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Scupola, Ada; Steinfield, Charles

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# Explaining ICT Infrastructure and E-Commerce Uses and Benefits in Industrial Clusters

***Evidence from a Biotech Cluster***

Charles Steinfield
*Michigan State University*
*steinfie@msu.edu*

Ada Scupola
*Roskilde University*
*ada@ruk.dk*

## Abstract

*The literature on industrial clusters has not focused heavily on the role of the ICT infrastructure, nor on the potential implications of electronic commerce . In this paper, we examine the theoretical bases for bringing these research streams together, and develop expectations for how firms in an industrial cluster might utilize and derive benefit from a public, broadband ICT infrastructure, particularly in support of e-commerce applications. A case study of a successful biotech cluster in Denmark and Sweden – the Medicon Valley – provides a preliminary test of these expectations. Distinctions in uses and benefits based upon firm size are considered. A key finding is that small firms that would not otherwise be expected to gain from global e-commerce can rely on the cluster "brand" to enable trade with unknown and distant partners.*

## 1. Introduction

A considerable literature has focused on the critical role of business and industrial clusters found in cities and regions as drivers of any nations' economic health [9, 15, 32, 40-43, 47]. In much of this work, the emphasis is on the way in which clusters of firms in common industries benefit from geographic co-location, enabling companies to achieve a higher level of competitiveness than they would otherwise if located outside of the cluster [41, 42]. Tacit and explicit knowledge spillovers through formal and informal communication channels that enhance learning and innovation by firms in the cluster, the presence of supportive local institutions, the availability of specialized suppliers and service providers, access to a qualified pool of workers, and pressures from local competition are several of the many factors posited to explain the growth and dynamism of local and regional industrial clusters [16, 33, 42, 47, 51, 59].

The role of information and communication technologies (ICTs) in the development and maintenance of local industrial clusters has not received a great deal of attention by this research community. This is surprising, given the attention policy makers and researchers pay to the role of communications infrastructures as an input to local and regional economic success [34, 38]. More recently, governments are focusing on the need for a local broadband infrastructure in order to stimulate the growth of local industry, particularly in knowledge intensive sectors like biotechnology and high technology [35, 36]. One of the key goals behind investments in local broadband access technologies, as well as other aspects of public telecommunications infrastructure, is to improve conditions for small and medium-sized enterprises (SMEs) [35, 37]. SMEs are considered to be engines for economic growth, and in the United States, they account for the majority of the workforce and the gross domestic product [49]. Public sector support is often justified by the argument that SMEs do not have the resources to build and maintain the ICT infrastructure needed to support inter-organizational transactions [37].

The goal of this paper is to explore how ICT networks may be used in industrial clusters, especially by small businesses. The two primary research questions addressed are as follows:

1) *How do firms embedded in a cluster use public ICT infrastructures such as broadband access to the Internet?*
2) *Under what conditions do firms in a cluster, and especially small firms, benefit from Internet usage?*

Addressing these two research questions contributes to emerging theory on the mechanisms through which business clusters convey competitive

advantage. In addition, the answers can provide insights into a fundamental policy issue for local, regional, and national governments: how provision of a public ICT infrastructure aids clusters.

These questions are investigated through a case study of a European biotechnology cluster known as the Medicon Valley, located in Denmark and Southern Sweden. Interviews with ten organizations in the cluster, including several SMEs, yields a number of insights into the complex interactions between use of ICT networks and membership in an industrial cluster. The remainder of the paper is organized as follows: In section two, previous literature relevant to the question of how ICTs are used in industrial clusters is reviewed. In section three, details about the case study are provided, including an overview of the research approach and general background on the Medicon Valley. In section four, findings from the interviews are described. A discussion of the results and implications for theory and practice is provided in section five. The sixth and final section offers conclusions, as well as study limitations.

## 2. Literature Review

The clustering of economic activity is a well known phenomena, usually explained by the benefits that proximity affords firms and consumers in reducing many different types of transaction costs [29]. Leamer and Storper [30] observe, for example, that clustered retailing reduces buyers' shopping costs, proximity reduces transportation costs in many types of material productions, and intellectual exchange is greater when participants are located near each other. Porter [42, p. 10] defines business clusters as a "critical mass of companies in a particular field in a particular location…" which, in addition to producers of some good or service, includes "…suppliers of specialized inputs, components, machinery, and services, and firms in related industries." Clusters can also include "firms in downstream industries, producers of complementary products, specialized infrastructure providers, and other institutions that provide specialized training, and technical support" as well as industry groups such as trade associations [42, p. 10]. Porter and other researchers have studied many aspects of industrial, or business clusters, including the preconditions for cluster formation, the forces driving cluster growth and development, the flow of knowledge and resources within and across clusters, and factors that influence cluster competitiveness and innovativeness [8, 9, 11, 42, 45, 47].

Despite the wealth of industrial cluster studies, relatively little research has specifically examined the role of information and communications infrastructure in influencing cluster success. There has been extensive research examining the role of the telecommunications infrastructure in economic development, particularly for less developed nations, regions, and rural communities [18, 22, 24, 31]. There has also been a significant discussion about the importance of the telecommunications infrastructure for urban development [34]. As noted above, these discussions have received renewed attention in recent years to help justify policies that facilitate the rapid deployment of broadband access technologies such as digital subscriber loop (DSL) [35-37]. Yet, for some reason there has been relatively little explicit attention to ICT infrastructure use within the context of industrial cluster research [58].

There are good reasons to explore ICT usage in industrial clusters. First, knowledge about ICT usage can better inform policy-making, suggesting opportunities for more targeted interventions than simply blanketing a region with broadband access. Some types of cluster members – small businesses in particular – may need extra assistance, for example, in incorporating ICTs into practice [18]. Second, ICT usage patterns may reveal underlying cluster dynamics that can complement existing cluster studies and help researchers better understand how clusters succeed. Research has focused, for example, on patterns of knowledge transfer among cluster members, focusing on the kinds of formal and informal exchanges that occur within clusters and across regions in order to explain the innovative capacity of a cluster [12, 13, 15, 44-46]. Interactions over electronic networks may complement and enhance local knowledge sharing, replace it with non-local exchanges, or contribute to the importation of new knowledge that is then shared within a cluster [52]. Third, research on ICT usage in industrial clusters may also shed light on the local and global impacts of the increasing use of electronic networks for a wide range of transaction and coordination activities [20]. Electronic commerce researchers, for example, have begun to question the extent to which e-commerce helps or hinders local economies, and increases or decreases the centralization of economic activity [54, 56, 67].

### 2.1. ICT Usage in Industrial Clusters

At a very basic level, there are two somewhat independent functions that a local ICT infrastructure might fulfill in local business clusters. One set of functions relates to connectivity within the cluster for coordination and collaboration. This might include the increased ability that ICT networks provide for

employees to connect to their firms from home or other external locations, enabling telecommuting and telework. Although research findings are mixed, telework use may improve a firm's productivity as well as its ability to attract and retain certain types of workers who might need flexible arrangements [25, 64]. In addition to such intra-firm uses are applications of ICT networks to facilitate information sharing and collaborative work within and across firms in a cluster. Most research on ICT-enabled collaborative work focuses on the support of distributed teams engaged in brainstorming, coauthoring, design, problem solving, or decision making tasks [19], but this literature is generally quite disconnected from the research on coordination among firms in an industrial cluster. The second broad set of functions that an ICT infrastructure can provide for an industrial cluster is linked to the use of networks for electronic commerce transactions. There is a rich literature on electronic commerce, often distinguishing between business-to-business trade and business-to-consumer trade, but rarely is its use in the context of geographically-defined industrial clusters examined [57, 58]. Electronic commerce researchers have emphasized the way that electronic markets can support business communities, but these communities are virtual in nature, and, in some respects can be thought of as something of a substitute for proximity-based clusters [57, 58].

Most commonly economists and information systems researchers view the spread of ICT networks as one of the main factors contributing to globalization by virtue of the speed with which it allows communication, information, and transactions to flow across large distances, thereby reducing coordination and search costs that formerly inhibited such trade [5, 6, 10]. This view suggests that the advent of high capacity, global ICT networks enables increased outsourcing and encourages firms to replace local trading partners with distant ones that might offer lower costs and higher quality. At the extreme, the replacement of in-cluster trading relationships with distant ones might ultimately diminish the benefits that come from being in a cluster. This discussion suggests that, *greater use of electronic commerce may damage a cluster by weakening the trading relationships among members and reducing local cooperation*.

Others have argued for a more nuanced view of the connection between ICT usage and the activities of firms in local and regional business clusters, recognizing that such clusters exist in an increasingly interdependent and global network of economic relations among nations. In a wide ranging review of research on economic geography, Scott [51], citing Veltz [63] summarizes this view by observing the trend towards, "mounting levels of functional integration of different national economies; …durably anchored in … a worldwide archipelago of stable regional economies or global city-regions" (p. 494). ICT networks function to permit firms to locate in cities or regions where conditions are favorable (e.g. presence of a labor market with appropriate skills and education, presence of firms offering complementary products and services, etc.), without harming their ability to reach global customers and suppliers. Moreover, innovative firms can use their connections to a global ICT infrastructure like the Internet to bring new knowledge into a region, which may then diffuse among local trading partners [20, 67]. Some research suggests that large firms, especially multinationals, play an important role in bringing in new knowledge into a cluster, which then spreads to smaller firms and improves cluster innovativeness [52]. This view suggests then a competing interpretation: that *ICT usage enables export-oriented clusters to better access distant markets and import knowledge, without harming the internal dynamics that have helped to sustain the cluster*.

Within the field of information systems, two well known papers have directly explored to potential use of an ICT infrastructure to improve coordination within an industrial cluster, arriving at somewhat opposing conclusions. Johnston and Lawrence's [24] seminal work on value-adding partnerships focused extensively on the Prato, Italy textile industry. In this cluster, several large textile mills had disaggregated into small, specialized firms, each focusing on one part of the overall value chain in textile production (e.g. washing, coloring, cutting,, etc.). They showed how networks of firms worked in concert to meet the market demands for the good of the network, and pointed out how an inter-organizational information system was being used to facilitate coordination [23]. However, a decade later, Kumar and colleagues revisited the merchants of Prato, and found that the information system had been all but abandoned [27]. In their analysis, the system offered no real added value in terms of transaction cost reductions over the personal forms of coordination that had evolved over centuries of textile production in the region. Kumar et al [28] suggest that trust and personal relationships – the social capital of the region – were effective substitutes for the inter-organizational system, rendering it unnecessary. Other research on clusters characterized by intense internal trading relationships has similarly observed the crucial role of social embeddedness, noting how personal connections

create advantages for trading partners that may not arise in arms-length market transactions [62]. This line of work suggests that *attempts to automate transactions and replace personal interactions within clusters may cause more harm than good*, a finding that parallels many other studies of the impact of business-to-business electronic commerce on buyer-seller relations [26, 50, 53].

The intersection between the cluster literature and studies of ICT use by small enterprises also offers competing views. Resource constraints have long been recognized as a barrier to innovation with technology [60]. Smaller companies are often depicted as not having the requisite resources – either in terms of expertise or capital – to gain the same level of benefit as large firms when it comes to ICT usage [4]. Yet some cluster research suggests that smaller firms in a cluster may actually be more innovative than their larger counterparts, because they are less rigid and less locked into established practices [14]. *Smaller firms in a cluster, then, may benefit from ICT infrastructure investment while those outside of an established cluster do not.*

Much of the attention on business clusters today focuses on new industries, usually in emerging technology sectors such as information technology, new media and biotechnology [3, 11-14, 30, 44, 45, 47, 48, 66]. In these types of knowledge-intensive clusters, rather than emphasizing transactions within the cluster, or even explicit coordination among cluster members, researchers have begun to focus on other ways that such clusters improve their competitiveness. A number of cluster researchers emphasize the importance of local trade or government-sponsored associations that work to promote the development of the cluster [11, 14, 61, 66]. These associations engage in educational activities aimed at improving the cluster's human capital, branding and promotion activities such as conferences, exhibitions, Web sites, and business directories that help attract labor, venture capital, and business opportunities for the cluster, and online and offline social/community activities that create opportunities for knowledge sharing among cluster members, even when they do not explicitly trade with one another. These latter activities, strengthened by the geographic proximity of firms in a cluster, are also viewed as important mechanisms to improve the exchange of tacit knowledge – knowledge gained through habit, culture and experience that is not easily codified and shared [1, 21, 28, 39, 57]. Importantly, many of these activities explicitly involve *the use of ICT as a tool for cluster promotion and development*, even if not strictly for the purposes of supporting inter-firm electronic commerce transactions.

### 2.2. Summary

A number of key roles for the ICT infrastructure in business clusters are suggested by the above review. First, firms within the cluster benefit from the presence of high quality local Internet access. It can enable more flexible work arrangements and lower costs for firms to support distributed workers that need to collaborate. Second, although some concern has been expressed regarding the potentially destabilizing effects of the Internet on clusters, in that it permits firms to substitute distant trading partners for local ones, research from a social embeddedness perspective suggests this is an unlikely outcome. Rather, the studies reviewed above suggest that connection to a global ICT infrastructure like the Internet benefits clusters by improving access to distant markets without harming internal cluster dynamics. Moreover, the use of ICTs further promote cluster innovation by facilitating the transfer of technology from distant markets to firms in the cluster, which can then diffuse through informal channels even when firms in the cluster have little trade with each other. Third, a relatively less developed thread in the literature suggests that smaller firms in clusters may be able to benefit from ICT infrastructure investments, despite the common finding that they are less likely to gain from technology innovations. Finally, the review points out that in new knowledge-intensive clusters, an important use of ICTs is to help promote and maintain cluster brand identity, as well as to facilitate information sharing within the cluster.

## 3. A Case Study of the Medicon Valley

The roles for ICT infrastructures in business clusters were examined in a case study of a well known European biotechnology cluster, The Medicon Valley located in Denmark and Southern Sweden, in the summer of 2004. We selected this biotechnology cluster for several reasons. First, this is an increasingly important sector in many economies, and there have been repeated attempts worldwide to develop successful clusters in biotechnology [13]. Given this worldwide interest, there has been significant research on biotechnology clusters [2, 3, 13, 14, 17, 65, 66]. Second, small firms play a significant role in the field of biotechnology, and are important participants in biotechnology clusters [3]. Third, the Medicon Valley has been a highly

successful example of a biotechnology cluster, achieving a prominent global position in this highly sought-after sector [17, 65]. Fourth, it is a knowledge intensive industry, placing more emphasis on information transfer than the transfer of physical goods [13, 44, 45]. Hence, it offers great potential to reveal important uses of ICTs for information sharing and coordination within the cluster. Finally, biotechnology is a global industry, and the Medicon Valley has several significant multinationals that anchor the cluster (www.mediconvalley.com). As such, biotechnology clusters contain what Porter calls "traded industries" [43] offering an opportunities to explore global ICT usage, including e-commerce connections with distant markets.

### 3.1. Research Methods

Data for the study were gathered from archival sources, interviews with representatives from companies in the region, and interviews with representatives from the Medicon Valley Academy, a not-for-profit, member-financed association that works to promote the region. In all, representatives from ten organizations, including the Medicon Valley Academy, were interviewed. A mix of small and large firms were chosen to help reveal differing ICT and e-commerce usage patterns among smaller enterprises. Among the larger firms, high level managers responsible for IT infrastructure investment and application development were interviewed. Among the smaller firms, this type of position did not exist, and the head of each company was interviewed. All of the interviews were conducted in June of 2004, and each lasted a minimum of one hour. Interview questions were open-ended and unstructured, attempting to elicit the variety of ways that firms use ICTs to interact and exchange information and products with other firms in the region, as well as with suppliers and customers outside the region.

### 3.2. The Medicon Valley in Brief

The Medicon Valley occupies a region covering Copenhagen and surrounding towns in Denmark, and the southern part of Sweden region known as Scania, including such cities as Lund, Malmo and Gothenburg. It is home to five science parks, hundreds of biotechnology, life sciences and pharmaceutical companies, and more than a dozen universities. Table 1 provides a number of statistics about the region, based on information from the Medicon Valley Academy (www.mva.org).

Table 1. Statistics on the Medicon Valley

| | |
|---|---|
| Population in the region | 2.9 mil. |
| Number of universities | 14 |
| Number of hospitals | 26 |
| Number of life sciences researchers | 5,000 |
| Number of biotechnology companies | 125 |
| Number of pharma companies | 70 |
| Number of medical technology companies | 130 |
| Number of clinical research organizations | 15 |
| Number of employees in biotechnology, pharma, and medical technology | 41,000 |
| Percent of all life sciences exports relative to all of Sweden and Denmark | 60% |

Source: Medicon Valley Academy (www.mva.org)

The region has enjoyed remarkable success, and is now ranked as the number three biotechnology region in Europe (www.mva.org). It was officially named Medicon Valley in 1997, but has been a center for pharmaceutical and life sciences research for much longer, with four of the world's leading pharma companies located there: AstraZeneca, H. Lundbeck, Leo Pharma, and Novo Nordisk. The region is considered to be especially competent in three major biotechnology research areas: diabetes, inflammation, and neurosciences [7].

## 4. Findings

Tables 2 and 3 present basic descriptive information for each company interviewed, including the ICT applications for inter-firm coordination discussed in the interviews. Company identities are not revealed at the request of those interviewed.

The six firms listed in Table 2 are biotechnology and pharmaceutical producer firms, while the four firms in Table 3 provide various types of supportive products and services. In general, the pharmaceutical and biotechnology producers are all export oriented, with the lion's share of their output destined for markets outside Denmark. The large companies among the set of pharma and biotech producers all maintain extensive internal information technology infrastructures, and in some cases use extended information systems to enable structured transactions with large suppliers and distributors of their products in other countries. Several of the firms mentioned use of electronic commerce mainly in the form of inventory-replenishment for their global distributors, rather than for retail-oriented sales to consumers.

This is not surprising, given that their products would not normally be sold directly to consumers, but through a complex set of health care intermediaries. Within the cluster, there is little in the way of direct transactions or coordination among these firms. They do work with researchers from universities or smaller start-ups, and the interaction is largely using email when it does occur over an ICT infrastructure. Some efforts at structured computer-supported collaboration were mentioned, but generally, these efforts were not viewed as successful.

Among the small biotech producers, it was noteworthy to see a heavy reliance on local broadband access. These firms were both export-oriented, with nearly all sales going to distant markets. One small firm, producing blood test products, noted that despite having some reputation problems within the region, they benefited from the association with Medicon Valley in their global sales efforts. Nearly all interaction with remote clients was email-based. Both of these SMEs used the Web to promote their products, even though their online sites do not support transactions. In order to illustrate how remote customers are identified, the fermentation equipment supplier described a recent sale to a customer in China. The customer had found his company after searching online for fermentation equipment suppliers, and decided to contact him because he was in the Medicon Valley biotech cluster. The customer then emailed to establish communication, resulting eventually in a visit and formal contract.

Table 2. Descriptive Information on Biotech Producer Firms Interviewed

| Type of Company | No. of employees | Main products | Market Focus (local vs. non-local customers) | ICT applications |
|---|---|---|---|---|
| Large pharma | 18,800 | Wide range of pharmaceutical products, engages in research and development of new drugs. | Has presence in 69 countries, sells to distributors in 179 | Has a significant internal IT infrastructure, including global network linking operations. Has some limited e-commerce capabilities, but most connections with external partners are via email. Has many partnerships, involving research collaboration. Will allow some external connections to internal network and has tried using computer-based collaborative systems, but much still done using simple email. |
| Large pharma | 3,300 | Develops and manufactures drugs, significant R&D. | Sells drugs in more than 90 countries, R&D located in Medicon Valley. Has four manufacturing facilities elsewhere in Europe | Has a significant internal IT infrastructure linking company operations on a global basis. Has used e-commerce with partners to which it licenses drugs for sale, mainly for inventory replenishment. Engages in R&D collaboration with external partners, mainly via email. |
| Large biotech | 1,400 | Develops biotech products used for various types of disease diagnosis, especially for cancer diagnostics. | Has operations in more than 20 countries, and works with distributors in 50 countries. | Has significant internal IT infrastructure linking company operations. Uses IT to manage transactions with distributors. Supplies sophisticated IT tools for analysis for R&D collaborators, from universities and elsewhere. Also uses the Web to present its products to help find new distributors. |
| Large biotech research | 150 | Conducts science to develop chemical and biological compounds that have commercial potential. Creates spin-offs to capitalize on R&D results | Mainly located in Denmark, but is a subsidiary of a large food product producer that sells to a global market. Biotech R&D is mainly in collaboration with local researchers, especially in universities | Has a significant internal IT infrastructure, and facilities to support research. Main external ICT applications are email interactions among research collaborators, but also enable some high speed connections to research tools, especially for collaborators at universities. |
| Small biotech supplier | 4 | Produces a blood test product | Manufactures in region, sells globally using distributors. 97% of sales outside Denmark | Uses DSL for always-on Internet access, relies on email to connect with clients, send pdf brochures. Uses Web site hosted externally to provide product information, but not transactions. |
| Small biotech supplier | 1 | Produces fermentation equipment, mostly outsources the production to local craftsmen | Manufactures in region, sells globally without distributors | Uses DSL for always-on Internet access, relies on email to connect with clients. Uses Web site hosted externally to provide product information, but not transactions. |

The companies in Table 3 provide complementary products and services to cluster firms. All highlighted the use of Web-based promotion and email interactions, but a common theme was the importance of in-person communication in the region to obtain clients and provide services. The critical role of the member financed, not-for-profit association, the Medicon Valley Academy (MVA), was widely recognized by interviewees. Many MVA activities involve the use of an ICT infrastructure, including the development of an extensive Website that promotes the region, disseminates regional and biotech news and reports, lists companies in an online directory, and provides online job listings. Additionally, the MVA organizes many offline activities, including seminars and educational services, conferences and biotech events, and regular member meetings. They also provide substantial support services for firms considering moving to the Medicon Valley, for biotech workers relocating to the area, and for entrepreneurs seeking legal and financial advice. In large part, these are activities that capitalize on the proximity of members in order to benefit the cluster.

## 5. Discussion

In this section, we revisit the two basic research questions, as well as the expected roles for the ICT infrastructure in clusters generated by our review.

Table 3: Descriptive Information on Biotech Industry Support Firms Interviewed

| Type of Company | Number of employees | Main products | Market Focus (local vs. non-local customers) | ICT applications |
|---|---|---|---|---|
| Large ICT firm | no data | Develops ICT solutions for pharma and biotech companies | Danish subsidiary of large global IT supplier. Sells many products to other industry sectors in Denmark, but also selling specialized IT solutions to firms in region | Has a significant internal IT infrastructure, including global network linking operations. Also has extensive Web site, but sees IT solutions for biotech as too complex for Web sales. Mainly used for company information, overview of product line to potential clients to support in-person sales efforts. Sees market for security applications for biotech R&D. |
| Large personnel services firm | no data | Provides recruitment services, especially for helping recruit scientific staff | Local division of large global employment services company. Emphasis is on recruitment services for biotech firms in the region | Internet used extensively for filling jobs, accounts for 90% of jobs filled. Many portals with CVs. But high level and very specialized jobs filled through personal channels. Relies extensively on email, but only after initial in-person contact to help market services to companies in region, complementary to job fairs, attendance at events like Biotech Forum. |
| Business Consulting Firm | no data | Provides range of business consulting services, emphasis on strategy, economic issues | Has offices in several countries, small group located in Medicon Valley focusing on gov't and private sector firms region | Internal ICT usage, but limited to email, and traditional communication system connections to clients in region. Extensive use of Web, dissemination of reports online, use of client sites for highlight results of consulting reports. Customer acquisition largely through word of mouth referral, however. |
| Medicon Valley Academy | approx. a dozen staff, 40+ firms in region belong as members | Member-financed. Provides range of support services to promote region, including networking, legal advice, events, education, business directory, on and offline publicity | Located in the region, with offices in Lund, Sweden and Copenhagen, Denmark to enable close ties to government affiliated venture capital and support agencies in both countries. | Uses the Web extensively to promote Medicon Valley, maintains an online database of firms in the Medicon Valley, and publishes online newsletters and reports to help publicize regional activities. Has email contacts with members and helps connect members with each other and with external constituents. Also offers job listings online. |

## 5.1. How do firms embedded in a cluster use public ICT infrastructures?

In the case of Medicon Valley, as expected, all firms benefited from the presence of high quality, broadband Internet access. For the larger firms, fully capable of implementing their own private data communications infrastructure, the public infrastructure clearly supported their ability in the region to support research collaborations with scientists at other smaller firms and at universities. It further enabled better access to research facilities from home, which might, in fact, improve the attractiveness of the firms in the region to biotechnology professionals. We clearly saw that an important aspect of biotech cluster competition is competition for human resources – the clusters that can attract the scientists have an advantage.

Smaller firms heavily depended upon low cost, broadband Internet access. Each described the importance of a network connection for business. It enabled low cost and timely communication with distant partners, and facilitated company presentation and promotion online.

Few firms in the cluster were engaged in what we might consider to be sophisticated electronic commerce, where transactions were provided in an automated fashion online. Yet e-commerce of a sort was practiced, even by smaller firms. They received inquiries from non-local customers who saw their Website. They initiated transactions and sometimes took orders via email.

A concern from the review of literature is that better network access might stimulate greater interaction with firms outside the cluster, to the detriment of the cluster. Our interviews suggest that is not the case at all. To be sure, the cluster is oriented

towards exporting products – only a small fraction of output of these firms stays in the region. And clearly, access to a high quality ICT infrastructure supports non-local transactions, even if largely handled in non-automated fashions. However, there was no evidence of a weakening of the cluster due to increased ICT use. Indeed, much ICT use was for the purpose of local interactions, particularly between the support service organizations and the producers, and between research institutions and the producers. Furthermore, interviewees often described the importance of in-person contact to initiate relationships and generate referrals. ICT use with distant suppliers and customers appeared to strengthen the cluster. Larger firms could maintain connections to foreign biotechnology expertise, and as well as to distributors and their own decentralized operations, all while keeping critical research and management staff in the region. Smaller firms also with ties to the region could successfully generate business without having to move closer to their customer bases. These findings are consistent with the findings from cluster researchers who argue that connections to global markets and sources of knowledge strengthen the cluster and ensure a healthy mix of firms and increased innovative capacity [20, 52, 67].

The internal benefits of an ICT infrastructure were further highlighted by the role of the MVA, illustrating the interaction between online activities and geographic proximity. Members of the cluster support the MVA in their efforts to promote the cluster. The MVA has helped to build the brand name of the region – The Medicon Valley- and promotes it extensively throughout the world. Their use of ICT serves both a local and distant audience. It encourages connections locally, through online job listings and announcements of events and seminars. But it does not substitute for in-person events and meetings, through which personal connections are made that can lead to research collaborations.

### 5.2. Under what conditions do small firms benefit from Internet usage in a cluster?

Our second question focused specifically on small businesses and asked how they benefited from the use of a public ICT infrastructure when located in a cluster. The findings reported here are suggestive of a cluster legitimizing effect that has not been discussed widely in previous cluster research. It was rather surprising to hear that small businesses were able to rely on a crude form of electronic commerce – static presentation of their firm via the Web in order to generate business from customers in other countries. Prior research on e-commerce use by small firms would not lead to this prediction, and instead suggests that such companies - except for those selling niche products otherwise unobtainable in other markets - find it difficult to generate sales online [54, 55]. The lack of a brand name, technical and financial resources to produce a professional looking online presence, and limited resources for marketing and promotion of their Website all should mitigate against success in attracting remote customers. However, when embedded within a cluster that has become well known in a given industry – essentially the cluster brand is established [66] – such remote e-commerce appears feasible for small firms. *Clients find and trust them, and are willing to initiate transactions using the Internet because these small companies are in an established cluster with a strong reputation for excellence in the given industry*.

## 6. Conclusions

This case study has highlighted the critical role of the ICT infrastructure for industrial clusters, and yielded new insights into how small businesses in particular may benefit. Our research leads to the proposition that ICT use does not threaten, but rather enhances cluster viability and vitality. It further suggests that ICT infrastructure alone would not have the same effect. Rather, it is the interaction between cluster dynamics and ICT infrastructure that produce the types of benefits highlighted above. The research reported here suggests that small firms would not gain as much from the use of the ICT infrastructure if not located in a cluster with a strong reputation. Presence in a branded cluster appears to help remote clients find small companies, and trust them to perform the kinds of activities needed.

These findings are merely suggestive of hypotheses that require further investigation. Nonetheless, such preliminary results, if confirmed in subsequent research, should be encouraging to policy makers who are working hard to ensure high quality broadband infrastructures for economic development. However, the analysis here also warns against isolating the question of ICT infrastructure from other business development policies, and especially from policies designed to encourage the development of clusters in targeted sectors like biotechnology and high technology. The two work in concert, and may not otherwise yield the same benefits.

Our study is clearly limited, in that it is merely one case of one type of cluster, and we were able to conduct only a relatively small number of interviews. As such, we recognize the speculative nature of the

findings, and realize that we are merely presenting an opportunity for additional research to confirm the types of effects encountered in this study. A much better test would be to contrast the gains from the use of improved ICT infrastructures obtained by isolated firms with those in established clusters.

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