Social Capital, ICT Use and Company Performance: Findings from the Medicon Valley Biotech Cluster

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Abstract

This study explores how some kinds of ICT uses, as well as social capital and other means of access to knowledge resources, are related to company performance in a knowledge-intensive business cluster. Data were collected through a survey of companies in the Medicon Valley biotech region located in Denmark and Southern Sweden. Responding companies included established producers of biotechnology-related products as well as small biotechnology start-up firms emphasizing research and development. The results suggest that when ICT use was aimed at accessing and enhancing human and intellectual capital, such as use of online databases for recruitment, intranets to enhance employee access to information and education, and collaborative tools to connect with off-premise researchers, companies reported better performance outcomes. Social capital in the form of connections to people who can provide access to information and opportunity predicted company performance, particularly for small start-up companies. The pattern of results complements prior work that establishes the importance of social capital in regional business clusters by demonstrating how ICT use complements personal relationships to enhance the likelihood of success among companies in the region.

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1. Introduction

Over the past several decades there has been much interest in industrial localization of economic activities as a way to explain economic growth and increase innovation and competitiveness (Asheim and Isaksen, 2002; Krugman, 1998; Porter, 1998; Porter, 2000). Such industrial agglomeration has been referred to in a number of different ways, including industrial districts (Becattini et al., 2003), local and regional innovation systems (Cooke, 2001; Cooke, 2002), local production systems (Crouch et al., 2004), and local and regional business clusters (Porter, 1998). In this paper we adopt Porter's definition of business clusters, which he defines as "geographic concentrations of interconnected companies and institutions in a particular field" (Porter, 1998, p. 78). In addition to the companies providing products at various stages in the value chain of the specific industry associated with a cluster, there are also typically a variety of other supporting institutions and organizations that can provide specialized training, education, information, research and technical support. These include governmental institutions, universities, standards-setting agencies, think tanks, vocational training providers, and trade associations (Scupola and Steinfield, 2008).

The effects of such industrial agglomerations have been mainly explained by the interaction among the many actors located within a well-specified geographical region. Factors considered important to explain the growth and dynamism of local and regional industrial clusters include the presence of supportive local institutions, the availability of specialized suppliers and service providers, access to a qualified pool of workers, pressures from local competition (Maskell, 2001; Porter, 2000; Saxenian, 1994; Storper, 1995) and knowledge creation and learning processes within the region (Lundvall, 1988; Lundvall and Maskell, 2000). In addition tacit and explicit knowledge spillovers through formal and informal communication channels – indicators of a region's "social capital" – are considered to be very important, especially in knowledge and research intensive clusters such as biotechnology or semiconductor clusters (Almeida and Kogut, 1999; Owen-Smith and Powell, 2004; Bathelt et al., 2004). Recent literature is also investigating the benefits for companies located in clusters in using information and communication technologies (ICTs) to support exchange activities within and outside the cluster (Ciarli and Rabelotti, 2007; Scupola and Steinfield, 2008; Steinfield and Scupola, 2008).

This study adds to the emerging literature on the importance of relationships and communication in regional clusters by explicitly investigating the combination of social and relational factors, access to cluster-based resources, and specific forms of ICT use as predictors of individual firm success. Moreover, we distinguish between companies primarily conducting R&D, but not yet selling products, and those that are selling goods and services, considering that the needs of these two types of cluster participants, as well as how they measure success might be different. Specifically, we ask: 1) Is company performance in knowledge intensive clusters dependent on possessing social capital? 2) Does use of information and communication technologies that support both social and human capital influence company success? 3) If so, are these relationships contingent on whether a firm is mainly involved in R&D activities or is primarily a producer of goods and services for sale?

Much of the prior research on the benefits of regional clusters establishes that a key advantage is that companies in a cluster have greater access to many kinds of resources important to the industrial sector (Porter, 2000). In a knowledge-intensive cluster, access to such resources as university research, training, and a highly skilled labor force are examples of the kinds of knowledge resources that can bring benefits to cluster members. To address our research questions, we examine whether greater access to these kinds of resources matters to company performance. We further investigate whether use of ICTs to facilitate access to knowledge resources, and having social capital – conceptualized as the degree to which employees in a company are connected to others in the region who can provide access to information and opportunity – both influence the performance of companies embedded in knowledge-oriented clusters over and above the access provided by geographical proximity. The study is conducted in Medicon Valley, a knowledge intensive biotech cluster located in the Danish region called "Zealand" and Southern Sweden.

To answer the research questions we first build a theoretical model by conducting a review of literature related to innovation, industrial clusters, social capital and ICTs, supported by insights provided by a series of semi-structured interviews with key players in companies and institutions located in the Medicon Valley cluster. This model is then investigated through a survey of biotech companies located in the cluster.

The paper is organized as follows. This section has introduced the background and the research questions. Section two develops the research model and supporting hypotheses. In section three we provide a description of the Medicon Valley biotech cluster. Section four outlines the research methods used in the study. Results are presented in section five. Finally, sections six and seven discuss the findings, and provide conclusions and implications of the study.

2. Theoretical Model and Hypotheses

As noted above, theorists have identified many factors that can help to explain the relative success of companies in industrial districts, largely stemming from the way in which company location mediates access to knowledge, labor, resources, and relationships (Porter, 2000; Maskell, 2001; Saxenian, 1994; Storper, 1995). For example Bathelt et al. (2004) discuss and emphasize the information and communication ecology created by face-to-face contacts, co-location and co-presence of people or firms within the same industry or region called "buzz" as well as the channels used in long distance interactions and global communication called "pipelines". Access to knowledge-relevant resources is particularly important in a cluster dominated by R&D activity such as biotechnology clusters (Owen-Smith and Powell, 2004). In our review, we suggest that not all firms in a cluster benefit to the same degree due to differential access to cluster knowledge resources. The sections below develop arguments suggesting that cluster members richer in social capital, those having greater access to specific knowledge resources such as access to training or university research expertise, and those using ICTs to enhance access to knowledge resources will benefit the most. We also argue that it is important to control for broader organizational resource availability, e.g. size, as well as the kinds of activities in which a company is engaged. For example, in biotech regions, some biotech companies are mainly engaged in R&D, developing new compounds or diagnostic tests they hope to eventually license, while others are actually manufacturing and selling finished products (e.g. García-Muiña et al., 2009). The outcomes that are relevant in these two kinds of companies are quite distinct: traditional measures of performance such as sales, customer relationships, costs, etc. are not really relevant for the former type of company, but the extent to which other companies know about them and are aware of their activities should be. These traditional performance indicators are, however, important for the latter types of companies actually producing and selling products.

2.1 Social capital in knowledge clusters

Social capital (SC) is understood roughly as the goodwill that is engendered by the fabric of social relations in which an individual is embedded, and which can be mobilized to facilitate action (Adler and Kwon, 2002). The concept has become increasingly popular in organizational literature (Adler and Kwon, 2002; Nahapiet and Ghoshal, 1998) and has important implications for understanding the formation of relational networks in high growth, technology-intensive industries. In these industries, opportunities for cooperation are created by unintended spillovers and intended agreements (Walker et al., 1997). Social capital has been invoked often to explain the vitality of clusters. Indeed, some theorists even posit that clusters characterized by rich social networks that provide the social capital of the region represent a specific type of cluster, distinct from clusters that do not have such dense networks (Gordon and McCann, 2000).

The existence of social capital in a cluster of companies depends upon the ability of people to associate with each other and the extent to which their shared norms and values allow them to subordinate their individual interests to the larger interests of the community (Wolfe, 2002). Interventions that may build social capital in a regional cluster include providing incentives to activate local business and civic associations or to activate new associations; requiring, or including incentives for, multiple-firm sponsorship or inter-firm collaboration or economic development grants; and increasing investments in cluster-based communications systems and in inter-firm collaboration (Rosenfeld, 1997). Local business associations in Silicon Valley, for instance, also contributed to the development of the social infrastructure needed to leverage social capital (Rosenfeld, 1997). In the start-up phase of a company, there may be greater dependence on social ties to identify business partners because of the limited experience in the market. More established firms have worked with different business partners and therefore can rely on past experience to obtain needed resources. In biotechnology, for example, small startups have extensive expertise in technological innovation but lack resources in marketing and distribution possessed by large incumbents (Walker et al., 1997). Hence, social capital may be more important for start-up firms than for those that have moved to a later phase in their development.

A significant body of literature supports the notion that less codified, and socially enacted and embedded forms of knowledge, capital and network relations have important consequences for industrial performance and innovative capacity (Bathelt et al., 2004; Lundvall, 1988; Lundvall and Maskell, 2000). In geographically defined business clusters, social capital can be a key element in improving firms' performance. Explanations of successful local business clusters often focus on traditional social capital explanations, such as the importance of trust and social relationships, as a catalyst for knowledge sharing and innovation across firms that may not even be trading partners (Maskell, 2001; Bathelt et al., 2004). Putnam (1994) found in his comparative study of Northern and Southern Italy that the stock of social capital predicts economic performance, and that stock is enhanced by the dense social infrastructure. Also, social capital strengthens regional production networks (Romo and Schwartz, 1995) and Rosenfeld (1997) concludes that the most effective clusters are those with specialized support and considerable social capital.

Co-located firms within related industries enhance the ability to create knowledge by benefiting from social relationships and knowledge exchange via interactions with other companies within the cluster (Maskell, 2001; Bathelt et al., 2004). Rosenfeld

(1997) found that firms in clusters take advantage of a high level of social capital that bonds cluster members and provides opportunity for informal interaction and learning. Also clusters of firms have the social infrastructure that keeps information flowing continually, sparks new ideas, generates networks, and encourages new firm start-ups. These factors may improve corporate performance in terms of innovativeness, efficiency, sales, quality of products and new market opportunities.

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 (Saxenian, 2006). Because suppliers and customers simply need to interact with each other in order to do business, most relationships in a cluster will be along the vertical dimension (Maskell, 2001), including specialized suppliers and critical customers both of which can affect the firm's perceived market exposure. Specifically, Rosenfeld (1997) found that suppliers contribute to the stock of social capital by organizing social events that bring companies' owners and employees together, thus impacting on the quality of relationships with suppliers, a component of the firm' perceived market exposure. Also, maintaining regular interactions with a firm's customers can enhance the quality of their relationships and, in turn, the firm's market outcomes. Based on the above discussion, we can posit the following:

H1: Social capital will impact the performance of a knowledge cluster company

H2: Social capital will have a greater impact on the performance of start-up companies than mature companies in a knowledge-oriented cluster

2.2 Access to knowledge resources

Today, knowledge is often considered a fundamental basis of competition (Zack, 1999) and, particularly tacit knowledge can be argued to be a source of advantage because it is unique, imperfectly mobile, imperfectly imitable, non-substitutable and personally or socially embedded (Ambrosini and Bowman, 2001). Industrial districts constitute a place where knowledge is created, transferred and made accessible (Bathelt et al., 2004). The proximity between firms plays an important role in interactive learning processes (Lundvall, 1988; Lundvall and Maskell, 2000) in the sense that in many cases the exchange of information and knowledge is less expensive, more reliable and easier. Short distances not only reduce transaction costs and encourage innovation (Breschi and Malerba, 2001), they also facilitate the coordination of individual actors and stimulate the transfer of knowledge (Boschma and Lambooy, 2002).

The exchange of knowledge between firms in an industrial district can be formal or informal (Bathelt et al. 2004). In their research with a sample of engineers in a regional cluster of wireless communication firms in Northern Denmark, Dahl and Pedersen (2004) find that the engineers in different firms share quite valuable knowledge with informal contacts, meaning that informal contacts represent an important channel of knowledge diffusion. More recently, Sammarra and Biggiero (2008), based on the aerospace industrial cluster of Rome, find that technological, market and managerial knowledge are purposely exchanged between firms within the cluster for innovation. Companies in clusters can acquire knowledge from both inside and outside the region (Bathelt et al. 2004; Saxenian, 2006). For instance, Owen-Smith and Powell (2004) have shown in the case of the Boston biotechnology industry that access to new knowledge does not just result from local and regional interaction but is often acquired through strategic partnerships of inter-regional and international reach. Our focus is, though, on the access to knowledge resources from regional interactions within the industrial cluster.

From a global perspective, knowledge-based elements as determinants of a cluster's strength and performance have received a considerable amount of attention within qualitative and case-based research studies (Rabellotti, 1999). Economic agents are thought to gather together in close geographic proximity and establish relationships with one another in order to better perform certain economic activities (Morosini, 2004). From a narrower viewpoint, inter-firm knowledge sharing is essential to be innovative, thus increasing the company's performance. This is especially important for small firms in a cluster because they lack the financial resources, human skills, and marketing capabilities (Asheim and Isaksen, 2002). On the other hand, firms operating in knowledge intensive industries, such as biotechnology, need o be flexible in order to provide products and services in a rapidly changing environment (Gopalakrishnan and Bierly, 2006), where knowledge must be generated and shared continuously and organisations have to enhance their employees to be creative. Industrial clusters create a context in which this is more likely to happen, although, as proposed earlier, not all firms will enjoy the same degree of access to the knowledge resources in a cluster. In summary:

H3: Access to knowledge resources will impact the performance of a knowledge cluster company

2.3 ICTs and performance of firms in clusters

Many studies have been conducted that investigate the relationship between ICTs and clusters (Leamer and Storper, 2001). Generally, these studies can be classified into two main groups. The first focuses on the effects of the information and communication technology infrastructure on the agglomeration or disagglomeration of geographically localized activities (Steinfield and Scupola, 2006; Leamer and Storper, 2001). The second focuses on adoption and diffusion of ICTs in clusters (Scupola and Steinfield, 2008; Ciarli and Rabellotti, 2007; Rabelotti, 1999; Johnston and Lawrence, 1988; Kumar et al., 1998). Studies that explore the effect of ICTs on the performance of firms located in clusters are rare, despite the long history of research related to ICTs and company performance (Steinfield and Scupola, 2006).

Information systems researchers have found that ICTs, such as intranets, can be a source of value creation to firms by providing intra-organizational communication at reduced cost and by allowing employees to distribute and communicate their ideas more readily (Lai, 2001), thus positively impacting organizational performance (e.g. Meroño-Cerdan et al., 2008). In addition the literature studying the business value of information technology for organizations has also recently showed that IT can contribute to firm performance (Brynjolfsson and Hitt, 1996; Meville et al., 2004; Scupola, 2003; Shin, 2006). Examples of IT value creation in firms can be in process planning and support improvement (Barua et al., 1995); supplier linkages (Bakos, 1991); increase company innovativeness through e.g. new product and service enhancement (Barua et al., 1995) and finally in improving customer relationships as they can result in an increase in market share (Porter and Millar, 1985).

Kumar et al. (1998) have argued that being based in a cluster may obviate the need for ICT-supported transactions between firms, as personal interactions enabled by proximity and trust would substitute for more formal transaction automation. Their work, however, focused purely on inter-company transactions among small firms in the pre-Internet era. Moreover, their study did not consider the many internal applications of ICTs that can enhance company performance. Steinfield and Scupola (2008) distinguish between internal and external use of ICTs in their analysis of ICT use in a biotech cluster. Internal ICT applications are those that connected employees to each other and the company, including those who worked at different locations. External uses included e-commerce and other transaction support application involving other companies or customers.

Given our earlier discussions about the critical importance of access to knowledge, a skilled labor force, and knowledge management in knowledge intensive clusters, it is likely that ICT applications addressing these needs will be critical to success. Indeed, in unstructured and in-depth interviews with company managers in the region, interviewees often commented on their use of the Internet especially to seek out and recruit new employees. We thus focus our attention on ICT applications that address the needs to enhance human capital and improve access to the kind of highly specialized workforce needed by biotechnology firms. Hence, we propose:

H4: The use of ICTs to enhance human capital will impact the performance of a knowledge cluster company

2.4 Company characteristics

In a prior analysis of the Medicon Valley cluster, it was found that two types of biotechnology companies were prevalent: larger, more mature producer firms that are export oriented, and small, start-up R&D companies that may not yet have products that they manufacture or sell commercially (Steinfield and Scupola, 2008). In the former case, the lion's share of large company output is destined for markets outside the Medicon Valley cluster. These companies do not typically work very closely with companies in the region, but do connect with researchers from universities,or in the start-up companies located in Medicon Valley (Steinfield and Scupola, 2008). These small start-up companies are often formed as spin-offs from larger companies or universities, and maintain intense contacts with their prior research colleagues. They are mainly financed by venture capital. We expect that start-up companies will be more focused on building awareness of their expertise and their research work, than on actual sales. We also expect that the extent of resources available to a company, using size in terms of the number of employees, should influence performance.

H5: The primary activities of a company (R&D vs. manufacturing and sales) will impact the performance of a cluster-based company.

H6: The resources of a company (using size as a proxy) will impact the performance of a cluster-based company.

We treat the independent variables in these final two hypotheses as control variables, and focus our attention on the extent to which the other independent variables (social capital, ICTs and access to knowledge resources) explain the two types of outcomes (market exposure and market performance). An overview of the model is provided in Figure 1.

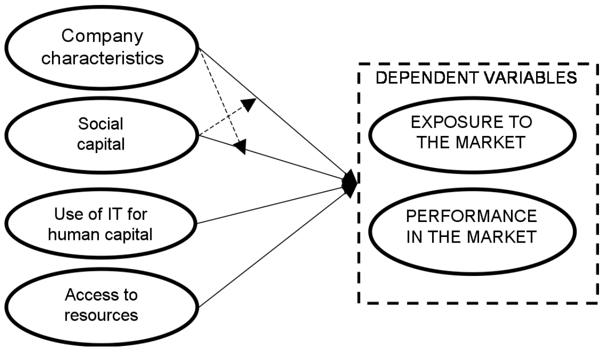


Figure 1: A model of performance of firms located in knowledge intensive clusters

3. An Overview of the Medicon Valley

The Medicon Valley cluster is one of the top European bioregions featuring cross-border partnerships between industry, universities, hospitals, science parks, investors and business services (see Table 1 for detailed characteristics of the region). Further information about Medicon Valley and Medicon Valley Alliance can be obtained from www.mediconvalley.com and www.mva.org, respectively.

Table 1: Characteristics of Medicon Valley (Adapted from the MVA home page, www.mva.org)

Population	Ca 3 mi. inhabitants - 22 percent of the total population of Denmark and Sweden
Number of universities	12
Affluent Population	GDP per capita is EUR 27,358 (EU average: EUR 21,990 (Eurostat, 2002)
Number of university students	140,000 of whom 2.000 are PhD students within life science
Number of researchers	10, 000
International accessibility	2 international airports. Copenhagen and Malmo
Number of hospitals	26 hospitals of which 11 are university hospitals
Science Parks	6
Other Characteristics	- Fixed link between Denmark and Sweden ensures easy travel between the two countries - Beautiful nature and distinct metropolitan areas. - Well educated labor force

4. Methodology

An online survey was sent to biotechnology companies in the Medicon Valley biotechnology region in order to test the hypotheses. To define the final version of the questionnaire we used both previously tested measures as well as new qualitative scales. In fact, prior to conducting the survey, we visited 17 companies in the region to explore the nature of their interactions with other companies inside and outside the region, the types of resources that made the region attractive, the kinds of activities in which their companies were engaged, and the various ways in which they used ICTs. The interviews served as input to the construction of the survey questionnaire and are not otherwise reported in detail in this paper.

4.1 Survey approach and sample

Once constructed and tested, the survey was sent to 244 biotech companies located in Medicon Valley, which accounted for about all of the biotech companies in the cluster that we were able to identify. In fact, as in other survey studies in the biotechnology field (e.g., García-Muiña et al., 2009) one of the main problems to identify the company sample was that there are no up-to-date national statistics covering all the firms dedicated to biotechnology in Medicon Valley. Thus, we first had to produce a database of firms

In constructing the database, we included only companies conducting biotechnology activities. This kind of companies develops biotechnology products and services in therapeutic areas for the treatment, prevention or diagnosis of illnesses such as production of vaccines, antibiotics, drugs and diagnostic kits. We did not include companies in the region offering support services such as the many accounting, IT services, consulting, and employment agencies that cater to the biotechnology industry. To build our database we started from the database created by Medicon Valley Alliance (www.mva.org) and supplemented it with other companies found on the web. The MVA database provided a total of 270 companies, but included a number of companies that we determined were engaged in the provision of support services. We excluded these support services companies in order to focus exclusively on companies researching, developing or selling biotechnology products. The list was supplemented with several additional biotech companies located in all the science parks of the Medicon Valley geographical region that were not accounted for in the MVA database.

An e-mail invitation to participate in the study was sent to the CEO or managing director of each company if we were able to identify this person. If not, we used the contact name provided on the company web page and requested that the recipient forward the questionnaire to the CEO or to a senior manager with a good overview of the company. The invitation included a presentation of the study, information about confidentiality, and a link to the survey. No compensation was offered for participation; however respondents were offered a summary of the results. Before sending the questionnarie by electronic mail to the complete population of firms, we carried on a pre-test where several firm CEOs and directors tested the questionnaire. The survey ran over a three-week period, using the online survey hosting site Zoomerang (www.zoomerang.com). Three reminders were sent to companies that had not yet responded. Sixty companies answered the questionnaire, and after excluding two companies that we were not able to reach via email, the response rate was approximately 25%.

4.2 Dependent measures

We developed two distinct outcome measures to reflect the different aspects of performance that might be relevant for R&D start-ups vs. mature companies that produce and sell products. A series of twelve performance related items based on aspects of performance over the past two years that our interviewees suggested would be important are listed in Table 2. These factored into two dimensions. The first, *market performance*, contains classic performance measures such as profitability and reductions in costs. The second, *market exposure*, contains items related to the visibility of the company to various stakeholders and its attractiveness to potential investors. Based on the interviews we expected that this latter measure would be quite relevant for R&D start-up companies. As shown in Table 2, these formed reliable scales.

4.3 Independent measures

Organizational resources were approximated by the number of employees in a respondent's company in the region. The *primary activity* of the company was determined by asking the company whether it was currently selling or distributing one or more products or services (N=39), or, conversely, was not selling a product or service at this time but was only engaged in R&D (N=21).

Given our conceptualization of social capital as being embedded in relationships, we created an index of *social capital* that focused primarily on the extent to which people in the company knew and trusted others in the region who might provide advice and access to information and opportunity. The six items proved to be unidimensional and formed a reliable scale. The individual items are provided in Table 3.

Table 2. Dependent items and scales

	Factor Loadings	
Individual Items and Scales	**Market Performance**	**Market Exposure**
Market Perform. (Cron. alpha=.90) Mean=3.17, S.D. = 0.89[a]		
We are widely recognized as one of the leading providers of our products/services around the world[b]	**.67**	.35
We were able to enter new markets around the world[c]	**.80**	.21
We increased our sales to customers outside the Oresund region[c]	**.88**	-.01
We improved the quality of our goods, services, and processes[c]	**.76**	.15
We improved our overall profitability[c]	**.78**	.07
We improved the quality of our relationships with customers[c]	**.71**	.27
We reduced the costs per unit of good or service provided[c]	**.62**	.27
We introduced new or improved products, services, or processes[d]	**.72**	.01
Market Exposure (Cron. alpha=.71) Mean=3.50, S.D. =0.77[a]		
Our company is attractive to potential investors[b]	.09	**.73**
We improved the quality of our relationships with suppliers[c]	.28	**.56**
We increased the visibility of our company inside the Oresunds region[c]	-.09	**.78**
We increased the visibility of our company outside the Oresunds region[c]	.35	**.80**

[a] Principal components factor analysis with varimax rotation. Scales created by averaging across items
[c] Item scales ranges from 1= strong disagree to 5= strongly agree
[c] Questions asked about performance over the last two years, with scales ranging from 1= strong disagree to 5= strongly agree. Due to missing data created by some items being non-applicable to some companies, not applicable answers were recoded to the midpoint of the scale (neither agree nor disagree).
[d] Constructed by adding yes responses to three separate items: new or improved products, new or improved services, and new or improved processes.

Our measure of ICT use was derived from the interviews where respondents identified the range of ways in which they used various ICTs, including the Internet and specialized collaboration software, to gain access to labor resources, research information and partners, and training and education. We called this measure *ICT use for human capital*, since it reflected uses aimed at enhancing the stock of knowledge and knowledgeable people in the company. Items used to create this measure are shown in Table 3.

Access to knowledge resources was measured through a series of items inquiring about the ease of access to such cluster resources as research output from universities or research institutions, training and education for employees, skilled labor, and collaboration partners at universities (see Table 3). These items were often discussed as important cluster resources contributing to learning and growth of Medicon Valley in the interviews.

Table 3. Independent items and scales

Individual Items and Scales	Mean	S.D.
Social Capital [a] (Cron. alpha=.83)	3.26	0.79
In this region there are often opportunities to meet people who: ▪ can expose us to new developments in the industry ▪ can introduce us to new business partners ▪ are useful sources of new information relevant to our company Company employees have strong personal contacts in this region that: ▪ we trust to advise us on important issues or problems faced by our company ▪ can connect us to sources of financing or other key business transactions ▪ we trust for help when seeking a partner in a business or research collaboration		
ICT Use for Human Capital [b] (Cronbach's alpha=.76)	2.65	1.26
Rate extent of company's use of following IT applications: ▪ connections to online services for recruitment ▪ an intranet that supplies information/education to your employees and/or selected business partners ▪ group collaboration software to support project teams with member not located on your premises		
Access to Knowledge Resources [c] (Cronbach's alpha=.78)	3.34	0.79
Ease of access to following resources when needed: ▪ new knowledge generated by university or research institutions ▪ training and education for current employees ▪ a highly skilled labor pool when seeking new hires ▪ universities or research institutions for collaboration on projects		
Primary Activity ▪ R&D ▪ Production and sales	 N=21 N=39	 35% 65%
Number of Employees in the Region	70.5	330.6
Notes: [a] Principal components factor analysis with varimax rotation revealed 1 factor. Item scales ranges from 1= strongly disagree to 5= strongly agree [b] Item scales ranged from 1-not at all to 5= very often. [c] Ease of access item scales ranged from 1=not at all easy to 5=very easy.		

5. Results

A regression analysis was run to estimate the effects of independent variables on the two measures of performance (Table 4). As expected, the primary activity of the company (R&D vs. sales) strongly influenced company outcomes, with the more mature producing companies reporting higher scores on both market exposure and market performance. The number of employees was related only to market performance, not market exposure. This is not surprising since start-up companies mainly seeking to increase their visibility to other companies that could have an interest in licensing their intellectual property or investing capital into their company can actually be quite small. Even with these control variables in the model, the amount of perceived social capital, the extent of ICT use for human capital, and the ease of access to knowledge resources all significantly predicted market exposure. Access to local knowledge resources did not predict market performance, however.

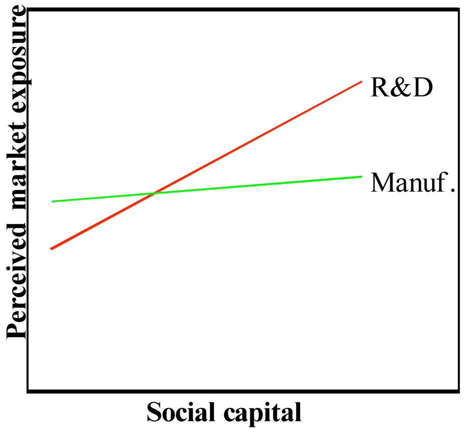
In order to test hypotheses 2 - that the effect of social capital would vary by type of firm - we created a dummy variable as an interaction term with the product of primary activity and social capital. In both regression equations, this variable (primary company activity) was significant as well. The shape of the interactions is shown in Figure 2, revealing that social capital is a much more important predictor of market exposure and market performance for the R&D start-up firms than for the more mature firms usually involved in production and/or selling of biotech products and services.

Table 4. Regression results predicting market exposure and market performance

Dependent variable	Perceived market exposure	Perceived market performance
Independent variable	**Scaled Est.**	**Scaled Est.**
Constant	3.63	**3.12** **
Primary company activity[1]	**0.32** ***	**0.34** ***
Log of number of employees	0.22	**0.71** **
ICT use to enhance human capital	**0.66** ****	**0.43** **
Perceived social capital	**0.83** ****	**0.51** *
Access to area knowledge resources	**0.40** *	-0.10
Social capital by primary activity interaction	**-0.52** **	**-0.69** *
N=58	Adj. R^2=.50 F=10.58 p<.0001	Adj. R^2=.57 F=13.73 p<.0001

[1] 0= R&D, 1= produce and sell products
* p<.05, ** p<.01, *** p<.001, **** p<.0001

In summary, the regression models accounted for a substantial proportion of the variance in both market exposure (Adj. R2 = .50) and market performance (Adj. R2 = .57). Hypotheses 1, 2, 3, and 5 were supported fully, hypothesis 4 was supported only for the market exposure outcome variable, and hypothesis 6 was supported only for the market performance outcome variable. We next turn to a discussion of these findings.



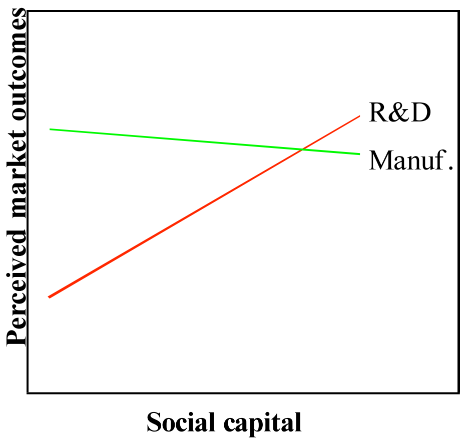


Figure 2: Interactions between perceived social capital and type of company on both measures of performance

6. Discussion

The results reported here reveal the extent to which personal and ICT-facilitated access to people and knowledge resources is critical to the performance of the companies in a knowledge-oriented biotechnology cluster. Social capital, in the form of relationships to trusted people in the region who can connect biotechnology companies to potential partners, financial resources, advice, and other types of information and opportunities influences the likely success of companies in the cluster, especially the start-up R&D companies.

The relevance of social capital in knowledge clusters has received a great deal of attention in the literature. Our results add support, at the individual company level of analysis, to previous cluster studies that have found that social capital plays an important role in the economic growth of regional knowledge clusters (Maskell, 2001; Rosenfeld, 1997; Putnam, 1994; Romo and Schwartz, 1995). The results indicate that companies located in an industrial cluster can improve their performance by leveraging relationships and opportunities to connect to other firms in the region. The interaction of company type with social capital further demonstrates how companies at different stages in their life cycle rely more or less on these personal relationships. The companies focused purely on R&D are smaller and have fewer resources available compared to the more established producer companies. These characteristics make R&D firms rely more on personal contacts and relationships for access to knowledge, financial investors and skilled labor, while the more mature firms in the region may simply have less need to leverage social capital to access needed resources.

As we would expect from earlier work that questions whether ICT use can substitute for personal relationships to access cluster resources (Kumar et al, 1998), such a substitution effect appears to be unfounded in this data. Indeed, both personal relationships and the types of ICT uses measured here – applications that enhance a company's access to people and knowledge resources – contribute to visibility and overall market performance. Hence these two types of variables are best viewed as complementary in their effect on the success of knowledge cluster-based companies.

7. Conclusions and Limitations

Biotechnology clusters are good examples of knowledge-based regions, where focus is placed on innovative capacity (Owen-Smith and. Powell, 2004). The results reported here confirm the value of engaging in cluster activities that can help to form and maintain relationships with professionals in the region – such as the social networking support often provided by non-profit regional associations. The results further support the hypotheses that such activities mostly benefit start-up companies by introducing the professionals working in these firms to employees in universities, research centers, support companies, and more established producers that may be clients for their intellectual property.

In addition knowledge clusters may also increase ease of access to relevant knowledge resources, such as university research, training and education, skilled workers, and research collaborators. Our results show that companies that do report easier access to these resources do feel that they are more visible to potential customers and other stakeholders.

Regarding the role of ICTs in this process, the evidence suggests that there is value in promoting greater use of such technologies in knowledge intensive clusters, even though the types of activities such as R&D, products and services may be less amenable to such applications as e-commerce. Rather, it appears that ICT usage to enhance human capital – either by helping to locate and recruit new skilled workers, strengthen human capital through ICT-enabled information access or training, or supporting collaboration with off-premise researchers – can complement other personal and institutional strategies designed to improve the knowledge resources in the cluster.

Of course, the findings are limited in that they are only based on one cluster, with a small sample size. Moreover, the approach of using only one respondent per company, in some cases without knowing if we were able to connect with the right person, opens the door to many biases and potential problems with the accuracy of the reported data. Additionally, our use of newly created indexes and scales, and the reliance on self-report as opposed to other more objective sources for the performance factor, further constrain our ability to generalize too widely from these findings. Nonetheless, the results both offer new insights and support previous findings about how personal, organizational, and technology mediated interactions might all serve to enhance the performance of companies located in knowledge clusters, usually highly dependent on innovation for success.

8. References

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