Networks of dedicated biotechnology and service firms in Vancouver

Martin J. Bliemel and Ian P. McCarthy

Date Received (in revised form): 15th April, 2008

Martin J. Bliemel
is a PhD candidate in Strategy and Entrepreneurship at the Segal Graduate School of Business, Simon Fraser University at Vancouver, Canada. He also holds a BSc in Mechanical Engineering and MBA, both from Queen's University at Kingston, Canada. Martin is interested in how high-tech entrepreneurs build and use their social networks while developing their new ventures. He has presented his work at conferences such as Academy of Management, West Coast Research Symposium and Administrative Sciences Association of Canada, and has also participated in international workshops such as EUDOKMA and Max Planck Summer Institute.

Ian P. McCarthy
has worked for several years as a industrial engineer before earning his PhD in operations strategy from the University of Sheffield. He is currently the Canada Research Chair in Technology and Operations Management in the Segal Graduate School of Business at Simon Fraser University. His research focuses on the design and operational performance of technology-based organizations; in particular, he is interested in control systems, customization of products and services, and the design and management of new product development processes.

Abstract
Survival and growth of firms depends on their relationships to other organisations, including key suppliers, customers, supporters and competitors. This study compares geographic aspects of the networks of biotechnology firms (DBFs) and contract research organisations and service firms (CROs) in Vancouver, Canada. We find that for DBFs the key actors (organisations and individuals) that they network with are globally located (ie not local), despite the DBFs having originated from a local university. In contrast, CROs are more likely to network with local actors, and with actors on the same continent. Of the DBFs providing performance data, the distribution of their performance is consistent with recent developments in structural embeddedness theory (ie network coupling theory). This suggests that their performance may be inhibited if they are under- or over-embedded in their network, with the greatest opportunity for success in a medium range of coupling.
Journal of Commercial Biotechnology (2008) **14,** 265-273. doi:10.1057/jcb.2008.17;
published online 27 May 2008

Keywords: *biotechnology, contract research, network, relationships, proximity*

INTRODUCTION

This paper reports research on how biotechnology firms relate to key actors (eg customers, suppliers, competitors and supporters) within the biotechnology innovation system. In particular, we investigate the way in which senior executives of dedicated biotechnology firms (DBFs) and contract research organisations and service firms (CROs) consider their inter-firm network to be structured. To do so, we use geographic relationships as indicators for the strength of relationships, and investigate the resulting structural embeddedness of the firm.

Correspondence: Martin J. Bliemel, Segal Graduate School of Business, Room V255, Simon Fraser University, 500 Granville St, Vancouver, BC, Canada V6C 1W6
Tel: +1 778 782 7738
Fax: +1 778 782 5122
E-mail: mbliemel@sfu.ca

Structural embeddedness is the extent to which a firm is connected to other actors (organisations and individuals). In terms of networks it indicates how actors are connected to each other, and the propensity for flows of information, cash and other resources to occur between the actors, which in turn can enable or constrain an actor's ability to pursue their business goals.[1,2] As a result, structural embeddedness has been argued to have a non-linear relationship with the performance of small to medium-size enterprises[3,4] as well as some high-technology start-ups.[5,6]

Recent research in structural embeddedness, including this study, challenges prior research that purports that having more connections is always better,[7] whether measured in terms of quantity or quality of the relationships. Studies remain inconclusive whether more relationships or stronger relationships lead to greater firm performance.[8–11] Somewhat related to networks, Porter[12,13] introduced his anatomy of a cluster, and argued that firms realise net benefits from close proximity to their suppliers, customers, competitors and supporters. While geographic proximity contributes to knowledge spillovers,[14–17] there is still little evidence that biotechnology firms require or benefit from geographic proximity to all the key actors in each of the categories introduced in Porter's cluster model.[18–23] By comparing technology-based firms (ie DBFs) in Vancouver, Canada, against labour-based firms (ie CROs) in the same region, this study sheds light on the conditions under which it is better to co-locate with important actors in the same industry, and under which conditions one might maintain remote relationships with the same.

This study finds that DBFs are geography agnostic with regards to key customers, suppliers and competitors. Counter to agglomeration economy theory[24,25] or Porter's clustering arguments,[12,13] the technological platform on which DBFs base their business model is not dependent on being located in the same region as these actors. Their basic requirements to survive and grow are cash and talent. While angel investment and venture capital tends to remain in the region of the investors, cash raised in public markets is relatively location independent. Furthermore, given that the average cost of developing a drug is approaching \$1bn,[26] DBFs frequently resort to public markets early in their lifecycle. As for talent, the DBFs generally maintain some relationship with universities, either to license the intellectual property (IP) from them, or to recruit talented individuals from there. Either of these processes benefits from being located near the university, but close proximity is not necessary.

In contrast, while CROs acknowledge they operate in a globally competitive environment, especially since separate medical trials are required for each individual country or market, they nonetheless place great emphasis on being near their key customers and suppliers, resulting in many key competitors clustering around the same key clients.

In this paper we construct a proxy for structural embeddedness based on the proximity to key actors. Based on this embeddedness measure, we find that DBFs predominantly maintain medium levels of structural embeddedness, with some low levels structural embeddedness, but none that have high levels of structural embeddedness. In contrast, the same structural embeddedness measure indicates that no CROs maintain low levels of structural embeddedness, and are evenly split across medium and high levels of structural embeddedness. For the DBFs reporting financial performance data, the results support prior theories that being over- and under-embedded is detrimental to high growth, with the greatest opportunity for performance being in the medium level.

The following sections provide more detail on the method of data collection and analysis, followed by a review of the results and discussion, including implications for management and further research. We conclude with an overview of this study.

METHOD

Network relationship data were collected by pre-mailed questionnaires and subsequent interviews with founders or senior executives of 35 firms in the biotechnology cluster in Vancouver, Canada, over a period ranging from 2001 to 2003. The data set includes 25 DBFs, and ten CROs. The original research was performed as part of a larger cluster research initiative by the Innovation Systems Research Network (ISRN), which is summarised in an ISRN book 'Local Networks and Global Pipelines.'[22] For some DBFs, data on the compound average revenue growth rates (CAGR) over the preceding three years were collected during the same interview process using a second questionnaire. Revenue data for the remaining firms, if available, were also collected using secondary data sources such as the Lexis/Nexis database, local business intelligence publications and corporate press releases. Revenue data for 11 of the 25 DBFs were attained.

In addition to asking whether their firm was a university spin-out, each interview participant was asked a variety of questions, including six that described how they described the proximity to key (1) customers, (2) suppliers and (3) competitors, (4) how frequently they maintained communication with public research institutions, (5) whether they considered their firm to be part of a regional network of related firms (6) and which associations they participated in. Categories of responses were created based on the verbal responses given as per prior research methods using similar data sets.[27] Each category was coded into an ordinal scale and was then normalised to range from 0 to 100 per cent indicating the degree of embeddedness in the relationship.

Separate embeddedness values were created for suppliers, customers, competitors and supporters, as per the four categories in Porter's anatomy of a cluster. Since the inputs to biotechnology firms includes physical products (eg chemicals) as well as IP or talent from public research institutions, supplier embeddedness value was created by averaging the normalised values for key supplier proximity and contact with public research institutions. Customer and competitor embeddedness was derived directly from the normalised values of the respective key customer and key competitor proximity questions. Supporter embeddedness was comprised by the average of the normalised values for the perceived presence of a local cluster or industry association, and the available responses about participation at the association's networking events. Other responses in the interviews indicated that these events and organisations provided the opportunity for the firms to meet representatives from supporting professional service firms.

The overall level of structural embeddedness was constructed by averaging each of the four normalised embeddedness levels, resulting in a measure between 0 (under-embedded) and 100 per cent (over-embedded). The firms were grouped into three different bands of embeddedness of equal width, each 33.3 per cent wide; anything below 33.3 per cent was deemed *low* embeddedness, 33.3 per cent–66.6 per cent *medium* embeddedness, and above 66 per cent *high* embeddedness.

In order to investigate the degree to which biotechnology firms foster 'local buzz, and global pipelines'[21] or '[local] channels and [long-distance] conduits'[8], the medium embeddedness firms were investigated further to categorise them by the composition of their four embeddedness values. Firms with low levels of embeddedness in their competitive monitoring activities (supporters and competitors) but high levels of embeddedness in their supply chain (customers and suppliers) were labelled as having local networks and global pipelines (LNGP). Vice versa, firms with high levels of embeddedness in their competitive monitoring activities (supporters and competitors) but low levels of embeddedness in their supply chain (customers and suppliers) were labelled as having global networks and local pipelines (GNLP). Firms with medium embeddedness values across all four areas were labelled as having a split balance (SPLIT).

RESULTS AND DISCUSSION

Firm origins and performance

The 35 firms interviewed may be considered a representative sample of the adolescent biotechnology community in Vancouver, Canada. Of the DBFs, 76 per cent indicated that they spun out of a local institution, 12 per cent were started from scratch, and the remainder was spun off from other firms. The high percentage of institutional (ie university or government research lab) spin-offs indicates that access to the university is important to the new ventures community. Vice versa, it is important to the researchers in the university to access others in the local area who can help with the spin-off process, beyond the support of the local technology transfer offices.

Differences between DBFs and CROs include their business model and variability of their revenue growth rates. For those CROs reporting revenue growth rates, the CAGR varied between −7 and 11 per cent, with the exception of one lab that reported eight employees and 59 per cent CAGR, but ceased to exist by 2006. For DBFs reporting revenues, the average CAGR was 83 per cent, ranging from −78 to 410 per cent indicating the rapid scalability of a technology-based business.

Contact with universities

Considering only the contact with universities (Figure 1), we see that DBFs are usually very often in contact with universities. In comparison, the CROs are usually often in contact with universities, with some not maintaining this relationship at all.

We see that DBFs usually maintain frequent contact with the universities, enabling the transfer of knowledge post spin-off process. Only a few claim no contact with universities whatsoever. Likewise, the CROs place importance on maintaining contact with universities. We speculate that they may be in contact with universities in pursuit of referrals to the DBFs with which they are in frequent contact.

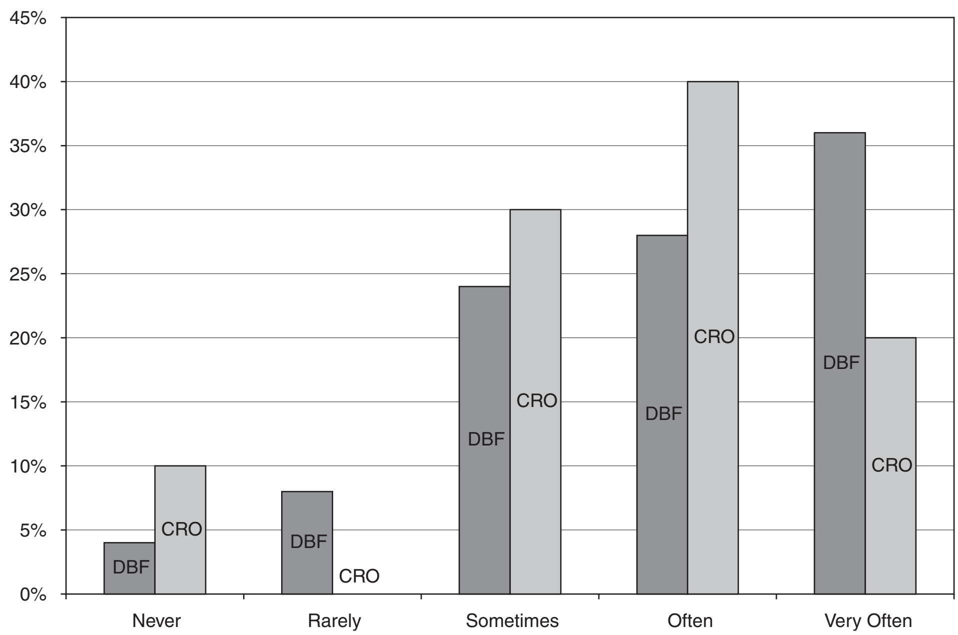

Figure 1: Contact with universities

Distribution of key actors in firms networks

Since the questions regarding the location of the key customers, suppliers and competitors were worded similarly, we can compare their distribution across both organisation types (Figure 2). The DBFs see themselves as operating in a global economy, with their key customers being located globally (64 per cent) and across North America (28 per cent) and none locally. Non-applicable replies (8 per cent) refer to firms that think of themselves as not (yet) having meaningful customers of any sort. The global and North American emphasis is mirrored in the distribution of their key suppliers (74 per cent combined) and competitors (92 per cent combined). In these two relationship types, there are a few reports of local key suppliers and key competitors. When considering that one of the key inputs to these firms is cash and talent, it may be that these firms are not referring to suppliers and (direct) competitors in the conventional sense, but suppliers and competitors in terms of a more general knowledge-based ecosystem. Many of these DBFs are research-intensive organisations that are still pursuing commercialisation of their first (and often only) IP asset. As such, they do not consume supplies, or yet have customers or direct competitors in the conventional sense.

When considering the same profiles for the CROs (Figure 2), we see a marked shift in the geographic distribution of these key payers. Across all three actor types, at least 30 per cent are reported to be local. The key customers are the most internationally distributed category, with 40 per cent located globally, 10 per cent located across North America, and an additional 20 per cent mixed across the two categories. While CROs foster a solid local foundation for their business, they recognise that there are only a limited number of customers in the area, and that customers located elsewhere need to be seriously considered and marketed to. The distribution of key suppliers for CROs is similar in that there is a strong contingent of locals (30 per cent), an additional 10 per cent

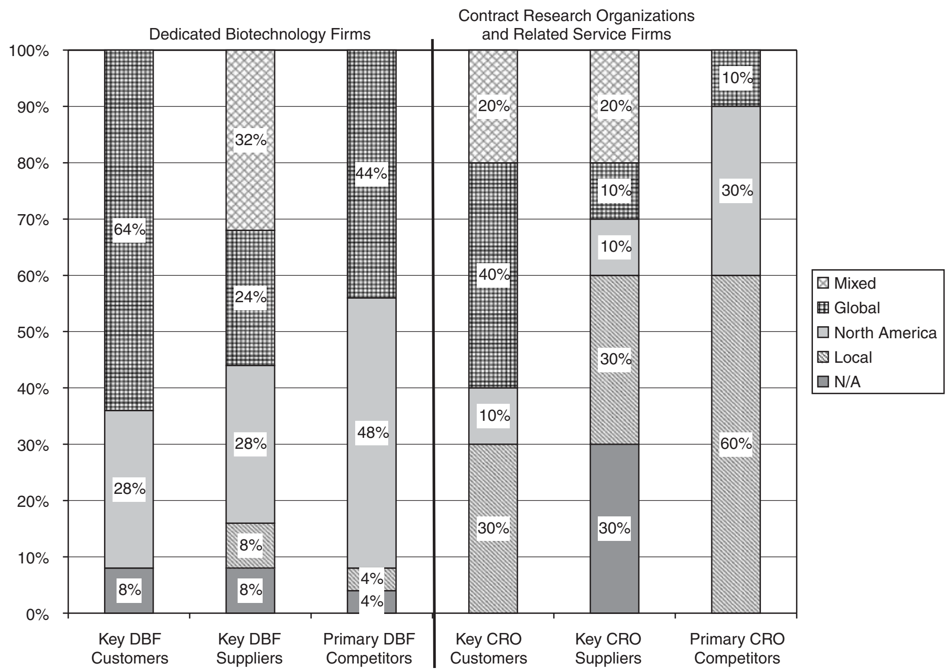

Figure 2: Distribution of key actors

located in North America, plus another 20 per cent mixed across North America and globally. The proportion of globally located key suppliers (10 per cent), however, is much less than globally located key customers, with 30 per cent of the CROs reporting that this category is not applicable to their business. In terms of the distribution of key competitors of CROs, they consider the majority of them (60 per cent) to be local, 30 per cent to be within North America and 10 per cent to be global. This emphasises that there is a local pool of talent, and customers (and perhaps capital) for which they directly compete in order to service their key customers around the globe.

Average embeddedness of firms

After creating and averaging the embeddedness values for each of the four relationship types (customer, supplier, competitor and supporter), we can look at the distribution of this average structural embeddedness measure across firm types (Figure 3). Agreement with prior structural embeddedness research[2,3,10,28–31] is implied, in that firms that are over- or under-embedded are under-represented because they are inefficient ways of structuring the network and lead to poorer performance and eventually the firm's death.

Within the DBF category, we see that they predominantly have medium embeddedness levels, some have low embeddedness levels and none are highly embedded with the network of firms in their environment. One might speculate that if they were to become highly embedded, then this process would be synonymous with becoming acquired by a pharmaceutical company, thus the non-existence of highly embedded DBFs as independent entities. CROs, on the other hand, show no indication of low embeddedness, and are split evenly across the medium and high structural embeddedness groups.

Of the DBFs and CROs that have medium levels of structural embeddedness, we can examine whether the data support the idea of 'local buzz and global pipelines'.[21] Of the firms with overall medium structural embeddedness levels, approximately

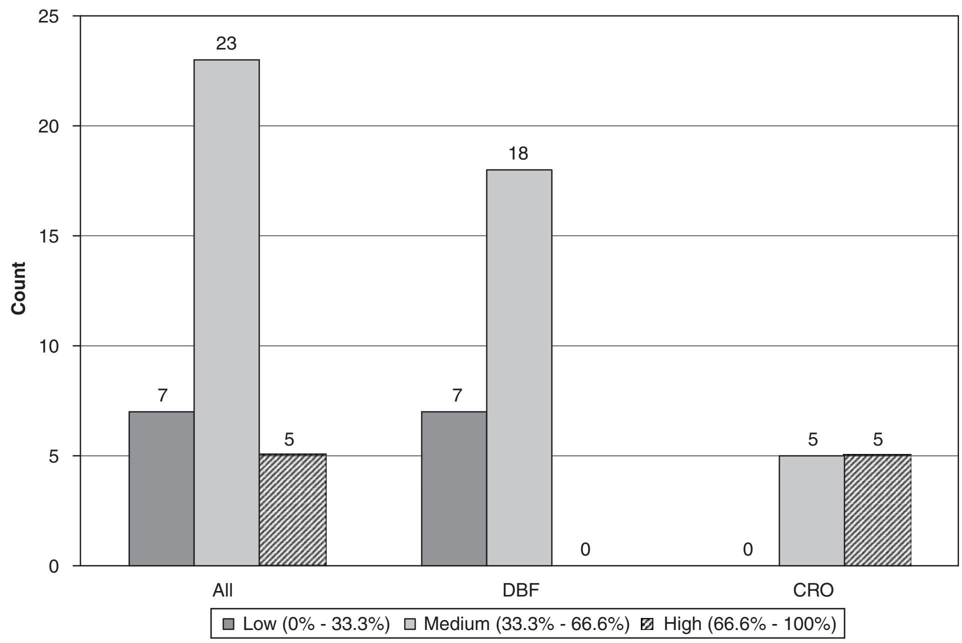

Figure 3: Average embeddedness by firm type

40 per cent of both the DBFs and CROs have high levels of embeddedness regarding support and competition, and have low levels of embeddedness regarding suppliers and customers. This can be interpreted as having local networks for monitoring purposes and global supply chains, thus demonstrating that LNGP are a viable and prevalent business model. The vast majority of the remaining medium embeddedness firms have medium levels of embeddedness in both their supply chain and monitoring network. Only one DBF has low levels of embeddedness regarding supporters and competitors, and high levels of embeddedness regarding customers and suppliers (ie GNLP). This firm was pre-revenue at the time and still figuring out their business and innovation models.

Structural embeddedness and DBF performance

Plotting the average embeddedness levels against CAGR for the DBFs for which CAGR data were available reveals a distribution of performance as suggested by prior structural embeddedness research (Figure 4).[3–6] Firms that are under- or over-embedded have marginal growth rates, while firms with medium levels of structural embeddedness show the greatest growth rates, positive or negative. Thus, while growth is enabled by not being under- or over-embedded, having medium levels of embeddedness still does not guarantee superior growth rates.

Overall, we did not find much support that firms strive to connect within the cluster they are located in, as proposed by Porter.[13] While there is some debate whether the biotechnology industry in Vancouver is a legitimate cluster[32], the DBFs tend to leverage only a select number of local resources (eg universities and professional service provides), while focusing on a global market for their IP. The inter-firm network structure of the CROs shows some support for arguments of

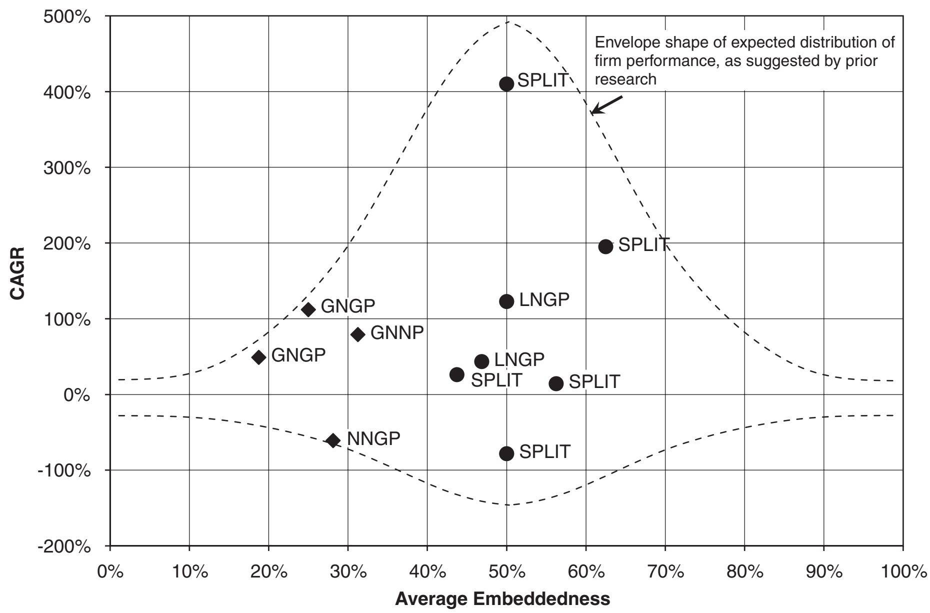

Figure 4: Average embeddedness versus CAGR (DBF only). Labels indicate the composition of the embeddedness level. SPLIT means all embeddedness levels are in the medium range. LNGP refers to a local network and global pipeline structure. The other labels are combinations of GN (global networks), NN (national or local networks), and GP (global pipelines) and NP (national or local pipelines). ◆ denote low embeddedness levels, while • denote medium levels of embeddedness

co-location and agglomeration economics, but they too acknowledge that commercial viability in today's economy depends on looking well beyond local opportunities and partners.

CONCLUSIONS

The geographic distribution of key actors in a firm's industry plays an important role in the development of the firm. Particularly for DBFs, the knowledge spillovers from the universities they were spun off from often play a supportive role. Ultimately, for DBFs and CROs, their relationships to other organisations matter, and are facilitated through close proximity. No firm is truly independent, and no firm can survive if it is overly constrained by demanding network relationships. Survival and growth of DBFs and CROs firms depend on finding an appropriate structure of relationships to their key suppliers, customers, supporters and competitors.

The appropriate structure of relationships for biotechnology firms depends on their business model. Technology-based businesses such as DBFs tend to have a more global perspective and are more agnostic regarding the geographic location of the actors they relate to. Labour-based businesses such as CROs tend to acknowledge the global nature of business, but maintain focus on close relations with local customers, and keep a close eye on local competitors.

From the geographic distribution of key actors, we can infer the degree to which the firms are structurally embedded with other organisations in their environment. Of the DBFs providing performance data, the structural embeddedness showed a relationship to firm performance consistent with prior research. Firms that operated too much in isolation demonstrated more modest growth or quietly burned through their resources. In comparison, firms with a medium level of structural embeddedness demonstrated greater variance in performance. Their network structure appears to catalyse their performance. Some medium embeddedness firms excelled with their configuration of network relationships, while others perished. While no highly embedded DBFs were found in this study, structural embeddedness theory tells us that being too constrained may be detrimental to growth, and that they may be captive to the agenda of the actors in their network. Ultimately, medium embeddedness does not guarantee greater performance, but can enable it.

Acknowledgments

We extend our greatest appreciation to the members of the ISRN who have provided input about innovation systems, cluster theory and access to their data. In particular, we thank Dr Adam Holbrook, Dr Richard Smith and Monica Salazar, without whom this study would never have been possible. Many thanks also to members of the Simon Fraser University Faculty of Business Administration, who attended research seminars and provided exceptionally constructive critique. Thanks also to participants of presentations at the MIT Technology and Policy Program, West Coast Research Symposium and Administrative Sciences Association of Canada, who provided valuable feedback on earlier versions of this study.

References

1. Zukin, S. & DiMaggio, P. (1990). *Structures of Capital: The Social Organization of the Economy*, Cambridge University Press, New York.
2. Granovetter, M. (1973). The strength of weak ties. *Am. J. Sociol.* **78**(6), 1360–1380.
3. Uzzi, B. (1997). Social structure and competition in interfirm networks: the paradox of embeddedness. *Admin. Sci. Quart.* **42**(1), 35–67.
4. Uzzi, B. (1999). Embeddedness in the making of financial capital: how social relations and networks benefit firms seeking financing. *Am. Sociol. Rev.* **64**(4), 481–505.
5. Yli-Renko, H. & Autio, E. (1998). The network embeddedness of new, technology-based firms: developing a systemic evolution model. *Small Bus. Econ.* **11**(3), 253–267.
6. Yli-Renko, H., Autio, E. & Sapienza, H. J. (2001). Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. *Strategic Manage. J.* **22**(6–7), 587–613.
7. Gargiulo, M. & Benassi, M. (2000). Trapped in your own net? Network cohesion structural holes, and the adaptation of social capital. *Org. Sci.* **11**(2), 183–196.

8. Owen-Smith, J. & Powell, W. W. (2004). Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community. *Org. Sci.* **15**(1), 5–21.
9. Podolny, J. M. (2001). Networks as the pipes and prisms of the market. *Am. J. Sociol.* **107**(1), 33–60.
10. Baum, J. A. C., Calabrese, T. & Silverman, B. S. (2000). Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. *Strategic Manage. J.* **21**(3), 267–294.
11. Powell, W. W., Koput, K. W. & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. *Admin. Sci. Quart.* **41**(1), 116–145.
12. Porter, M. E. (1998). Clusters and the new economics of competition. *Harvard Bus. Rev.* **76**(6), 77–90.
13. Porter, M. E. (2000). Location, competition, and economic development: local clusters in a global economy. *Econ. Dev. Quart.* **14**(1), 15–34.
14. Audretsch, D. B. (2003). Managing knowledge spillovers: the role of geographic proximity. *Geogr. Strat.* **20**, 23–48.
15. Zucker, L. G., Darby, M. R. & Armstrong, J. S. (2002). Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. *Manage. Sci.* **48**(1), 138–153.
16. Al-Laham, A. & Souitaris, V. (2007). Network embeddedness and new-venture internationalization: Analyzing international linkages in the German biotech industry. *J. Bus. Venturing*, doi:10.1016/j.jbusvent.2007.09.001.
17. Maskell, P. (2001). Towards a knowledge-based theory of the geographical cluster. *Ind. Corp. Change* **10**(4), 921–943.
18. Holbrook, J. A., Salazar, M., Crowden, N., Reibling, S., Warfield, K. & Weiner, N. (2004). The biotechnology cluster in Vancouver, in Wolfe, D., Lucas, M. (eds.), *Clusters in a Cold Climate*, McGill-Queen's University Press, Kingston.
19. Niosi, J. (2003). Alliances are not enough explaining rapid growth in biotechnology firms. *Res. Pol.* **32**(5), 737–750.
20. Stuart, T. E. & Sorenson, O. (2003). The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms. *Res. Pol.* **32**(2), 229–253.
21. Bathelt, H., Malmberg, A. & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Prog. Hum Geogr.* **28**(1), 31–56.
22. Wolfe, D., Davis, C. & Lucas, M. (2005). Global networks and local linkages: an introduction, in Wolfe, D. (ed.), *Global Networks and Local Linkages: The Paradox of Cluster Development in an Open Economy*, McGill-Queen's University Press, Georgetown, ON.
23. Boschma, R. (2005). Proximity and innovation: a critical assessment. *Reg. Stud.: J. Reg. Stud. Assoc.* **39**(1), 61–74.
24. Marshall, A. (1930). *Principles of Economics: An Introductory Volume*, 8th edn. MacMillan, London, [c1920].
25. Feldman, M. P. (1999). The new economics of innovation, spillovers and agglomeration: a review of empirical studies. *Econ. Innov. New Technol.* **8**(1), 5–25.
26. DiMasi, J. A., Hansen, R. W. & Grabowski, H. G. (2003). The price of innovation: new estimates of drug development costs. *J. Health Econ.* **22**(2), 151–185.
27. Keroack, M., Ouimet, M. & Landry, R. (2004). Networking and innovation in the Quebec optics/photonics cluster, in Wolfe, D., Lucas, M. (eds.), *Clusters in a Cold Climate*, McGill-Queen's University Press, Kingston.
28. Gnyawali, D. R. & Madhavan, R. (2001). Cooperative networks and competitive dynamics: a structural embeddedness perspective. *Acad. Manage. Rev.* **26**(3), 431–445.
29. Moran, P. (2005). Structural vs. relational embeddedness: social capital and managerial performance. *Strategic Manage. J.* **26**(12), 1129–1151.
30. Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: the network effect. *Am. Sociol. Rev.* **61**(4), 674–698.
31. Granovetter, M. (1983). The strength of weak ties: a network theory revisited. *Sociol. Theor.* **1**, 201–233.
32. Salazar, M., Bliemel, M. & Holbrook, D. (2008). A comparison of R&D indicators for the Vancouver biotechnology cluster. *J. Commer. Biotechnol.* **14**(3), 233–246.