**Non-cluster Firms**
Customers	26.17	95.1	66.14	203.15	113.75	7.4
Suppliers	6.95	5.05	4.34	4.15	2.01	0.03
Competitors	4.92	4.65	14.21	21.63	5.03	0.13
Consultants	2.39	1.53	1.32	0.78	1.35	0.08
Alliances	1.2	0.3	1.68	0.52	2.19	0.2
Industry Associations	0.86	1.08	0.61	2.43	0.88	0.05
Government	0.38	0.35	0.63	0.1	0.21	0.02
Other units of the firm	1.21	0.2	1.22	0.42	2.99	0.73
Total	44.09	108.27	90.15	233.18	128.4	8.65

Are sources of knowledge different for IT firms within and outside clusters? Table 12 shows that in relative terms, for process capabilities cluster firms reportedly rely more on consultants within the cluster and alliances outside clusters while non-cluster firms rely on customers within and outside clusters and the Internet. For other sources of process related knowledge, the two sets of firms are not significantly different. This is somewhat consistent with the econometric results as non-local customer networks have a positive impact on capability for non-cluster firms and other local and national network capital has a positive impact on capabilities for both cluster and non-cluster firms.

Table 12: Comparison of Sources of Process related Knowledge between IT firms within and outside Clusters

Important sources of Process Knowledge	Proportion of Cluster Firms indicating as a source	Proportion of Non-cluster Firms indicating as a source	Test of Difference in Proportions
Customer(NL)	15.48	16.48	N(NC)
Internet	13.60	33.70	Y(NC)*
Customer(B)	8.93	14.44	Y(NC)
Firm(NL)	8.80	9.81	N(NC)
Consultant(L)	8.50	5.74	Y(C)
Alliance(NL)	6.62	2.41	Y(C)
Firm(B)	6.31	6.48	N(NC)
Customer(L)	5.95	13.15	Y(NC)
Others[†](NL)	4.43	0.74	(Y(C)
Alliance(L)	4.31	3.70	N(C)
Others(L)	3.83	7.22	Y(NC)
Competitor(L)	3.76	6.11	Y(NC)
Competitor(NL)	2.49	3.89	N(NC)
Competitor(B)	2.37	0.00	Y(C)
Consultant(B)	2.25	6.48	Y(NC)
Consultant(NL)	1.58	7.41	Y(NC)
Others(B)	1.52	0.00	Y(C)
Alliance(B)	0.85	0.00	Y(C)
Y ( )– Proportions are significantly different and N( )- Proportions are not significantly different; NL- Non-local, L-local, B- Both local & non-local;			
NC- means that firms outside clusters have higher proportion, C - firms within clusters have higher proportions			
[†]- Others include industry associations, recruitment from other firms			

For practice capabilities, cluster firms rely more on internal systems, consultants within the clusters and alliances outside clusters whereas firms outside clusters rely more on Internet and consultants outside non-cluster locations (Table 13). It is possible that the absence of local consultants, inadequate internal systems and other advantages that cluster firms have reduces the ability of firms outside clusters to leverage networks especially foreign ones.

Table 13: Comparison of Sources of Practice Knowledge between firms within and outside clusters

Important sources of Practice Knowledge	Proportion of Cluster Firms Indicating as a Source	Proportion of Non-cluster Firms Indicating as a Source	Test of Difference in Proportions
Firm(L)	46.97	33.68	Y(C)*
Internet	9.40	28.60	Y(NC)
Customer(NL)	8.08	4.30	Y(C)
Firm(NL)	7.51	4.74	Y(C)
Customer(L)	6.84	4.56	Y(C)
Firm(B)	6.44	10.96	N(NC)
Customer(B)	6.44	7.19	Y(NC)
Others†(L)	6.30	8.07	N(NC)
Consultant(L)	5.26	3.25	Y(C)
Alliance(L)	4.14	3.33	N(C)
Alliance(NL)	3.97	1.67	Y(C)
Others(B)	3.16	0.00	Y(C)
Others(NL)	3.13	1.32	Y(C)
Consultant(B)	2.53	5.00	Y(NC)
Consultant(NL)	1.04	4.82	Y(NC)
Alliance(B)	0.58	0.00	Y(C)
Y( )- Proportions are significantly different, N( )-Proportions are not significantly different; NL- Non-local, L-local, B- Both local & non-local;			
(NC) means that firms outside clusters have higher proportion, (C) firms within clusters have higher proportions			
†- Others include suppliers, research labs, competitors, recruitment from other firms			

To summarize, process and practice capabilities contribute to the performance of firms in clusters, whereas these capabilities do not have the same effect on performance of firms outside clusters. Additionally, quality certification effects performance of firms outside clusters and share of engineers' effects performance of firms within clusters. Further, large firms are able to better leverage international customer capital and other local network capital for capability formation within firms in clusters, whereas large firms outside cluster are not able to leverage networks in a similar manner.

5. Conclusion

Our empirical analysis shows that networks help develop capabilities which in turn affect performance positively. Leveraging networks for capability building and leveraging capabilities for performance is not automatic. Leveraging of capabilities requires skilled labour (engineers), availability of technical training and intellectual infrastructure that are more readily available in clusters whereas payoffs for quality certification are more for firms outside clusters. Our result on quality certification is corroborated by evidence provided by Gao et al.(2010) who found that quality certification effects performance of firms only outside clusters. It is likely that certification in the case of Indian IT industry is serving as a signaling mechanism for firms in early stages only. Firms in clusters (probably in later stages) do not require signaling mechanisms for better performance. Moreover, as agglomeration economies kick in and clusters become brands in themselves, even smaller firms within clusters may not require quality certification as a signal to its customers, or it may cease to be a critical distinguishing feature as most of the firms in clusters may have acquired it. To summarize, location in clusters can help firms access information and/or resources to identify, adopt and exploit critical processes and practices. Although, recent literature points to the importance of networks (local and non-local) for performance of firms in clusters, we also show that the structural features (including presence of various institutions) contribute to the capability formation and performance of firms.

In our study, we have also observed differences in the capability building process across firms within and outside clusters. While scale economies is important for firms to leverage their networks for capability formation in clusters, size of firms does not play an important role in capability formation for firms outside clusters. Recent studies have still not resolved issues around importance of local knowledge spillovers, face to face interactions, spatial proximity, network openness, network strength and non-local knowledge transmission for firm performance in clusters. Kesidou and Romijn (2008) have shown that local knowledge spillovers are more important than international knowledge transmission, whereas Weterings and Boschma (2009) have shown that spatial proximity are not as important for innovative performance of software firms. We extend findings from these studies by highlighting the role of national networks. Other studies could not capture this affect since the studies were situated in countries or regions which are not of the scale of India. Our study shows that both international customer networks as well as other local networks contribute to the capability formation of firms in clusters, whereas national customer capital enable knowledge transfer to firms outside clusters. Thus, we add an additional dimension on how knowledge flow mechanisms ride on flows of value chains of the firm i.e., how non local customers (international customer capital) as well as other local networks (other local network capital) contribute to the capability formation of firms in clusters. Policies to facilitate network building would help firms build capabilities on critical processes and practices. Incentives to network seem desirable. In any case relaxing constraints that have been highlighted in the study is an obvious area of policy intervention.

Although, we consider our work as important contribution, there are some limitations to this study. The study was primarily cross sectional in nature and we could not capture changes in capabilities and networks of firms within and outside clusters over a period of time. Besides, we could not empirically establish the nature of relationship between process and practice capabilities as well as quality certification and share of engineers in a firm. Given high collinearity between these elements, our attempt to explore this through interaction terms was not feasible. Moreover, information on the *time of adoption* of various processes and practices is not available which means that we cannot use time elapsed as weights as well. Such a weight could have been a decent proxy for "learning by doing". In the same vein, intensity/extent of adoption of processes and practices may vary across firms but could not be captured. Availability of such information would also have helped us create some weights but collecting such data on a large scale is very difficult and resource intensive. Additionally, our study was not able to delineate the role of informal and formal network linkages. Both informal and formal interactions between firms are likely to complement each and contribute to the knowledge flow mechanisms within clusters (Bell, 2005). Delineation of the dynamics of informal and formal networks in capability building would help us inform the firm strategy as well as cluster policy better. Our analysis could not explicitly explore the role differences in the nature of competition (market structure) played in the processes of capability building and exploitation by firms within and outside clusters. Some insights on this might inform policy.

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Appendix 1

Computation of process and practice capabilities of IT Firms

Processes of IT Firms Included in the Survey

Processes for IT firms	
Requirement Analysis	Y/N
High Level Design	Y/N
Low Level Design	Y/N
System Requirement Specification	Y/N
Functional Requirement Specification	Y/N
Coding	Y/N
Testing	Y/N
Installation	Y/N
Post Production Support	Y/N

Process Capability Index[12] = $\sum_{i=1}^{10} X_i$ where $X_i = \begin{cases} 1 \text{ if firm adopts process } i \\ 0 \text{ otherwise} \end{cases}$

Practices of IT Firms Included in the Survey

Coding Practices	
Code Readability	Y/N
Code Reusability	Y/N
Error reduction	Y/N
Speed of coding	Y/N
Code Execution	Y/N
Knowledge Management (KM) Practices	
Testing	Y/N
Bench Marking	Y/N
Formal KM Sytems	Y/N
Acquiring New tools	Y/N
Informal KM Practices	Y/N
Security Practices	
Hardware Maintenance Practices	Y/N
Data Security	Y/N
Disaster Management	Y/N
Physical Security	Y/N
System downtime	Y/N
Human Resource (HR) Practices	
Training practices	Y/N
Job rotation	Y/N
Mentoring	Y/N
Cross functional teams	Y/N

Practice Capability Index = $\sum_{i=1}^{19} X_i$ where $X_i = \begin{cases} 1 \text{ if firm adopts practice } i \\ 0 \text{ otherwise} \end{cases}$

[12] We interchangeably use process capability index, process capabilities and process capability as part of this study. Similarly, we also use practice capability index, practice capabilities and practice capability as part of this study.