Economic Geography and Networks: Role of local and non-local ties in Cluster Evolution

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Abstract

The organization of geographic clusters plays an increasingly significant role due to the presence of network ties that exist within the location and beyond. This has proven to be particularly true for knowledge-intensive industries, where the organization of resources – people and technology – has been a primary driver for firm and regional performance. With the help of a longitudinal case study of the IT cluster in Bangalore (India), we investigate the effect of local and non-local network ties on its evolution. We argue that local and non-local networks play a clear role in cluster evolution. We propose a U-shaped relationship between cluster evolution phases and the distance among the network tie members. Our study also outlines the role that *embedding*, *expansion*, and *extension* of ties plays in transitioning cluster from one phase to the other. The consideration of non-local ties is rather nascent in the cluster literature and promises to enhance the understanding of how clusters develop at both levels - policy as well as firm

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1. Introduction

In 2013, Electronics City and other technology parks outside Bangalore exhibit every feature of a modern technology cluster such as Silicon Valley, Cambridge or Tel Aviv. Locating in such regions does not concern foreign companies about the reliability and legitimacy of these locations. In Bangalore this was not always the case. Turning back the clock by 30 years, Electronics City was merely an empty shell with little more than the name to it. How could the city develop from arbitrary location to become one of the world's leading software clusters?
Over the years, there have been several domestic as well as foreign software and related service firms that chose Bangalore for locating their operations – giving rise to a complex network of ties across different actors. However, very little is known whether these networks – within the local region and beyond – played a role in the development of Bangalore cluster? Through a longitudinal case study, we investigate the evolution of a knowledge service cluster (KSC) to scrutinize the role of network ties and their changing influence on the cluster and its development.

The development of industrial clusters has received extensive theorizing over the last decades. Classic works (e.g., Marshall, 1920) point towards the development of clusters due to shared positive externalities from infrastructure, skilled labor pool and knowledge spillovers. While it is established that there are certain externalities that attract firms to set up operations in clusters, firms often access resources and knowledge through network ties – local or non-local. In order to advance understanding on the role they play in cluster development, there is a need to first delineate the effects of network ties that enable firms to transfer the benefits of clustering. Scholars have found different types of network properties and environmental contingencies under which networks can help clusters sustain innovation and perform better (e.g., Eisingerich et al., 2010; Mahmood and Zheng, 2009). However, others have also questioned whether clustering is a sufficient or even necessary condition for knowledge flows and innovation (e.g., Aharonson et al., 2008; Stuart and Sorenson, 2003). In this paper, we carve out a clear role of network ties in the evolution of clusters, by proposing individual and combined roles that different network ties

play over time. Thereby, we advance theory on clustering in general, and contribute to the emerging literature on geographical clusters in general and KSCs, in particular; defined as "as geographic concentrations of lower-cost technical and analytical skills serving global demand for increasingly commoditized knowledge services, including software development, engineering support, product design, and analytics" (Manning, 2012).

In order to derive meaningful conclusions, we follow the established definition, proposed by Gulati et al. (2000), wherein an organization's network is described as its set of relations, both horizontal and vertical, with other strategically significant actors. As the focal construct in this paper is a cluster of firms, we define local networks as internal ties within a geographical cluster and non-local networks as external ties beyond the geographical boundary of the cluster. Our objective – to shed light on the role of networks in cluster development – not only fosters integrating the cluster literature with that on networks, but also facilitates better understanding of clusters significantly involved in global operations. Insights from this study are expected to allow MNCs and SMEs alike – particularly in knowledge-intensive service industries – to make location decisions that enable leveraging networks of developing clusters.

This study contributes to cluster and social networks research by combining literature on the cluster lifecycle (Bergman, 2008; Menzel and Fornahl, 2010) and social networks (Eisingerich et al., 2010; Stuart and Sorenson, 2003; Zaheer and McEvily, 1999). We inductively develop propositions around the dominance of the networks in each phase of cluster development, and the role they play in transitioning the cluster through each of its phases. Based on our analysis, we argue that both local and non-local networks played key roles in its evolution, yet there was a changing pattern between local and non-local networks across this cycle. While non-local network ties are found to play a dominant role in the foundation phase, local network ties are found to have a stronger influence in the emergence and growth of the cluster. Non-local network ties re-emerge as a stronger factor in the consolidation phase of the cluster evolution.

2. Theoretical foundations and conceptual framework

We aim to explore and explain the evolution of a cluster by investigating the role of local and non-local networks. Therefore, our conceptual framework builds on established notions and consensus in extant literature on clusters and networks and the way they act and complement each other in evolutionary processes.

2.1 Clusters

Porter (2000) defines a cluster as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (p: 254). Compared to this classical geographical view, scholars recently focused on the role of networks within clusters. For example, Tallman et al. (2004), describe a cluster as a "group of firms tied together by geographical co-location and complex social interaction," (p: 261). This revised view emphasizes proximity and *local* social networks as an important conduit for flows of (tacit) knowledge (Almeida, 1999; Arikan, 2009), and resource mobilization (Stuart and Sorenson, 2003) conferring competitive advantage to firms in clusters (Folta et al., 2006; Porter, 1990; Porter, 2000). Cluster-based firms are shown to maintain a high pace of innovation compared to firms not located in clusters (Baptista and Swann, 1998), reinforced by high levels of employee mobility which accelerates tacit knowledge flows (Arikan, 2009; Saxenian, 1994). Aharonson et al. (2008) questioned these deterministic findings of clustering being a sufficient or even necessary condition for innovation. Similarly, Breschi and Lissoni (2001) and Boschma (2005) have argued that geographic proximity is rather a proxy for social proximity and more attention should be paid to networks (Stuart and Sorenson, 2003). Hence, the main mechanism that contributes to the localized character of such knowledge spillovers is informal interaction–within cluster-based communities of entrepreneurs and technicians–which in turn leads to inter-firm links in cooperation networks, labor mobility, and the creation of spin-offs (Ter Wal and Boschma, 2009). While these inter-organizational linkages can be both horizontal and vertical, the important element of trust is usually developed in buyer-supplier relationships (Hibbard et al., 2001; Morgan and Hunt, 1994; Park et al., 2010). This can have beneficial implications for innovation outcomes at the firm level (Anderson and Weitz, 1992; Eisingerich et al., 2009; Tuli et al., 2007). However, at the cluster level, this informal interaction is not evenly distributed; for instance, knowledge networks function only selectively among some of the organizations (Giuliani, 2007).

By combining technology life cycle and industry life cycle models with a synthesis of cluster literature (e.g., Maskell, 2001; Menzel and Fornahl, 2010), Bergman's (2008) framework of cluster life-cycle adds a dynamic element to our understanding of clusters. In Bergman's

(2008) cluster life cycle, the first phase is described as the existence of a cluster succeeded by one of expansion or growth. In the final phase, the cluster reaches exhaustion when industry maturity becomes a threat to the cluster's continued viability; at this point it will either experience lock-in or a renaissance. This conceptualization of cluster development provides a background to the focal phenomenon our study – cluster development.

2.2 Social Networks

Research on social networks has increased dramatically over the last years (Brass et al., 2004; Parkhe et al., 2006). Broadly speaking, the literature on social network theory can be divided in two streams. The first one comprises of scholars with an emphasis on cohesion and embeddedness (e.g., Coleman, 1988; Uzzi, 1997), whereas the second stream looks at structural holes and weak ties (e.g., Burt, 1992; Granovetter, 1973). These two strands lead to conflicting predictions about optimal network configuration, because they stress different network functions. For example, scholars taking the former view argue that denser ties reflect trust, thereby enabling network actors to corroborate the same knowledge and to collaborate. The latter stream argues for networks characterized by structural holes, in which focal network actors with non-redundant ties bridge previously unconnected actors, to provide focal firms with novel information and knowledge. Scholars have begun to move beyond this conundrum of perspectives to emphasize the benefits of certain network types using contingency approaches, specifying industry life cycle phases, environmental conditions, or tie function. For example, Rowley et al. (2000) relate strong ties to exploitation and weak ties to exploration; Gargiulo and Benassi (2000) found cohesive networks less adaptive in the context of the computer industry, which is a fast-changing environment; and Hansen (1999) found weak ties to be highly useful in search, but impediments to the transfer of complex knowledge.

We arranged extant literature on the dimension of geographic distance i.e. local vs. non-local ties. Scholars have focused on the role of *local* networks as performing the key function of transferring (tacit) knowledge via informal collaboration, labor mobility, and spin-offs (Arikan, 2009; Giuliani, 2007; Stuart and Sorenson, 2003; Ter Wal and Boschma, 2009). Zaheer et al. (2009) found, that entrepreneurs' personal local networks influence their selection of a startup location (cf. Sorenson and Audia, 2000). While local networks are seen to be an important factor

in clustering, scholars have more recently also acknowledged the role of *non-local* networks and their contribution to knowledge spillovers (Mahmood and Zheng, 2009; Tallman and Phene, 2007).

While there is a large body of research on social networks, geographical distance between network actors is understudied. Rather, geographic space potentially contradicts several characteristics of social networks, in particular if argued that tie strength is inversely correlated to physical distance between network actors (Whittington et al., 2009). Hence, we concur with Breschi and Lissoni (2001) and Boschma (2005) that clusters need to be investigated more closely with regards to the social networks literature and the functions networks perform.

2.3 Clusters and Network Ties

In our review of economic geography and related literatures, we found some research on the role of social networks in clustering. The most prominent network theme in the cluster literature is perhaps that of boundary spanners, which relates to weak ties bridging structural holes. Zaheer and McEvily (1999), found that firms in geographic clusters with bridging and sustaining ties to regional institutions are well-positioned to access new information, ideas, and opportunities, yet those with fewer non-redundant ties (or structural holes) acquire fewer competitive capabilities. Similarly Stuart and Sorenson (2003) conclude that "people almost always have more, more diverse, and stronger ties to contacts in the geographic region in which they reside. This suggests that the form of social capital most valuable in the resource mobilization process is, to a large extent, a geographically localized currency." (p. 249). Eisingerich et al. (2010) investigated network properties such as strength and openness and environmental uncertainty to show which configurations can help clusters sustain innovative performance.

In our study, the focal unit is that of a geographical cluster of firms and other organizations, therefore we conceptualize local ties as mainly cohesive and strong linkages with other organizations in the same area. Non-local ties are conceptualized as ones that extend or span boundaries beyond the geographical cluster, typically weak ties. While this could be too parsimonious for a firm-level investigation, this seems reasonable to study cluster ties. This dichotomization simplifies the investigation of network ties and differential effects on a KSC,

contingent on life cycle evolution (cf. Hite and Hesterly, 2001; Madhavan et al., 1998).

Bathelt (2005) argues that clusters need a mix of local and non-local transactions to innovate. He argues that clusters can only create new knowledge and continue to grow if the cluster firms have linkages with external markets and employ a mix of local and non-local transactions. Otherwise they experience a technological lock-in due to overembeddedness (cf. Uzzi, 1997) and cognitive isomorphism (Pouder and St. John, 1996). Other scholars have investigated the interaction between clusters and non-local (ethnic) ties. This literature predominantly sees non-local networks as a substitute for missing local factors rather than as complementing local ties (e.g., Kerr, 2008; Nanda and Khanna, 2010; Zaheer et al., 2009). A recent exception is Mahmood and Zheng (2009) who found non-local (international) networks to be a source for local innovation in the case of Taiwan.

We add to recent advancements in the literature which addresses similar aspects through an industry-level (e.g., Ter Wal, 2013a; Ter Wal and Boschma, 2011) or inventor-level perspective (Ter Wal, 2013b), respectively. At the cluster level, Giuliani (2011) finds a persistent pattern of strong local firms acting as technological gatekeepers by importing external knowledge and diffusing this knowledge locally, without disentangling different phases. Giuliani (2013) analyzed networks dynamics in a cluster tracing the emergence of ties with rich social network data; however, her study focuses on the local elements of the cluster networks. We contribute to this literature by investigating both internal and external networks during cluster level evolution in a more sequenced fashion.

3. Methods

Our choice of methodology was driven by the research objective of our study: What role do the local and non-local networks play in cluster evolution? To answer this research question, we chose an exploratory, qualitative case study of Bangalore IT cluster. Through an exploratory study, we seek to generate a theoretical explanation of the role of network ties in cluster evolution. Since the cluster-level phenomenon is difficult to dissociate from its context, case study method (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 1984) has been widely used to investigate it (e.g., Eisingerich et al., 2010; Saxenian, 1994). Furthermore, our research question also demands investigating longitudinal data for an in-depth understanding, explanation

and interpretation. This required qualitative data in form of rich experiences of managers describing how they witnessed the evolution of the cluster and the role of networks. While we analyzed the data in an iterative manner, for the ease of presenting, we present the data in a relatively structured and linear form followed by separate section on its analysis (Suddaby, 2006). For instance, the division of data into cluster phases was arrived at after the analysis, but for the purpose of presenting it in a more readable and comprehensible format, we structure the data according to these phases in our presentation.

3.1 Study Setting

We adopted a theoretical sampling technique so that the study setting is illuminated and extends relationships and logic among constructs that we aim to develop (Siggelkow, 2007). We selected the Bangalore IT cluster because it is a cluster that evolved from a simple technology park location in mid 1980s, to high maturity in recent years. At the same time, the history of Bangalore IT cluster is documented well and also relatively fresh in the minds of the managers in the region – particularly the longstanding ones in the firms that have co-evolved with the cluster. From an empirical perspective, it is an interesting case, given that the supply of human capital facilitated by local network ties and client demand arising out of non-local network ties (particularly that of MNC firms) have been often named as the primary drivers of the evolution of the Indian IT industry. From a theoretical perspective, the cluster is mature enough to discern both – local and non-local – networks and investigate their effects on cluster evolution. So far, there have been several studies focusing on Bangalore IT cluster (e.g., Arora et al., 2001; Arora and Bagde, 2010; Athreye, 2005; Patibandla and Petersen, 2002), however they mainly addressed its evolution empirically, without making explicit theoretical arguments about the role of networks in aiding the evolution of clusters.

A cluster that specializes in software service is bound to have global networks at some point in time by virtue of the service offered by firms located in the cluster. The non-local networks in such a cluster can exist in multiple forms: human capital, client relations, virtual teams, parent-subsidiary networks. This provides a rich context to study the dynamics of their relationships with local ties. Having identified a KSC as a good sampling strategy, Bangalore cluster was selected because through domestic firms and MNCs it exhibits both types of networks

that are put forward in the literature to investigate their effects on cluster evolution; and empirically, it is an interesting case given the limited number of studies that addressed its evolution making explicit theoretical arguments. In addition, it has recently been highlighted that it boasts of all types of services offered by the firms located there (Manning, 2012). Overall, we believe that many insights can be gained from studying the evolution of the Bangalore cluster for other more upcoming locations and therefore was selected as a relevant case study.

3.2 Data Collection

The Bangalore IT cluster provides a rich context with domestic firms that have internationalized, as well as foreign MNC firms that have established their presence in the emerging economy of India. In order to analyze the networks within the cluster, we developed a broad database of secondary information on the cluster. This included historical evidence from annual reports of the firms headquartered in Bangalore, and published case-studies on Indian IT industry in Bangalore (e.g., Balasubramanyam and Balasubramanyam, 2000; Basant and Chandra, 2007; Lorenzen and Mudambi, 2012; Sonderegger and Täube, 2010).

To collect primary data, we carried out qualitative interviews with entrepreneurs and employees in different organizations to cover a large variety of responses ranging from middle management and top management of firms to government officials, and research and development (R&D) employees of firms to members of academic institutions and ministries of state. The data was collected between 2003 and 2008, across three different phases (cf. Ravasi and Schultz, 2006 for a similar empirical strategy). They were not restricted to firms operating from Bangalore in order to better grasp the evolution of IT industry in India as a whole – a phenomenon which has been closely related to the evolution of Bangalore's IT cluster. Moreover, we also interviewed senior executives of Indian software firms at an offshore location in order to get a complementary picture of non-local networks (cf. Arora et al., 2001; p.1268). We followed a rigorous data collection protocol in the form of a directive interview. We recorded the interviews, whenever possible, or documented the notes within 24 hours to ensure the accuracy of the collected data. Once transcribed, we sent the transcribed interviews to the respective respondent for endorsement and cross-validation.

3.3 Data Analysis

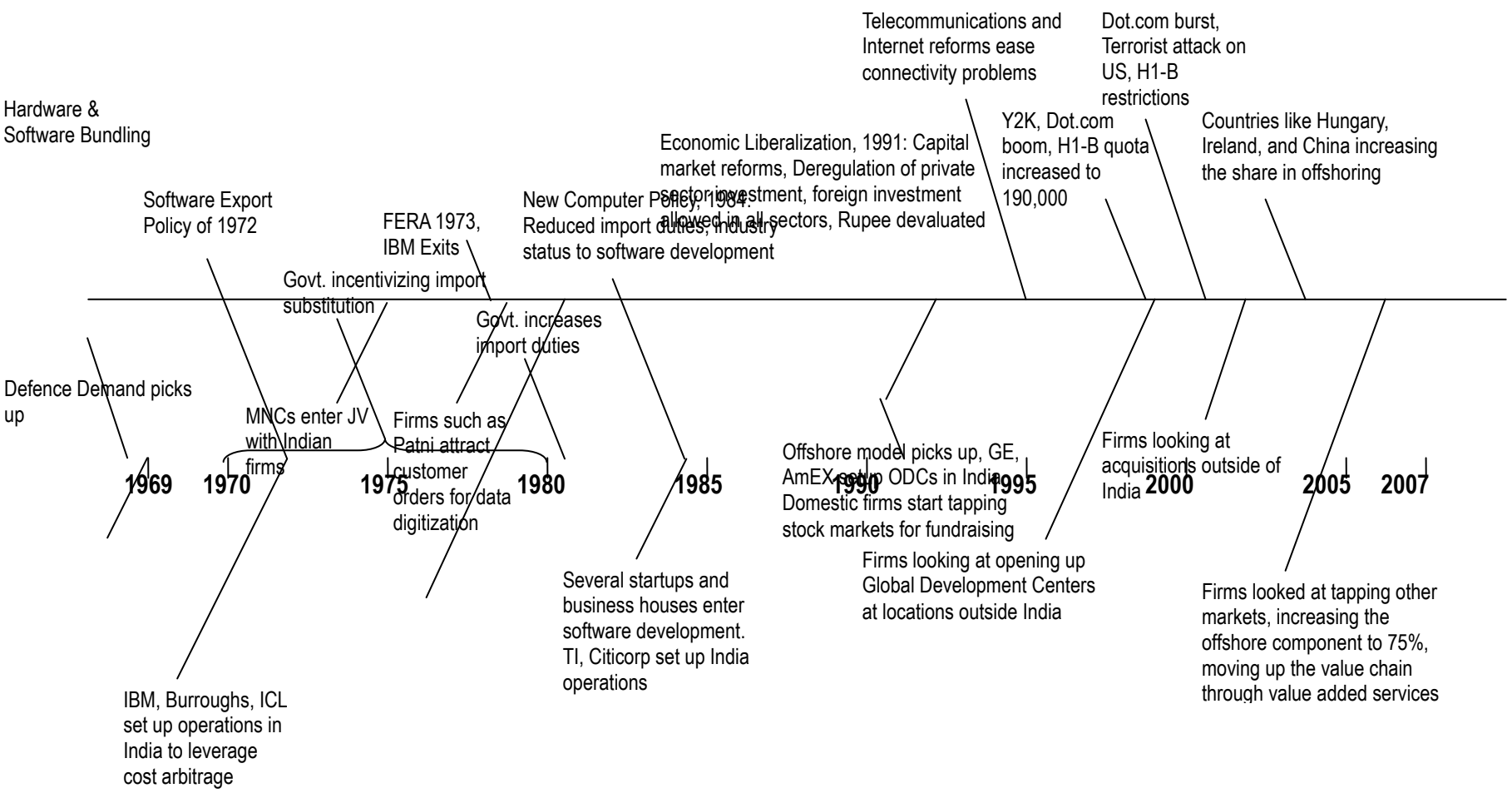
As suggested by Miles and Huberman (1994), data collection and analysis were undertaken in an iterative manner, using constant comparison (Suddaby, 2006). In order to infer meaningful results and make sense out of the patterns, we chose to anchor our analysis in the theoretical framework of local and non-local ties, across the different phases of cluster evolution. We first organized the secondary data chronologically and prepared a figure of the cluster evolution. Next, we collected primary data on networks and revisited the data on cluster genesis to find out the linkages between the networks and cluster evolution. We then arranged these data chronologically and identified themes based on local and non-local networks. These network categories were scrutinized on a longitudinal basis, and their effects on enabling cluster growth were investigated. In particular, the role of network ties on enabling the transition from one phase to the next was analyzed and inferences drawn from the analysis.[2] The categorization of longitudinal data and coding was undertaken independently by each of the co-authors, and then merged so as to ensure internal validity and reliability (Yin, 1984).

4. Case Analysis: Bangalore Software Cluster

Bangalore is one of the top 5 metropolitan cities in India. Over the last years, Bangalore has become popularly known as the IT capital or the Silicon Valley of India, owing to the presence of a large and growing software services industry. As outlined in the Figure B.1 below, we look at the history of Bangalore's development as a KSC in four phases that roughly coincide with the phases foundation, emergence, growth, and consolidation identified in theoretical (Bergman, 2008; Menzel and Fornahl, 2010) and empirical literature (e.g., Athreye, 2005; Lateef, 1997)in order to carve out the influence of local and non-local networks over time.

[2] We thank an anonymous reviewer for pointing towards this interesting theoretical contribution.

Figure B.1: Evolution of the Bangalore Software Cluster



4.1 Cluster Foundation (until c. 1984)

Through the decade of 1970s, there were several measures by the Government of India – especially the newly formed Department of Electronics, that led to a successful formulation of the Software Export Policy in 1972. The policy was aimed at providing incentives to the export-oriented software firms. Encouraged by the policy initiatives, and also triggered by the exit of IBM from India in 1977, there were more local players starting up their operations in late 1970s. In spite of difficulties in redistributing work to India, work did not stop coming to the Indian software firms:

> "In 1970s, pre offshoring, the man had to go the machine (the computer) or the machine had to come to the man. There was no such thing as the computer system or the users of the system staying in one geography and the designers or the operators of the system sat somewhere else, and didn't even meet or talk to each other. Such a redistribution of work group had not been done in the 70s, and it was considered inconceivable." (Senior executive, Indian MNC)

Since the 1970s, around 150,000 engineering graduates could not find a job in India (Arora et al., 2001), while the US faced a shortage of skilled software labor. Indian IT firms were able to send employees to their US clients' offices to work on temporary projects at relatively low wages, a business model widely referred to as "body shopping" (Lakha, 1994).

In the face of these new market conditions, the Government of Karnataka initiated a policy to promote software development as a preferred choice for new ventures. It started by promoting Bangalore as location choice for doing business and initiated an IT industrial park (Electronics City) on the city outskirts in 1978. Although the park was not developed for another decade, this was the first such initiative in the country and psychologically critical in establishing the image of Bangalore as a technology region (Heitzman, 2004). In response to these foreign market developments domestic firms like WIPRO or Infosys entered the software industry and located in Bangalore in the early 1980s.

Consistent with import substitution policy import and export restrictions severely limited foreign trade during this period.

> "At that time we had the Department of Electronics. Import of computer systems was strictly prohibited or it took a long time to import machines. If you are only doing a half a million dollar or quarter million dollar project, why would you import a whole machine?" (Senior executive, Indian MNC)

However, there were some exceptions: imports were allowed for hardware and software training and education institutes, which were founded in large numbers since the 1970s. Moreover, Non-resident Indians (NRIs) were permitted to import hardware in order to export software. Thereby, earlier emigration waves of engineering talent helped kickstart the software industry in Bangalore by providing technology infrastructure through Indians abroad.

4.2 Cluster Emergence (c. 1984- c. 1992)

With a new Software policy in 1984, software development was recognized as a commercial sector, with all the incentives of industry status extended to it as a part of the partial liberalization of the economy. 1988 also marked the beginning of serious infrastructure development for the Indian IT industry. In particular, planning for the Software Technology Parks of India (STPI) started and in 1991, took over the privately established satellite station erstwhile owned by Texas Instruments, while the latter actually helped defining rules of STPI.

> "STPI-Bangalore was the first Internet provider, actually the first and biggest of 39. It provides a single window for GOI [Government of India] schemes." (Secretary, Department of IT and Biotechnology)

In 1988, NASSCOM (**N**ational **A**ssociation for **S**oftware **S**ervice **COM**panies) was founded to represent industry interests. While in the beginning of the software boom, Bangalore entrepreneurs held regular informal meetings, the forum for young entrepreneurs turned into more formal events of NASSCOM or TIE[3], where founders and CEOs met. Both types of meetings characterize the increasing role of local social networks, coupled with a pub culture of a relatively small community in which industry people meet informally to exchange gossip and news about job openings or technology, which is exemplified by one of our interviewees speaking about the "beer drinkers club of IT" in Bangalore (interview with Country Head, Foreign MNC, 2003).

Texas Instruments (TI) opened a development center in Bangalore in 1985, which started

3 TIE is "The Indus Entrepreneur", an entrepreneurial network founded in Silicon Valley and with multiple branches in India and other major IT clusters around the world.

operations in 1986, primarily to leverage wage arbitrage and take advantage of the talent pool available in India. The entry of a well-respected MNC with a lab that aimed to produce complete software products offshore sent a strong market signal (see also Arora and Bagde, 2010)[4].

> "TI were the first MNC to invest in global R&D centre, it was 'pioneering, pathbreaking', because early Indian companies just came up, like Wipro, HCL [did not even mention Infosys]. They set a new paradigm to access India's R&D capabilities: a team can be based in India for customers outside India – that's the concept of a remote R&D centre […] since communication infrastructure was not there, productivity was low and a lot of travel needed. That's why they came up with an [organizational] innovation, they built a new satellite link, which now belongs to BSNL" (Founder and CEO, Indian Hardware Technology Firm, former Country Head, Foreign MNC)

While TI had set up its own satellite link to improve communications with the US, hence leverage the Indian within its global operations, it helped domestic firms in the region when TI allowed them to utilize the excess bandwidth to communicate with clients in the US (Lateef, 1997). They demonstrated the usefulness of good satellite links and leased excess satellite capacity to many leading firms like Wipro and Infosys.[5]

More importantly, while MNCs such as TI naturally have a non-local tie from subsidiary to headquarters, they also engaged in local embeddedness. For instance, TI also reached out to local educational institutions in an effort to tap into scientific talent directly. It was involved in curriculum development activities and funded laboratories, especially with the Indian Institute of Science (Athreye, 2005). Further MNCs followed TI, not only physically, but also in terms of local engagement:

> "We always had a soft corner for education: we give out our education software for free and hardware "crazily" discounted. We have project labs in Delhi, like a BioLab on SUN machines with the Department of Biotech and we are involved in course curriculum (development) for IITs, IIITs [Indian Institutes of Information Technology], RECs [Regional Engineering College] and provide machines. We even have our first two Centres of Excellence on E-Learning at IIT-Madras and in Trivandrum. " (Country Head, Foreign MNC)

For instance, Nortel in 1989, STMicroelectronics in 1990, Motorola in 1991, and IBM (returning) in 1992 increased the scope of their local activities in Bangalore. In parallel, two

4 http://www.ti.com/ww/in/company_info.html, accessed on November 22, 2010
5 This cooperation would probably have been impossible if TI had not been serving a captive parent market.

domestic laboratories opened in Bangalore, the Centre for Artificial Intelligence and Robotics and the Defense Avionics Research Establishment in 1986; and the Centre for Airborne Systems in 1991. Bangalore had emerged as a cluster for scientific and knowledge-intensive activities.

4.3 Cluster Growth (c. 1993-c. 1999)

After the Indian government liberalized trade and removed many restrictions on imports, exports and foreign investments starting 1991, devaluation of the Indian Rupee further strengthened Bangalore's cost advantage, leading to a sudden surge in offshore development. In addition, Indian software firms were granted export and tax benefits with greater ease than before, and bureaucratic requirements for business were reduced. These domestic policies fostered growth of local ties and economic activity.

> "The idea was that there were a lot of exciting possibilities for growth and the decision was made in 1990 or 1991 that they will not sell out following liberalization." (Senior executive, Indian MNC)

In 1993, Indian companies like Infosys and Wipro moved into Electronics City, which had been in existence for 15 years on paper, but in which little infrastructure had been developed. Infosys took advantage of the abolition of the bureaucratic Capital Comptroller of Issues policy and tapped equity markets to arrange for funding, which they used to set up the first building for software developers in Electronics City. While the IPO is non-local in nature, the funds raised have been used very locally.

> "In 1994, when we came out to this big campus, at that time it was small with a few acres of land. It was a very horrendous kind of a decision moving out of the city. There was the attractive possibility of growing and it looked as though the 1990s provided a lot of opportunities for a fairly high kind of growth, and so on. Infrastructure is still waking up, it was more so then. It took several years in the making, for example, Hosur Road [approach to Electronic city] was a single lane." (Senior executive, Indian MNC)

Due to a lack of basic infrastructure, like roads and electricity, on the outskirts of Bangalore, Infosys had to invest a lot of time in convincing local authorities to supply them with necessary utilities, and also invested in setting up facilities within its own campus. Once the local authorities started planning for new facilities, more companies, both domestic and MNCs looked

at Electronics City as an ideal location for building software development centers. Eventually, most MNCs actually (re-)located to the Export Promotion Industrial Park at Whitefield, another technology park in Bangalore which was among the first in the country.

The last decade of the 20th century saw several foreign IT companies setting up their operations in India. Based on general satisfaction and trust accorded to the work done in India, MNCs began to immerse even deeper in the local networks and located full-fledged R&D centers, which entailed a higher knowledge-intensity than development and maintenance centers, in Bangalore.

Local connections developed and intensified between MNCs, Indian software services firms, regional educational institutes, and ancillary firms within the cluster; all of which shared infrastructure and labor markets. High employee turnover meant that firms were also increasingly connected through the social networks of their employees. During the growth phase, this phenomenon was much more pronounced for junior employees, but it later began to extend to the managerial level as well. The MNCs also influenced business practices in the city through international reporting structures, and by requiring collaboration between employees in Bangalore and around the world.

> "The most important effects of offshoring are intangibles: communication skills, exposure and adaptability to multiple cultures, global orientation and professionalism, skill upgrading - technical and managerial - more fluidity as people have opportunities to stay in India, to leave and to return." (Senior Executive, Foreign MNC)

Local engineering colleges (mostly private) continued to supply large number of computer science graduates. By 1999, half of all engineering colleges and even more engineering students in India were located in Southern and Western states (Arora et al., 2001), even though only about one fifth of the Indian population lived in these states (Arora and Bagde, 2010). As demonstrated by MNCs, not only is supply attractive, but also the ease of campus recruitment; especially at engineering colleges.

> "There is availability of good people […] and at entry level we hire college graduates – with a slight preference for locals. However, people are willing to relocate, because [our brand] is attracting" (Chief Manager HR, Foreign MNC)

Some of the larger firms (e.g., Infosys) were able to raise money locally (and domestically) as they developed close links with the capital markets and went public. However, personal investments by non-resident Indians (NRIs) and, more importantly, by Silicon Valley VC firms with partners of Indian origin were even more significant. Interestingly, in 1994-95, Draper International and Waygate Capital were among the first investors that entered Indian IT and software market with investment proposals – mainly from entrepreneurs or investors of Indian origin (Dossani and Kenney, 2002; Naroola, 2001). Thereby, they followed prior entry of technology MNCs in order to benefit from embedding within local networks.

4.4 Cluster Consolidation (c. 2000 onwards)

While Indian software service in general, and Bangalore in particular, grew from body shopping and developed through offshoring, consolidation of the Bangalore cluster was brought on by the business model innovation of service delivery to global and distributed development; which Infosys named the Global Delivery Model. They diversified into BPO (business process outsourcing) and consulting practices to diversify their markets and strengthen the existing delivery base.

> "From an overall capability perspective of the firm, the global delivery model was the centerpiece around which everything was building. If you think of the concept of a global delivery model, it is about being able to do work from a location outside of the client premises. That is at the core of all this. From a business sense, it is about being able to produce goods where it makes the most economic sense, and where you have the most talent, and sell where it is more profitable." (Senior executive, Indian MNC)

In the new millennium, MNCs continued to enter India – especially Bangalore, setting up their back-office operations and in some cases research and development as well (e.g., General Motors' technical center operations began in 2003; ABB set up an IT lab in 2002, IBM and Microsoft, established Indian research and development centers between 2000 and 2007, Cisco established "headquarter East" in 2006).

Since 2000, Bangalore has been recognized as an important location for the global IT industry, and therefore MNCs were queuing up to invest in India – mainly to tap into the local markets for acquiring resources to handle their back-office. At the same time, many Indian firms were looking to expand to other countries – either for nearshore offerings or other offshore locations.

All the top software companies in Bangalore started their operations in different regions such as North America, South America, China and Europe. The factors can be clearly seen in the quote below:

> "There are many GDCs [global delivery centers…]. We have many near shore centers, regional delivery centers, global delivery centers and offshore centers. For example, we have GDCs in Chennai. GDCs are having the scale and the skill typically like in India and China. We have a small delivery center in Singapore and one in Kohama in Japan, and one such in Melbourne. If you see Latin America, there is Chile, Brazil, Uruguay – in Europe we have a large one in Hungary and many near shore centers in the US and in Canada and large number of delivery centers across the world." (Senior executive, Indian MNC)

Mobility between Bangalore-based firms and those in other cities remained high and became more noticeable at the managerial level as well. However, not all firms were equally affected: Several of our interview partners suggested that once employees joined an MNC (foreign or domestic with significant foreign operations), they rarely moved back to purely domestic firms. (Senior MNC managers switching to a local start-up are a rare but notable exception.) The overstretched labor market also prompted firms to work more closely with local educational institutions.

The rapid growth of Bangalore's IT industry required large capital investments. Foreign direct investment (FDI) by MNCs provided a large share of this. Domestic firms also increasingly used non-local ties to seek capital outside of India. Infosys listed on the NASDAQ exchange in New York in 1999; Wipro was listed on the New York Stock Exchange in 2000. Even after the dotcom bubble burst, global VC interest in the Indian market continued to grow. In the new millennium, especially after 2006, there has been an increasing trend of venture capitalists – predominantly Indian investors based in the US – who have been active investors in the Indian technology companies (Aggarwal, 2006).

5. DISCUSSION

Our findings are summarized in the form of Table A.1, where we categorize the network ties into local and non-local, and highlight their effects in each phase of cluster evolution and phase transition, respectively.

TABLE A.1: Summary of Network Ties effect on each Phase of Cluster Evolution

Period	Cluster Characteristics	Phase	Network Types	
			Local Ties with	**Non-local Ties with**
Until c.1984	• Favorable factor markets resulted in US companies looking to India for software development • Availability of English speaking engineers owing to the engineering colleges in public and private sector • Software incentives provided by central government aided in limited import • Land awarded by State Government for setting up a software export park • Foreign owned companies exit market owing to restrictive FDI policies	**Foundation / Seeding**	• Local factor suppliers like educational institutes (for developers with English speaking skills) and hardware vendors (for supplying computers) • Regulators for FOREX and duty exemptions • Local demand from defense industry	• Overseas firms for business development • Overseas firms for importing hardware • Overseas firms for software development knowhow • Clients through engineers traveling to work for Application development and maintenance at client locations

Period	Cluster Characteristics	Phase	Network Types	
			Local Ties with	**Non-local Ties with**
c.1984-c.1992	• With different educational institutes around, Bangalore promised to be a good place to invest with long term perspective • Ample real estate to support company needs, supported by the STPI scheme of central government • Investments by government undertakings (Public Sector Units) in defense research and robotics • Foreign firms like TI, Nortel, STM, Motorola, IBM enter India to leverage favorable supply factors • Economic liberalization led to shift from body-shopping to offshoring projects	**Emergence**	• Local factor suppliers like educational institutes (for developers with English speaking skills) and hardware vendors (for supplying computers) • Regulators for infrastructure and tax incentives	• Overseas firms for technology transfer • Overseas firms for business development and client servicing • MNCs (through onsite employees) for sharing of knowledge, practices • Emerging Indian Diaspora • MNCs (between) HQ their back office operations in India)
c.1993-c.1998	• Factor markets spur offshore development • Real estate and other infrastructure like transport available for support • Several small and big companies operating from Bangalore set up development centers in Electronic city • Primary equity market enables funding of growth in operations • Close coordination with educational institutes enables supply of skilled manpower for managing complex software development projects • Process standardization within firms to enable distributed development and gaining international recognition	**Growth**	• Market for raising money and buying technology • Cluster for infrastructure development and sharing • Ties between different local companies through employee turnover • Educational institutes for regular supply of manpower with required software development skills	• Clients for offshore project outsourcing • The growing Indian Diaspora • Off the shelf product providers like SAP, Oracle, Microsoft • Technology companies for hardware equipment and software platforms (e.g.: SUN, CISCO)

Period	Cluster Characteristics	Phase	Network Types	
			Local Ties with	**Non-local Ties with**
c.1999-till date	• Telecommunications and internet technologies enabled globally distributed software development • Firms expanding to international locations by setting up global development centers in order to leverage factor markets in other countries • Firms diversifying into BPO and consulting practices to expand market and strengthen existing delivery base	**Consolidation**	• Local educational institutes (including business schools) for supply of high skilled manpower • Ties between different local companies through employee turnover	• Ties between global development centers • Globally operating clients across diverse regions • Foreign regulatory authorities for expansion • Ties across business units (BPO, Consulting)

As evident from the table, our main interest from the analysis relates to the influence of networks for cluster evolution and the changing role over time (Ahuja et al., 2012; Brass et al., 2004: 809; Madhavan et al., 1998). The evolution of the Bangalore IT cluster suggests that formation of KSCs is triggered by the combination and sequencing of local and non-local networks. As entrepreneurs forged distant ties – either because of their education in the West, or due to the foreign MNCs heading to the East looking for supply of cheaper talent – it gave rise to non-local ties which facilitated inward knowledge flows and triggered foundation of the cluster. With global demand for customized software services, the cluster started taking shape. However, in order to have a positive spillover effect, the cluster would have to develop sufficient capabilities to process the demand and cater to it using the local factors and system of production. (Giuliani and Bell, 2005; Romanelli and Khessina, 2005).

In the next phase, as Indian software services gained reputation in Western markets, firms needed to scale up – not only to keep up with increasing demand. In order to fully emerge as a cluster, organizations forged and deepened local ties – with local engineering colleges, recruitment agencies, and training institutions. With offshoring becoming a successful tool for Indian software firms, there had been several local ties that were established with local regulators and investors. These local ties helped software firms in Bangalore achieve immediate economies of scale. Our findings complement research by (Madhavan et al., 1998), who found different impact of industry events on the shape of networks. Moreover, this reflects findings of external networks impact on performance of Indian software *firms* (Vissa and Chacar, 2009).

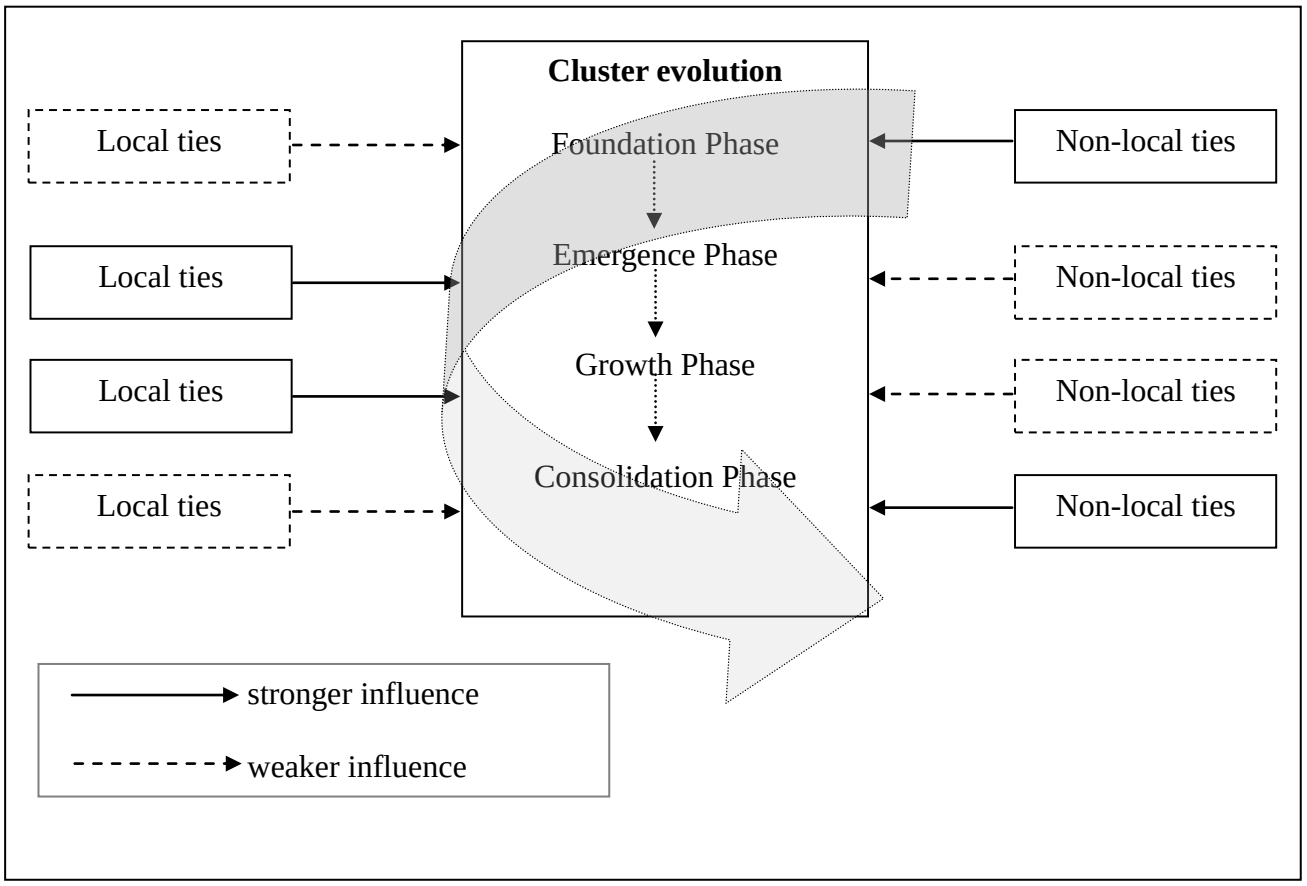
Later phases show a localization of non-local ties utilized, resembling the process described by Hite and Hesterly (2001) This finding is consistent with Arora et al. (2001) and Arora and Bagde (2010) who have shown the supply of human capital to form the local foundation. Nanda and Khanna (2010) found in a cross-section of Indian IT firms that non-local, ethnic ties decreased in importance once local cluster networks became available. Similarly Zaheer et al. (2009) found substitutive relationships between local clusters and global ethnic ties.

To summarize, we find that both local and non-local networks are important across the

entire lifecycle of the cluster and have the potential to influence, even reinforce and sometimes supplant, each other. In line with other empirical studies, we found that both local and non-local social networks were initially used as primary channels to access knowledge for trade or market entry (e.g., Ellis, 2000). Both types of networks grew larger and denser over time. Eventually, local networks were increasingly used for the inherent trust to corroborate the knowledge acquired externally. As might be expected, they developed more formal and market-based institutions during this process, e.g. national industry associations, international entrepreneurial associations, as well as local and international firm-level collaboration. Both types of networks also influenced each other, for instance, local knowledge networks became strong and deep enough to support new entry by non-IT MNCs seeking to tap a software development knowledge base. Conversely, MNC entry influenced business practices and relationships between local firms (Carberry, 2012). Software professionals gained high levels of international exposure through collaboration with foreign firms; resulting in local capabilities and reputations that further eased new MNC entry. We found that local and international labor mobility as well as growing business and alliance networks contributed to an increasing network density even as networks grew. The creation and maturation of local institutions, such as universities (and their increasing ties to local firms) helped making the local network denser and more cohesive.

Our case analysis of the history of Bangalore cluster highlighted differential effect of social networks in location theory as shown in the Figure B.2 below:

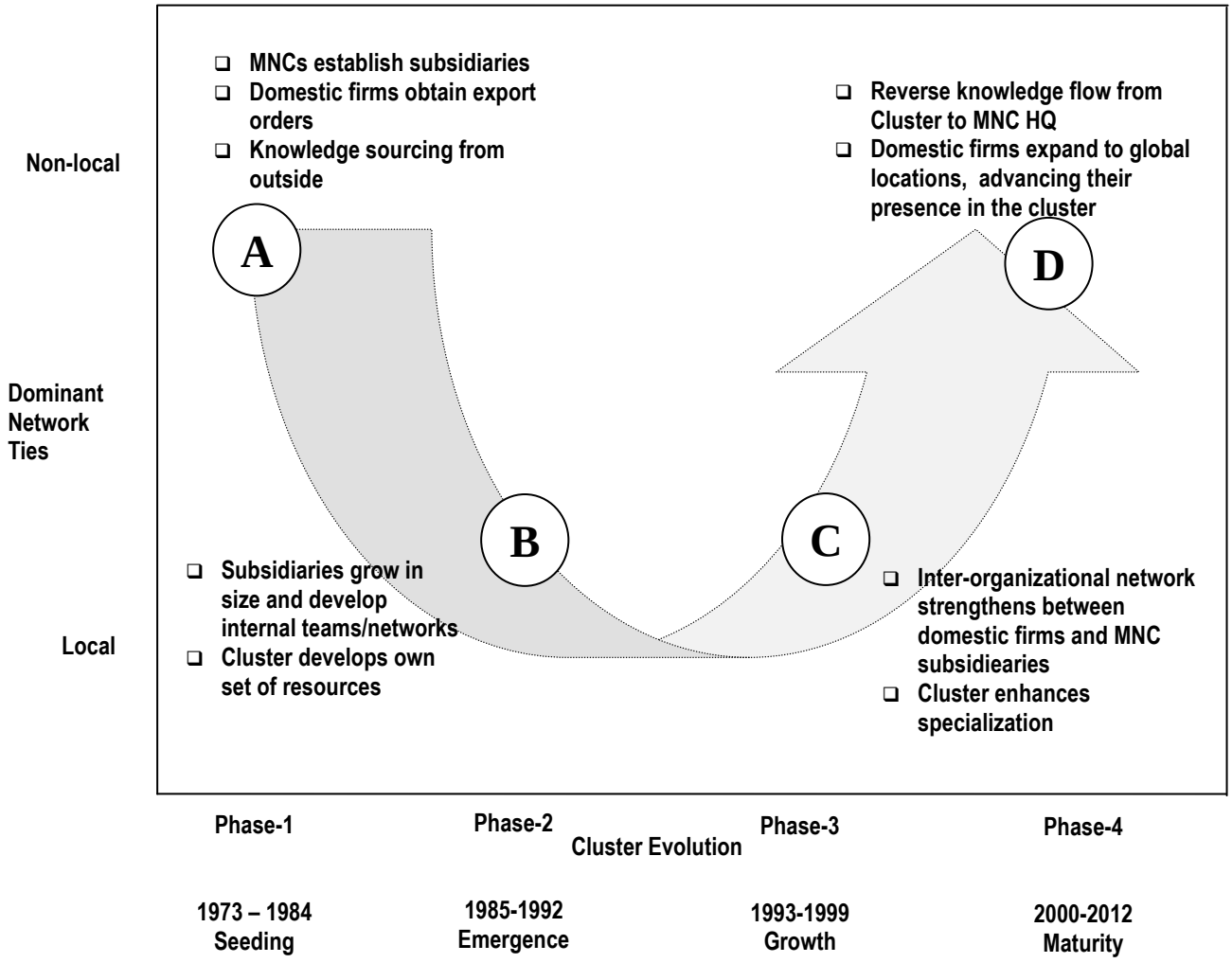
Fgure B.2: Network types in Cluster evolution



As highlighted in our model, cluster evolution from foundation to emergence is facilitated by establishing non-local ties followed and *embedding* these locally. Cluster growth is fostered by further *expanding* these ties locally. Finally, the transition from growth to maturity phase is triggered by the *extending* local ties to their non-local contacts. Our findings are broadly consistent with Eisingerich et al. (2010), who showed that network strength is more conducive to cluster performance under conditions of stability and network openness rather than in an uncertain environment. Related to their findings, we argue for a complementary, rather than a competing role of different network configurations. In a similar vein, our findings resonate with Hansen (1999) and Rowley et al. (2000), if one accepts the simplification of local ties being strong and non-local ties being weak on average. Our findings also complement Sorenson and Audia (2000) and Ter Wal and Boschma (2011)who find weaker effects of local ties for more established clusters. Moreover, we extend Giuliani (2011) who finds that local firms with strong *firm*-internal capabilities act as technological gatekeepers at the *cluster* level by importing external knowledge through their strong non-local links and eventually diffuse this knowledge locally. Our findings differ in terms of context, which seems to have different features and is more prone for comparison with KSCs, where non-local links need not necessarily come from strong local firms, but could stem from non-local firms, such as MNC subsidiaries. Moreover, we extend the finding by Giuliani (2011) of a persistent pattern over time; whereas we propose alternating roles within a staged process of cluster evolution. More specifically, we contribute to this literature by arguing for a sequential pattern of knowledge sourcing external to the cluster followed by knowledge diffusion within the cluster in the initial stages, and a reversal of the sequence in the later phases.

We further generalize these relationships as shown in the Figure B.3. The figure visualizes our general finding that one type of network ties dominates each phase and once the second starts kicking in, transition to the next phase occurs wherein the other type plays the dominant role; eventually the first type re-surfaces leading to another transition.

Figure B.3: Role of Different Network types in Cluster evolution



Based on our framework above, we argue for an important role for network ties in the evolution of KSCs. We structure our theoretical implications in form of four propositions. First, we argue that the foundation of KSC requires non-local ties that span across the cluster boundaries. This not only enables the knowledge flow into the cluster, but also provides an external demand trigger that lays the foundation of the cluster. These non-local ties play an exploratory role that helps firms accessing non-redundant knowledge. Once exploration and acquisition of knowledge is realized, the second and third phases witness an increased role of local and cohesive ties within the cluster to corroborate and internalize the external knowledge into the cluster. Finally, once the local ties are fully utilized and knowledge is exploited, non-local ties are instrumental again in extending to a wider geography – either through outside diffusion of knowledge, or widening the markets – or providing new triggers for cluster renewal. Based on this, we propose that

> *Proposition 1: The distance (between the network actors) of prominent ties will have a U-shape relationship with the evolution of knowledge service clusters.*

During the evolution of KSCs, non-local ties (e.g. customer relationships) can provide triggers for surge in demand for locally available factors that enable firms catering to the demand. Non-local ties can also consist of knowledge about distant markets, which are unknown to the local firms, or they could also bring along non-local knowledge embodied in foreign staff relocating to the cluster. Sometimes these ties are relatively weak as they act as boundary spanners, however they help transform local elements (human capital base, loose network of firms, fragmented infrastructure) emerge into a cluster. Based on this argument, we propose a specific role for embedding of non-local ties into the region:

> *Proposition 2: The embedding of non-local ties (into the cluster) will enable the transition of knowledge service clusters from seeding to emergence phase.*

As KSC evolves, local embedding of non-local networks (e.g. foreign staff of MNC

subsidiary) brings along non-local knowledge. The domestic firms and MNC subsidiaries within the cluster pursue opportunities of utilizing non-local (market, technology, product) knowledge. This pursuit pushes firms to expand their local ties within the region, often leading to development of industry or product capabilities that can help the cluster grow to the next level. In addition, with the grounding of non-local network ties firms often try to corroborate knowledge through cohesive local ties within the region, thus leading to local diffusion of non-local knowledge obtained in the emergence phase.

Proposition 3: The expansion of local ties will enable the transition of knowledge service clusters from emergence to growth phase.

The third transition, i.e. from growth to consolidation phase is triggered by two complementary antecedents, one opportunity-driven and the other needs-driven. Firstly, the diffusion of (non-local) knowledge inside the cluster in the growth phase helps local firms build up capabilities. Even local firms' exposure to non-local knowledge through informal exchanges (with more internationally-oriented firms, staff turnover etc.) fosters learning about distant markets, international products and services. In this process of local learning, the entire industry benefits from enhanced capabilities, thus enabling local firms within the cluster to internationalize by taking their capabilities abroad to tap foreign markets.

Secondly, this local diffusion of knowledge can also have negative consequences, for two reasons. From a network and knowledge perspective, too much emphasis on local interaction and exchange can lead to a cognitive and informational lock-in (Pouder and St. John, 1996), similar to network over-embeddedness (Uzzi, 1997). From a cluster life cycle perspective, local growth could cause congestion effects with increased rents, wages, or literally congested roads. In this case, what the cluster needs is a new external stimulus that reignites the development, similar to the initial trigger that led to emergence. An external stimulus addressing lock-in should come from new markets, while congestion rather reflects cost issues leading to a search for new, cheaper locations. Therefore, we propose:

Proposition 4: The extension of local ties (outside of the cluster) will enable the transition of knowledge service clusters from growth to consolidation phase.

6. Conclusion

This paper complements and advances extant literature on networks and clusters (Aharonson et al., 2008; Eisingerich et al., 2010; Nanda and Khanna, 2010; Zaheer et al., 2009), by putting forth the argument that local and non-local network ties play an active role in development of KSCs.

Our paper makes two contributions to cluster and network literature. First, one relates to the scope of network theory for cluster research, and the second one to the impact on clusters of different network configurations. The first contribution shows the relevance and applicability of network theory to the cluster development literature by proposing the different forms that these networks take to enable firms to access and diffuse knowledge and resources from an appropriate source. This, we believe, is a small but an important step from the role that networks were known to play as either local sources or boundary spanners. The second contribution comes from our propositions that exhibit the different influence these network properties and structures may have on cluster development; and how the evolution and interplay of different tie types can be affected by their antecedents such as local relationships, ethnicity, or prior arm's length business relationships.

Being an exploratory study, our paper was aimed at generating theoretical insights rather than statistical generalization. This is an inherent limitation in the methodology and can be overcome through a large-scale study of clusters that have evolved over the years with help of network ties. Furthermore, research on the necessary and sufficient non-local factors for cluster development is still underdeveloped. We speculate that strong non-local demand for products and services could help seed a cluster if some local factors, in particular a strong labor pool, are present. In essence, however, the initial phase of cluster development appears to continue to rely on a serendipitous combination of local factors; interplay of complementary local and non-local networks could be seen as contributing to continuous cluster evolution.

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