Networking in the life science sector: The missing link in British Columbia

Sarah Giest
Department of Political Science
Simon Fraser University
8888 University Drive, Vancouver (BC)
sgiest@sfu.ca

Prepared for BC Political Science Association Conference, May 2-3, 2013, Vancouver

Abstract

Several studies have identified that the Vancouver life science network faces a variety of challenges. Holbrook et al. (2003) pointed towards the little horizontal and vertical integration of the cluster and the difficulty of finding and retaining qualified personnel, due to competition from the US and Eastern Canada. Gertler and Quach (2005) emphasize Vancouver's dependency on a leading firm, QLT Inc., which has declined in recent years. And Wixted and Holbrook (2011) conclude that Vancouver's location will be a barrier to its development and the fact that governments, both local and national should step in. The paper identifies a management mechanism as a possible solution to most of these challenges based on European and Asian experiences in the biotechnology field. In these cases, network leadership has proven to create higher levels of collaborative and absorptive capacity – the ability to built fruitful relationships among stakeholders and gain new knowledge through those and outside links. Based on this framework, the paper analyses, which elements are missing in Vancouver and how a network manager could solve or offset some of these issues the life science field is facing.

Key words: network, network management, cluster, biotechnology, innovation, collaborative capacity, absorptive capacity

Introduction

Clusters have generally proven to be a source of better economic performance, as they are seen as local concentrations of knowledge providers from which various kinds of knowledge spillovers and knowledge links emanate for the region or nation – spreading the embrace of cluster policy (Cooke et al. 2007). Clusters are defined as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions' (Porter 1998, 78). The more common use of the cluster framework by

politicians and researchers stems from the expectation that such spatial concentration leads to higher levels of productivity, innovation and employment. Canada's federal government has been significantly influenced by the cluster model since it commissioned a study of the country's economy in the early 1990s. Subsequently, federal policy introduced several measures to improve competitiveness in Canada, including policies to promote economic clusters. Further, regional governments appreciate the fact that they control many of the policy mechanisms that promote cluster development (Smith, McCarthy and Petrusevich 2004).

The goal of the paper is to introduce a new mechanism for cluster development, which is based on evidence from case studies in Europe and Asia. Cluster or network management can help build network relationships among stakeholders from academia, industry and government and thereby enhance the levels of collaborative and absorptive capacity. Those two concepts in connection with network leadership identify the elements that make networking successful. Collaborative capacity looks at the purpose, communication, structure and resources a cluster has (Lai 2011) while absorptive capacity focuses on its ability to integrate and exploit knowledge from within and outside of the cluster (Bell & Albu 1999; Giuliani 2005).

The paper hypothesizes that many of those elements are missing in Vancouver, leading to a weak network. This mechanism of leadership might be able to address some of the challenges the life science industry is currently facing. Those challenges have been widely discussed in earlier studies and were mostly confirmed by the interviews conducted for this paper. The two key element that hold the small life science community in Vancouver together are the connection to the University of British Columbia and until a couple of years ago, the inspiration by QLT Inc. (Holbrook 2006). QLT pioneered BC's biotech industry and became an incubator and lead firm in the cluster before it faded due to a lack of funding. Today, the community mainly consists of a small number of firms and scientists working in the human healthcare sector. The stakeholders are somewhat connected, but the overall network lacks horizontal and vertical integration to the point that some interviewees were not sure if they should even call Vancouver's life science community a cluster.

In the following analysis, based on theoretical approaches and two case studies, the paper will pinpoint the strengths and weaknesses of the Vancouver network using the collaborative and absorptive capacity framework and show the benefits of a cluster management structure for Vancouver specifically and clusters in general.

Conceptualization

A closer look at government's efforts in supporting clusters shows that in many cases the attempt to create or support a cluster results in failure. An example for this is New Jersey's attempt to create a Silicon Valley high-tech sector, which eventually led to a limited research consortium (Leslie & Kargon 1997; Feldman & Francis 2004). There are also examples of success such as the Biotechnology clusters in Boston or San Diego. Those different experiences in cluster performance led researchers to the conclusion that there are unique factors associated with each success or failure. As Feldman and Francis (2004) put it, clusters have 'signature characteristics' (130) that lead them to develop certain infrastructure, industrial activity and the possibility of venture capital. Also, government initiatives treat each cluster as a unit, without thinking about inner networking dynamics or cooperation among stakeholders. This research challenges the uniqueness of success in clusters by hypothesizing that there is a generalizable strategy leading to higher levels of cluster performance.

The suggestion is to implement a core node in the network, called 'cluster facilitator', enhancing the levels of absorptive and collaborative capacities for a higher level of competitiveness. The facilitator can be an individual, a local association or knowledge institute (Gagné et al. 2010; Mesquita 2007). This role differs from the one of a leading firm or 'champion' in a cluster. Instead of having firm-related or personal gains through cooperation and attracting venture capitalists, the facilitator takes a neutral role or rather creates a 'neutral corner' for all participants of the cluster. Activities by stakeholders such as collaborative action, forming strategic alliances and sharing value/ supply chains benefit from this neutral corner (Cooke et al. 2007). The facilitator uses knowledge gained of the individual stakeholders within the cluster to support them in exploring development options. Throughout the development of a more mature cluster, the facilitator further motivates and empowers senior cluster stakeholders. This is followed by the development of a broader, long-term agenda and definition of short-term actions that will start moving the cluster in the direction of a 'vision' and defined goals. Once these elements are established, the facilitator can shift towards seeking opportunities to connect to other clusters and be more competitive beyond the regional or even national level (Ffowcs-Williams 2004). Research shows that "clusters usually have a critical need of some kind of leadership, but neither individual nor organizational actors wish to be led" (Sydow et al. 2011).

This dilemma can only be 'managed' or solved in a way a facilitator works – by addressing these issues non-hierarchical while enabling the cluster in terms of cooperation and moving forward.

Several studies have identified the characteristics and competencies cluster facilitators usually have or should have (Wardale 2008; Stoerring & Christensen 2008; Ingstrup & Damgaard 2010). Often only due to these personal traits and professional skills, the facilitator is able to carry out activities that lead to higher performance. Wardale (2008) defines five key facilitator characteristics as:

- Humility: the facilitator is approachable and not forcing own beliefs in the process;
- Flexibility: being open to changes and other approaches;
- Sincerity: being empathic and acting in accordance with own values;
- Professionalism: having predetermined knowledge of cluster dynamics and confidence to deal with them; and
- awareness of the dynamics arising from power, control and prestige.

Together, these traits emphasize the importance of neutrality and impartiality and a general experience or training of the facilitator in cluster management. This is also true for the favoured competencies, which include being able to establish and maintain positive client relationships, developing a participatory environment, stimulating group creativity and the production of effective results by guiding the group (Wardale 2008:51). Together these characteristics and competencies create trust in the facilitator work and also legitimate the facilitator's leadership role.

The collaborative and absorptive capacity frameworks enable the identification of activities by the facilitator that enhance growth and productivity within a cluster. These concepts are used to break down cluster capabilities into observable units, such as agreements, policy guidelines, virtual platforms, etc. which can then be analyzed separately and conjointly in terms of their efficiency and effectiveness. They also make the connection to overall growth as, even though such a relationship is a complex one to test, studies support the view that one or more of the above-mentioned dimensions of the absorptive or collaborative capacities of a cluster are related to its growth trajectory (Giuliani 2005; Giuliani 2003; Mytelka & Farinelli 2003; Cohen & Levinthal 1990, Baptista 1998; Mattews 2002).

Collaborative capacity entails purpose, communication, structure, and resources. All these elements are crucial for a network or cluster to connect multiple stakeholders (Lai 2011). Those elements are laid out in Table 1.

[Insert Table 1 here]

Absorptive capacity, compared to collaborative capacity, focuses on the ability of a firm, a cluster or country 'to integrate the existing and exploitable resources – technological opportunities – into the production chain, and the foresight to anticipate potential and relevant technological trajectories' (Narula 2004:6). To this, there are two dimensions: 1) the formation of linkages with extra-cluster sources of knowledge (i.e. extra-cluster knowledge base) and 2) the structural characteristics of the intra-cluster knowledge system (Bell & Albu 1999; Giuliani 2005) (See Table 2).

[Insert Table 2 here]

The original concept is based on firms that already have a certain knowledge base and therefore are able to find and absorb or learn certain information available, which is then used for technological development (Cohen & Levinthal 1990). Based on this, a broader concept for clusters entails two interrelated aspects: the formation of linkages with extra-cluster sources of knowledge and an intra-cluster knowledge system (Bell & Albu 1999; Giuliani 2005). The two dimensions of intra- and extra-cluster are closely related in the sense that extra-cluster knowledge needs to be transferred to intra-cluster firms by an entity with outside linkages that has the knowledge base to pick and distribute information. Overall, absorptive capacity describes the links within and outside the cluster for knowledge exchange and possible learning and evaluation processes.

European and Asian Experience

The analysis in the paper bases on three case studies in Vancouver (Canada), Medicon Valley (Denmark/ Sweden) and Singapore. Stakeholders were targeted according to the triple-helix structure, which consists of research institutions, government departments and companies (Etzkowitz 2003). The independent variable of cluster management is measured by the proxies of the absorptive and collaborative capacity frameworks. The concepts pose the common ground among cluster management in different sectors and circumstances. Also, they are used to break

down cluster capabilities into observable units, such as agreements, policy guidelines, virtual platforms, etc. which can then be analyzed separately and conjointly in terms of their efficiency and effectiveness.

The cases, to which Vancouver is compared to, were chosen based on the degree of government involvement and cluster management. In Singapore, government involvement in terms of funding and organizing the life science network is high. This is true for most Asian countries, as they are trying to fast-track the high-tech industry development in their countries. Medicon Valley, which is a life science cluster combining stakeholders from Denmark and Sweden, represents network management embedded in a multi-level government system. This case is similar to many European countries, as the EU currently trains and benchmarks cluster management – making this tool more visible in the European Union

Medicon Valley, Denmark/Sweden

The multi-level governance structure and policies affect the local process of industrial clustering in Denmark and Sweden. As the following section will show, the interviews conducted in the Medicon Valley with high-ranked officials from university, industry, government and the Medicon Valley Alliance reveal that different groups have different expectations of what the role of government should be and which policies best support the biotech cluster.

Overall, many obstacles and boosts of cluster competitiveness originate directly or indirectly from national policies: '1) national immigration and tax policy made Copenhagen less attractive to highly skilled foreign labour; 2) housing legislation has made it difficult to solve issues of housing affordability; 3) particular differences in national legislation of Sweden and Denmark have hindered the functional integration of the Øresund Region' (OECD 2009, 30). National government changes have also affected regional initiatives for clustering through a governmental reform in Denmark. Since the mid-1980s, local and regional governments have become more active in the economic development of Denmark. 'The net result was a conspicuous increase in the level of sub-national initiatives and from the early 1990s all regional and the majority of local government were engaged in activities aiming to stimulate indigenous economic activity, promote employment within their area, and secure a higher level of taxable income' (Halkier 2011, 332). Once the regional level established itself as a major player in

spatial economic policy, government aimed for a higher degree of coordination amongst actors on the sub-national level through permanent forums and joint Regional Development Plans, while the number of relevant actors grew significantly. Adding another level to European, national and regional governance of cluster development is the Medicon Valley Alliance (MVA). This organization is 'on the ground', connected to researchers, firms and also to government officials. It is the most important player for the Øresund Region to facilitate networking and partnerships (IRIS 2009). By supporting the networking activities as one cornerstone of the cluster development factors, it connects the multiple levels and facilitates the collaborative and absorptive capacities of the cluster.

MVA is funded by the three regions that belong to the Øresund partnership – Capital Region of Denmark, Region Zealand and on the Swedish side, Skåne – the universities, such as the Technical University of Denmark (DTU), Copenhagen and Lund University and most of the (small) biotech companies. This money accounts for about 50 percent of the MVA budget, while sponsorships and EU funding make up the other half. The constant struggle described by the Capital Region and MVA is that on the one hand it is difficult for MVA to continuously prove its value to individual companies or the universities as a lot of the work involves networking support, which can hardly be measured in exact numbers or output. On the other hand the Capital Region of Denmark aims to make MVA a self-sufficient organization in the sense that it relies on membership fees and sponsorships instead of government funding. The region points out that this is the only way that the idea of MVA can prove to be valuable to the cluster and it gives government the opportunity to evaluate.

Day-to-day activities by MVA include creating opportunities for Danes and Swedes to meet and partner up business- or research-wise. These meetings can take different forms; it could be scientists from the university giving a scientific talk about new developments in a certain sub-field of biotech with firms present or a form or informal meet-up for people to connect. Another important activity is lobbying politicians 'based on facts and through the media'. This implies assessments of the cluster developments and the publication of strategic visions. As one of the most important services, MVA describes the connecting of companies to a 'talent pool within Denmark and Sweden – for example at universities – but also outside through the ambassador

program[1]'. Another key task is the synchronization of plans within the cluster as 'it is so difficult to have all the different stakeholders, having the same agenda at the same time'.

In terms of strategic planning and maintaining the attractiveness of the cluster, MVA points out the following four things: First, they are targeting complex issues with an interdisciplinary approach. Thus, they are using the fact that there are so many universities involved that offer a wide range of research, which can be combined through networking activities. Second, similar to the first point, MVA tries to converge or 'bridge' different technologies for new innovative product by matching researchers and firms or firms and firms. The third activity with which MVA aims to gain a competitive advantage is 'clever networking' locally and globally. The fourth activity is what MVA calls 'smart specialization', where they focus on specific areas in which the cluster has an advantage and then specifically support this.

The example of Medicon Valley shows how dependent clusters are on favourable framework conditions created by all levels of government – from the European to the regional level. However, the importance of regional empowerment and increasing impact of regional initiatives and the cluster organization were also highlighted (Gualini 2004). This became apparent in the uptake of regional projects at the national level and the consultation of local stakeholders, such as MVA on innovation bottlenecks for national policy. Based on this, the role of MVA can be described as crosscutting the multiple levels, facilitating connections among them as well as integrating 'local buzz' and 'global pipelines' (Wolfe & Creutzberg 2003).

[1] The MVA Ambassador Program is a Medicon Valley Alliance initiative aiming to assist life science organizations in Medicon Valley in building international partnerships and business connections. This is done by posting Ambassadors in regions of relevance to the life science sector in Medicon Valley. Currently, MVA has ambassadors in Boston, Korea, on the West Coast in the US and there will be one posted to China soon. As one interviewee points out, 'because being posted, being there on a day-to-day basis, they connect, they create personal relations with venture capitalists'.

Singapore

Singapore has been ranked the most innovative country in Asia last year (2012). It was also ranked first for its innovation capabilities, due to a well-trained workforce, a robust research community and sophisticated financial markets. Globally, Singapore was placed just below the European nations of Switzerland and Sweden in the 2012 Global Innovation Index. However, while Singapore has done well in terms of innovation input, output results place the country 83rd globally. This means that Singapore has invested significantly to create the most conducive environment for innovation, but 'the output results of these efforts have come in below expectations' (Khuan 2012).

Starting out with the input initiatives, Singapore established a policy for creating high technology industrialization in the late 1970s. This led to closer relationships between private companies and government departments and generally to a heightened interest in improving productivity (Pugh 1986). This push for new technologies was connected to the decline in the manufacturing industry and the fact that Singapore lacks natural resources (Wan, Ong & Lee 2003). A big wave of investment followed in the 1990s, when several large companies including Schering-Plough and Novartis built manufacturing sites. In 2000, a more specific strategy was launched by government, targeting drug discovery and biotechnology. The goal was – and still is – to attract big (pharma) companies to the country. The government hopes that with big names and anchor companies, smaller firms will follow.

Further, as a visible commitment to the life science industry, Singapore built two state-of-the-art biomedical research parks. 'Biopolis' is home to public as well as corporate research laboratories. The technology center brings together over 2,000 scientists, researchers, technicians and administrators in one location (A*STAR 2009). The Genome Institute of Singapore and the Bioinformatics Institute were some of the first tenants to move into the high-rises called Centros, Matrix, Genome, Nanos, Proteos, Chromos or Helios. The second complex built to house research institutes is 'Fusionopolis'. Fusionopolis tenants focus primarily on engineering research. Together, Biopolis and Fusionopolis are strategically co-located at 'one-north'. Beyond these two hubs created by government, many firms also settled into the Science Park. It is located along Singapore's Technology corridor and in close proximity to research and tertiary institutions such as the National University of Singapore (NUS), the National University

Hospital (NUH) and one-north. The state-of-the-art facilities and the funding commitment by government also attracted star scientists to Singapore over the years. 'Alan Coleman, co-creater of Dolly (the cloned sheep) has relocated his research to Singapore. So have Sir David Cane, discoverer of the p53 cancer gene and Edison Lin, the former Director of the US National Institute' (Ali 2006). The well-known scientist Michael Hayden from Vancouver's University of British Columbia also opened a lab in Singapore.

The main driver of these developments in life sciences is government. Singapore has made investment, infrastructural and strategic commitments to the industry; hence the high-ranking position on the innovation input side. Key stakeholders are the Biomedical Science Group of Singapore's Economic Development Board (EDB), Bio*ONE Capital and the Agency for Science, Technology and Research (A*STAR). A*STAR, the former National Science & Technology Board, is a statuary board under the Ministry of Trade & Industry. It basically is a R&D funding body and a crucial R&D performer at the same time, due to the many research institutes under its lead. With the type of funding and the research focus, A*STAR guides the cluster and structures the relationships among stakeholders.

The Economic Development Board (EDB), as a government agency, is responsible for the outward visibility and connections of the cluster. Many of the interviewees emphasized that they met people from the EDB in other countries before and for some, this is where they were recruited. The EDB is represented in 12 key locations around the world to facilitate partnerships, including several locations in China, France, Germany, Sweden, UK or the US. This poses a communication and knowledge-exchange channel with other clusters, such as Boston or Medicon Valley and thus enhances absorptive capacity in terms of knowledge inflow. Bio*ONE capital is the corporate investment arm of the EDB and manages funds connected to life sciences. This puts investment decisions into the hands of experts in the field, instead of government officials.

In terms of collaborative and absorptive capacities, A*STAR plays the key role in facilitating networking among stakeholders inside and outside of the cluster. One aspect that stood out during the interviews concerning cooperation was the recent effect of the change in funding. For some of the research institutes, all the funding used to come directly from A*STAR in five-year chunks. Thus, when meeting performance targets and while being in contact with A*STAR, every five years, new and often more funding would be provided. Today, for institutes

such as the Singapore Immunology Network (SIgN), 75% of the funding is provided by A*STAR, while 25% has to be attracted through collaborative projects with other institutes or preferably industry. According to some stakeholders this also encouraged institutes to sell some of their equipment that existed in duplicates during the time when more funding was available. By sharing some of the machines in laboratories, more people are getting in touch with each other and find common ground to collaborate or exchange knowledge.

To specifically enhance cooperation among research and industry, A*STAR also created 'Exploit Technologies', a technology transfer institute under its leadership. Exploit Technologies is meant to be an industry-research interface, in which teams of technology transfer professionals harness new technologies, increase the value of intellectual property and incubate business ventures to create commercial impact. Building the mentioned hubs, Biopolis and Fusionopolis, also caters towards the vision of a collaborative ecosystem that is in close geographic proximity. In this sense, A*STAR clearly funds, structures and provides the strategic vision for the cluster. It is obvious, that all these activities are also predominantly geared towards the applied side of life sciences. According to stakeholders in the cluster, this has to do with the close relationships between A*STAR and the EDB and EDB's vision to build a track record of successful commercialization and the goal to leap frog to a higher spot in the global competition in terms of commercialization.

Related to absorptive capacity, as mentioned before, the EDB has locations around the world to connect to experts, industry and top researchers. Also, A*STAR or rather its research institutes have close relationships with departments in Boston and Stanford, which fosters knowledge exchange and they are also used as entrepreneurial incubators. In terms of tapping the knowledge and opportunities of other clusters, A*STAR identifies and funds 'home-grown' and outside talent to either come to Singapore or train in high-ranked institutes outside the country. In fact, the current scholarship program is geared towards Singaporeans that are willing to come back home after their education in another country is paid for. This reduces the risk of brain drain and increases the amount of human capital.

Overall, what we see on the input side of innovation in Singapore is that the framework and administrative structure is geared towards sector specialization (Kumar & Siddique 2007). Government spun the network strategically by setting out a plan and acted on it. The key is the partnership model between Singapore's lead agency, A*STAR and the public and private sector.

'This partnership links basic and applied research and cuts across traditionally separate disciplines, serving as an engine for economic growth' (Nature 2011). The government is aiming to continue down this path, securing an S$16.1 billion (US$12.9 billion) in research and development for 2011-2015, which represents a 20% increase over the previous five years (Nature 2011).

However, the set-up of innovation input initiatives masks some of the difficulties seen in commercialization. As mentioned earlier, the translation of the amount of funding into applications has been rather slow. During the interviews with officials from A*STAR, research institutes and industry, three issues stood out. First, the investments apply to a broad range of research, which means Singapore is currently 'betting on many horses', but has not found its niche or competitive advantage in the field yet. This makes it difficult to focus on one area and also for companies to identify where the industry is heading. However, this is bound to change, as A*STAR gave out S$70 million (US$56.6 million) to stem cell research alone – a big amount compared to the number of researchers working in the field. Several interviewees also identified stem cell research as an area where Singapore could become competitive.

Second, there is currently a discussion about the aggressive shift by A*STAR from funding basic research to pushing the applied side of life sciences. This has mainly to do with cutting 25% of the funding for some research institutes in favour of possible industry collaborations. One stakeholder pointed out that if he would have to find another 5% beyond A*STAR support, the institute would not survive. Singapore as a young cluster compared to other life science hubs, is still 'heavily driven by risk-averse academics and government-funded scientists' (Lee 2012). However, A*STAR knows that industry is only interested in coming to Singapore when a solid R&D base is established and a credible talent pool can be found.

The available talent pool is the third issue especially the applied institutes and companies are struggling with. According to some interviewees there seems to be a gap between junior and senior researchers or more generally speaking between routine work and the management positions. Leading positions, as I experienced myself when talking to directors, CEOs and Vice-Presidents, are often in the hands of foreigners, so-called 'expats'. They come in for a couple of years and then leave without having someone from Singapore to fill their position. Also, people often only stay with one company or research institute for some years, even if they are not leaving the country. Thus, retaining talent is a difficult endeavour and it seems that attracting it is

also becoming more difficult. Living expenses – especially housing – has gone up and firms are nowadays reluctant to cover those costs for their foreign employees. Also, an immigration discussion[2] has just recently erupted in Singapore about the number of immigrants in the country and the effect on the local population. It might be that Singapore starts losing some of its appeal and will have a human capital problem in the future.

Vancouver's collaborative and absorptive capacities

BC or rather the Vancouver Biotechnology network is facing similar challenges that can be attributed to the missing cluster management and the lack of absorptive and collaborative capacity following from that. The British Columbian cluster is 'dominated by firms in the healthcare sector, [and] is home to about 90 privately owned firms, as well as six clinical trial organizations, a handful of government facilities and a major research centre at the University of British Columbia' (Bogomolny et al. 2004). The BC government heavily invested into R&D with more than $1.6 billion in expenditures since 2001. The Canadian government is providing $60 million in funding for new centres of excellence in commercialization and research alone (Vancouver Economic Commission 2011). On top of that, BC committed to a Western Economic Partnership Agreement (WEPA) with the federal government, in which both governments contribute $25 million to WEPA over four years (2009-2013) to support long-term economic growth and competitiveness in BC. This includes strengthening knowledge-based businesses and technological innovation.

However, in this process, the network became very dependent on one firm, QLT Inc., which generated 87% of the cluster's revenue before it declined, without forming strong relationships among stakeholders or creating a management system for the network (Gertler & Quach 2005). Today, there is little horizontal integration and even less vertical integration (Holbrook et al. 2003). These obstacles to innovation are paired with the challenge of finding

[2] The city-state currently has a population of 5.3 million, and is now more densely populated than Hong Kong. Under a government white paper – which was approved in February 2013 despite widespread public anger – Singapore will aim to increase its population to 6.9 million people over the next 20 years by granting permanent residency to 30,000 people and allowing an inflow of some 25,000 new citizens every year. New social programmes, including marriage and parenthood initiatives, as well as infrastructure schemes, will accommodate the burgeoning population, with immigration calibrated to retain its current ethnic ratios. However, skyrocketing housing prices, overcrowding, long working hours, low birth rates and an ageing population – that the government terms Singapore's "silver tsunami" – are all major contributors to discontent. (Hodal 2013)

and retaining qualified employees, because there is 'substantial competition with US and Eastern Canada due to economic disadvantages in Vancouver – primarily high personal income taxes and housing costs – these are somewhat offset by the cultural and climatic conditions of the area' (Holbrook et al. 2003, 7). On top of that, Vancouver has become a hub for IP 'vendors' – this means that firms often do not manufacture or market a product, but rather sell intellectual property to larger multinational companies (Gertler & Quach 2005; Holbrook et al. 2003).
As the following analysis will show, these issues are directly related to the levels of absorptive and collaborative capacity and thus show the importance of implementing a cluster management structure. Collaborative capacity entails purpose, communication, structure, and resources. All these elements are crucial for a network or cluster to connect multiple stakeholders (Lai 2011).

Purpose

In the Vancouver biotechnology sector a purpose to network activity is missing, although it is something which is desired by stakeholders. Interviewees, mainly managers and directors from LifeSciences BC, Genome BC and Mitacs, all agreed upon the fact that currently there is no common goal or strategy for biotechnology in the province. They argued that this is due to several factors but mainly to the fact that the life sciences sector is split into smaller groups, none of which is big enough to actually drive the agenda of the industry.

From an industry perspective this problem was partly addressed in 1991 by the establishment of LifeSciences BC (former BC Biotech Alliance Society) – an industry-led and membership-driven organization committed to connect and represent industry members:

> We...represent the industry to key government decision-makers, aggressively promote the sector by showcasing BC's biotech sector nationally and internationally, and create networking and collaborative opportunities both within the community and with external groups key to the success of BC's biotech companies. (BCBiotech 2005:5)

In this sense, LifeSciences BC is a steward of industry partnerships. By unifying at least some of the biotech industry stakeholders, LifeSciences BC facilitates collaboration among them as well as devotes resources to managing the image of the collaborative (Ansell & Gash 2012). This also speaks to the element of structure and (industry) leadership as this union lowers transaction costs for single entities and also represents many different firms under one organization. However this

initiative has not yet been able to overcome sector fragmentation to such an extent as to develop an overall cluster vision capable of linking stakeholders in the cluster.

The key point here is that although there is some kind of unity, the industry – as emphasized in several interviews – needs a clear strategy to define the future path and goal of life sciences in BC. Due to the fact that Canada has a socialized healthcare system, for example, it is the government's responsibility to define healthcare and provincial governments might do so in new ways to open up markets for such products as digital developments or other innovative products and thus make it more attractive for firms to innovate or invest. As one industry representative put it: 'government should not fund life sciences. Government should come up with – and I keep coming back to this – this idea of some sort of industrial strategy that they are going to focus on.'

Communication

In order to create some sense of purpose and direction, industry, research and government need to agree on the direction of life sciences. But especially in the area of healthcare, industry and government interests often involve trade-offs: for example profit maximization versus risk minimization. To establish a common ground, communication is key in the network.

Communication in general and communication channels in particular ensure information transmission in a cluster and also put information in the context of solution-seeking (Lai 2011). This means that through information links, such as formal agreements or active communication, crucial information on the industry, the network, but also knowledge are exchanged.
The biotechnology sector in British Columbia has some of these informal linkages and communication mechanisms, but no formal structure for them. Both, LifeSciences BC and Genome BC have procedures in place to communicate within their organizations and also among each other. For example, each board has a member of the other organization present and involved in discussions. Further, Genome BC managers and directors highlighted the following cooperation mechanisms:

- sector consultations;
- taskforce networks; and
- connections developed by research project managers.

Sector consultations are industry-led taskforces, including champions and decision-makers, experts in the field, industry, government and academia that come together occasionally and identify what the research priorities and current challenges are for activities in areas such as genomics. Also, they emphasize possible areas in which genomics could address those challenges and make the network more competitive or sustainable. This involves a lot of dialogue, consultation and outlining what the situation is and what activities would be useful in the future.

The second communication mechanism, the taskforces, was – up to this point – a one-time initiative led by industry. They were formally set-up in 2006 and ran for about two years. They gave advice on how to design a research program and where investments should be made. Although these taskforces have not been formally active since then, the same individuals or same groups of end-users, industry and others are now directly involved in Genome BC projects either as co-funders, advisors or researchers. They provide materials or locations for the research. Those participants are often also the people that are called when a new project is launched in order to get ideas on how to collaborate and which stakeholders should be involved.

The third major communication mechanism within Genome BC is the existence of a network of research project managers (RPMs). They are crucial to the development and realization of research projects, because RPMs get to know their six to twelve projects very well and are able to communicate with key stakeholders within their field. RPMs also draw together a specific group of researchers for each project, which is able to exchange knowledge from the science to the social science side and back. Thus projects themselves and project managers are able to foster knowledge transfer not only within one specific group, but also beyond disciplinary boundaries. One example of this dynamic is a Genome BC water project where RPMs were able to add the right expertise to a starting scientific team, which got national recognition. In this role, RPMs can be seen as having a catalyst position in the network by going beyond the organizer or administrative role and engaging in the substantive content of negotiations with the goal of 'identifying and exploiting opportunities for productivity value' (Ansell & Gash 2012). It is a bridging work between different stakeholders and disciplines through communicating who has the right expertise and which people should connect to create a successful new research project.

Such sources of information and the right combination of high-skilled labour is one key to higher innovation performance, even on a small scale or in one sector (Dossou-Yovo &

Tremblay 2012). These elements of communicating and cooperating can be a good example for the whole network to formally set-up communication mechanisms on a more regular and formal note to further the performance of the cluster. Beyond the Genome BC elements, however industry associations, government departments and NGOs must also play a crucial role in the communication structure of the network. Industry associations usually include clients and customers of firms to get an idea of the market. Government departments have people inside the ministries that are from industry, and can communicate market needs to governmental stakeholders. NGOs pay more attention to the social perspective, but they are able to integrate the for-profit side, government and civil society on certain issues. This all can contribute to the enhancement of communication between different stakeholders on biotechnology topics. Currently, however, as some interviewees pointed out, there is a certain degree of inflexibility and also an unwillingness to make such an effort on the part of these network players.

In order to implement a communication structure its benefit and effectiveness has to be shared with stakeholders. The role of the provincial government in this area has been lacking, however, partly due to the funding scheme in BC. For example, Genome BC is funded by Genome Canada, which is again government-financed. This money comes with strings attached. As the later section on resources will show, the money is cut out for specific types of projects, which are decided by an independent board. There is no room for unusual areas of research, student- or internships or dedicated intra-organizational communications efforts. The low levels of communication also have to do with the underlying set-up of the network. Basically, the money is linked to a set structure of research project work and partnering, which makes the work less commercial in nature. It is currently very much focused on research, while commercialization and translation are less apparent.

The current focus of much activity on health also poses an obstacle – especially for the communication about biotechnology with government. As one interviewee put it: ‘particularly in life sciences, it is a political hot potato right now, no one wants to touch healthcare and yet we are going to have 60 percent of our expenditure going towards healthcare’. Government is focused on cost control, while industry and research is looking for innovative ways to move forward. As communication is running in opposite directions, a provincial industry strategy would help to create purpose and at the same time a common ground for communication.

The current communicative situation in BC needs a collaborative leader or intermediary organization to create transparency by circulating information to all stakeholders about goals and status-quo as well as establishing a framework in which devlopments and ideas can be communicated (Ansell & Gash 2012; Dossou-Yovo & Tremblay 2012). A cluster manager or facilitator can fill this role by communicating plans and goals to the network and also link individual stakeholders for them to share (tacit) knowledge. This connection to government and the communication between government officials and industry is so important, because public sector contributions to seed and venture capital are needed to risk-share in the early stages of a company's development and thereby enable many technology-based companies to grow to a viable size (Jenkins et al. 2011). The lack of communication is one component of the commercialization gap in BC – if research, industry and government do not exchange ideas and plans, no product can be developed in the long-run. It also highlights the fact that there is an underlying problem in the network structure that feeds into incoherent communication patterns and a lack of purpose.

Structure

The structure of a cluster describes formal or informal procedures of networking, such as an interagency planning document and the definition of clear roles through agreed and informed policy guidelines. This structure then 'allows flexibility and adaptability for collaborators to remain open in the midst of major changes, such as transformations of major goals or members' (Lai 2011:451).

In BC, it is a challenging time for coherent structural elements as many organizations and institutions in the life sciences have undergone changes concerning their mission. The current disorganized health focus is an obstacle, but also an opportunity for re-framing the network. Starting with the issues connected to health and the healthcare system, it is obvious that this sector includes a diverse set of actors, which may not appear in the networking structure, but might have a crucial role in bringing a product successfully to the market. Such firms or organizations are also not necessarily part of the LifeSciences BC umbrella, because they cannot afford the membership or simply do not want to participate. The difficulty of identifying all the important stakeholders is connected to forming informal and formal structures, defining a purpose and mapping out communication channels.

Another aspect that has to do with the relationships between healthcare and structure is the fact that in a socialized medicine system there is little incentive to create a working structure or rather improve the existing one. Government is unwilling to make significant changes, because healthcare is a politically charged topic with a pattern of costs and benefits to providers, consumers and funders which are difficult to alter. And from an industry perspective, it is inaccessible. BC has a provincial legislation that reinforces the Canadian Health Act which includes provisions forbidding extra billing for facilities or materials and a cap on what can be charged for services by doctors that opted out. Thus, the healthcare system is trapped in a series of segregated budget functions. LifeSciences BC sums up the problem the following way:

> The development of British Columbia's biopharmaceutical, medical device industry and all related academic and industrial institutions who feed the lifescience industry, are directly and negatively impacted by our present healthcare system, and in particular, by BC's Pharmacare policies[3]. We believe there is a better way forward – one that recognizes the interests and value of industry while advancing the public interest and delivering appropriate patient outcomes (LifeSciences BC 2007:4).

On the positive side, the healthcare system offers an existing infrastructure and network based on the single-payer system. A database of individuals for providers and firms in the sector is in place, which could potentially be extended with genomics components and other innovative aspects. This would also facilitate post-marketing and surveillance studies. Combining these obstacles and opportunities it seems that both industry and government could find a common path to pursue life sciences innovations in healthcare – this means that government being in charge of healthcare-related issues has to work with industry associations like LifeSciences BC for them to start pulling together the multitudes of smaller clusters that currently exist in the sector and make a coherent structure possible which would facilitate development of a unified purpose and its communication.

[3] The Ministry of Health Services has two main goals for the B.C. PharmaCare program: 1) cover drugs that support the health and well-being of British Columbians, and 2) make sure that the drugs PharmaCare covers are affordable and give the best value for money. To meet the first goal, PharmaCare covers a drug only if it has a proven record of safety and effectiveness. To meet the second goal, PharmaCare compares each drug to the drugs it already covers that treat the same condition. For example, if more than one drug provides the same health benefit, PharmaCare may cover only the drug(s) that offers the best value (B.C. Ministry of Health Services 2010).

Two elements that contribute to some prospects for a successful transition in the current informal structure of the BC biotech network are more accessible project funding and the role of Industry Technology Advisors (ITAs) in the IRAP program. The latter program is one cornerstone of the BC innovation policy and offers assistance to SMEs. It further provides advisory services through ITAs and funding support of high-risk R&D projects. IRAP provides support to non-profit and post-secondary institutions for the provision of technical and commercialization advice to SMEs. Thus it creates an informal structure for knowledge transfer, consultation and advice within networks. And although IRAP generally seems to be a successful program, it falls short in supporting BC on a larger scale. The main criticism is that it not only disappears between other programs due to its size, but its funds are also typically exhausted early in the fiscal year. Smaller firms complain about the excessively difficult first-time applications process and the length of time between application and decision (Jenkins et al. 2011). Beyond this government-led structuring, there has also been change in the BC R&D ecosystem. As one interviewee put it: 'there is a lot more acceptance of the fact that you can access other programs in terms of funding, to get work done in academics or vice versa.' Thus, programs are becoming less rigid in their definition of where the funding is coming from and who participates, which makes inter-agency cooperation easier and ultimately more successful.

Another interviewee pointed out, however, that at present some life sciences companies are reluctant to work with universities, due to Intellectual Property (IP) issues, the uncertainty of academic programs being able to support long-term large-scale projects and the pace of research. So in order to create some kind of structure that enables those linkages, those issues have to be addressed. This line of thought leads back to the importance of communication in both the development of a purpose and successful network re-structuring to achieve it, if each side does not articulate the issues, a structural framework can hardly be set up. The successful government component of IRAP also shows that there need to be agreed and informed policy guidelines not only regarding contents and goals of BC biotechnology, but also structural elements for communication and cooperation. Overcoming these problems, in turn, is related to the available resources of financial and knowledge regarding biotechnology work.

Resources

Resources not only include financial means, but also intellectual and human capital to develop and sustain collaborative efforts – predominantly knowledge, skills and money (Lai 2011). In a network, most stakeholders are in some form of interactive dependency, usually based on the exchange of these resources (Pennings 1981). These resources affect their ability to communicate and develop the structure and purposes required for successful cluster-based commercialization activities.

In the BC biotech network, stakeholders currently struggle with the way government provides some of the resources and also with the lack of opportunities to attract human capital. There is a variety of governmental support to the network, but not all of it is effective. Genome BC, for example, is a major investor focusing on furthering the tool of genomics for biotechnology. About 25 percent of the funding for Genome BC comes from the province and about 50 percent from the federal government. Thus, provincial investment is crucial to projects supported by Genome BC. This includes the ability to gather human resources for projects by bringing together the right stakeholders. This resource position is of course limited to the extent that genomics is a small part or tool of an increasingly broad spectrum of life sciences. And second, they are tied to government in leveraging provincial and federal funds, which makes cooperation with industry difficult. Especially government-funded programs are subject to restrictions, such as that money has to stay in BC and caps on how much one project can receive or specifications on program participants. The research-focus of most programs is also mostly not tailored towards industry needs. For government support that is not channeled through Genome BC or Genome Canada, stakeholders from the BC network highlighted the following programs:

- National Research Council Industrial Research Program (NRC IRAP);
- Natural Sciences and Engineering Research Council (NSERC);
- Centre for Drug Research and Development (CDRD);
- Institutional Programs Office;
- Technology Transfer Offices (TTOs).

Technology Transfer Offices are the primary point of contact for companies and other entities that wish to acquire technologies and make use of resources of the government-led

Communications Research Centre. For BC, technology transfer is an opportunity for small- and medium-sized enterprises to establish IP through CRC's laboratory infrastructure. Those offices also support successful cooperation between firms through intermediation (Brenner et al. 2011). The Institutional Programs Office provides administrative and strategic support to researchers pursing major federal, provincial and regional infrastructure awards. In BC these awards are offered by the BC Knowledge Development Fund (BCKDF) and regionally by Western Diversification Canada (WD). To the provincial research community, such as UBC, the office offers services, such as internal reviews of funding applications, post-award workshops, financial and strategic support. Overall BCKDF and WD provide infrastructure and financial support for pre-commercial things with academic institutions doing community-based events related to economic development. This is different to what the Industrial Research Assistance Program does, which funds individual small- and medium-sized enterprises. But IRAP does not necessarily link up to universities and rather focuses predominantly on the industry-side of the biotechnology network.

The CDRD is a national not-for-profit public-private organization headquartered in Vancouver, which provides drug development expertise and infrastructure to enable researchers from leading academic and health research institutions to advance promising, early-stage drug candidates. Genome BC works closely with CDRD due to their platform of drug discovery and antibody development for drugs.

The last government-driven element that was highlighted in the interviews is the National Sciences and Engineering Research Council (NSERC). The agency supports university students in their advanced studies, promotes and supports discovery research and facilitates innovation by encouraging Canadian companies to participate and invest in post-secondary research projects. Thus, NSERC uses federal money to support collaborations between industry and academia. This funding is at the national level though, so the amount that comes into BC is somewhat unpredictable. On top of that, there is the scientific research and experimental development tax credit, which is not sectorally targeted and supports business R&D spending of various kinds. From this selection of government programs it becomes clear that there is a complex mix of resources existing at the national, provincial and regional level. This is also one of the major criticisms within the BC cluster: 'There is...a need for coordination across the full suite of federal innovation programs – and ideally also between programs of the federal and provincial

government – to avoid excessive 'stacking' of incentives that may result in subsidies that are higher than needed to achieve policy objectives' (Jenkins et al. 2011:4-2). From the perspective of firms in BC, finding the right program and calculating potential support has become more and more difficult and some suggest that the development of an online platform on which all funding programs are listed or even a 'match-making' service for firm and funding would be a good solution.

As mentioned previously, attracting and retaining human capital is also an issues, as the personal income tax and some of the job offers are not competitive to the US or Eastern Canada (Wixted & Holbrook 2011).

The remaining question is how adaptive is the cluster to these changes and – not always favourable – circumstances? Does it have the tools to prevent the network from falling apart and connect inside and outside of the cluster? Some first steps have been made through the connection to Singapore, for example, and the following section will look further into the absorptive capability of the BC network.

Absorptive capability

In terms of outside connections and valuable links, Vancouver is at a disadvantage due to its geographic location. It has a large population, but limited development opportunities for an inland hinterland (O'Connor & Scott 1992). Vancouver is dependent on its transportation and communication links. At the same time, the city is a 'pivot point' between North America and Asia, 'unlike many other high-tech cluster areas in Canada and the US. Its major continental competition is in California, which has similar geographical attributes' (Wixted & Holbrook 2011, 21).

This means that in the immediate area, Vancouver is missing a critical mass of other networks to connect to, especially when they are located further south. This would make a strong connection to the Asian market even more important. However, as the Singapore case study has shown, they have been successful in employing scientists from North America and made themselves attractive for foreign researchers. Overall, the location could be a barrier to Vancouver's development beyond a certain size (Wixted & Holbrook 2011). In terms of absorptive capacity, this tells us that there is not much of an inter- or extra-cluster knowledge system, due to the weak links within the cluster and the low critical mass and distance from

mega-regions for outside ties. Again, a cluster facilitator could be this missing link between outside-acquired knowledge and making it useful within the cluster as well as cultivating relationships to other networks.

Using the concepts of collaborative and absorptive capacity the results presented here show that the BC cluster is lacking most of the key elements of successful cluster-based commercialization activity (see Table 3). But the analysis in Table 5 misses the finer nuances of the network dynamics that cannot be displayed in a simple 'yes' or 'no' scheme. Stakeholders generally are aware of the strengths and weaknesses of the cluster, but also are a bit disenchanted by the facts. As shown throughout the paper, the BC cluster has a strong research component and there are informal and ad hoc cooperation mechanisms and resources in place with a largely informal structure and little purpose or communicative activity.

[Insert Table 3 here]

Based on the importance of linkages to enhancing both absorptive and collaborative capacity, the idea is to think about a cluster manager or cluster facilitator that is able to steer developments without being involved or profit from the actual business being done. This idea has yielded much improved results in other networks, such as the one located in Denmark and Sweden and Singapore.

The suggestion is for industry and/or government to implement a core node in the network in BC, called a 'cluster facilitator', enhancing the levels of absorptive and collaborative capacities for a higher level of commercialization. The BC cluster would benefit from such as an approach in several ways. As the analysis of the interviews and the current cluster set-up has shown, the network lacks absorptive and collaborative capability, which are connected to potential management by a facilitator. Further studies will have to investigate the actual connection between facilitator and rising levels of capacity, but the expectation is that cluster facilitators enhance the competitiveness of a cluster through their characteristics and activities and in so doing improve its structure, purpose, communication and resource allocation, leading to improved commercialization.

Concluding Remarks

During the interviewees it became apparent that in the short-term, the issues the BC biotech cluster is facing and trying to work on are:

- adjusting to the changing healthcare sector;
- pushing for a provincial industry strategy;
- attracting/ luring companies through provincial initiatives; and
- connecting to other clusters.

Overall the cluster does not rank very high in traditional terms. Regarding the number of job the network has created for example, there is no point in ranking BC. Instead, firms mainly are IP 'vendors' for US investors. The 'competitive advantage is embedded in the systems of such relationships, determined not just by size and nodal composition of the network, but the value that businesses are able to derive from their collective links' (Raines 2003:193). This means the goal of the BC biotechnology cluster should be to maximise the value of networking possibilities. Given the limitations of private sector involvement cited above, this is closely linked to the policy approach taken by governments. For the provincial and federal government it is not enough anymore to just support the university and research structure in BC. They have to further target the behaviour and networking within and the performance of the whole cluster. BC is not alone in facing obstacles that lead to lower levels of collaborative and absorptive capacity, of course. Especially after the financial crisis, government and venture capital resources are scarce and qualified personnel tends to go where there is still investment left.

In sum, existing network linkages are not working within the cluster to promote commercialization and bringing new products to market expeditiously and efficiently. With collaborative and absorptive capacity being low, overall cluster performance suffers.

Enhancing coherence within the cluster in terms of purpose, communication and structure could go a long way in focusing life sciences research in BC. This is especially needed since in the long-term Vancouver will never have the critical mass of European or American cities that often cross sectoral or national boundaries for research and commercialization purposes. And research as well as most commercialization can be done anywhere in the world today. Especially health-related life science is mobile and moves to where the money or human capital is. This means the most important competitive advantage in all of this for BC is the quality of the

network itself and the better management of networking processes for furthering life sciences is critical in this province.

The evidence of the other case studies also points towards the value of a cluster management structure supported by government and all sectoral stakeholders involved. In the Medicon Valley cluster, the Medicon Valley Alliance was able to become a central node in the network while being supported by industry and the academic community. It also has strong ties to all levels of government – local, regional and national – to ensure dialogue about current and future plans of the cluster. MVA was also a key player in branding the cluster and developing a network strategy. These actions clearly supported collaboration and the visibility and connections of the cluster with other biotech hubs. Singapore, even though the cluster is mainly steered by the government agency A*STAR, was able to develop a cluster management structure, which is in the process of building and sustaining collaborative features.

Looking at Vancouver, conditions are increasingly difficult, due to a lack of vertical and horizontal integration. As the analysis showed in more detail, the cluster is currently missing a strategic vision combined with a dialogue on how to shape life sciences in Vancouver. The region is also not emphasizing its strong points to offset the missing critical mass, for example by pursuing stronger ties to Asia. Comparing these conditions to the other cases, it becomes clear that obviously geographic drawbacks will not be changed, but that a leadership might pull together some of the current groups, such as LifeSciences BC and get government involved in actively shaping a strategic vision for the industry. In many complex situations, as Folke et al. (2005) have argued, cooperation requires leadership, because it can provide key functions, such as ‘building trust, making sense, managing conflict, linking actors, initiating partnerships among actors groups, compiling and generating knowledge and mobilizing broad support for change’ (58). Once network leadership is established this set-up reduces transaction costs of collaboration and motivates stakeholders to invest in building relationships.

References

Agency for Science, Technology and Research (A*STAR). 2009. Biopolis. Available at: http://www.a-star.edu.sg/tabid/861/default.aspx (accessed: 2013/02/28).

Ali, Farhan. 2006. Life Sciences in Singapore. Journal of Young Investigators. Available at: http://legacy.jyi.org/SCC/Article.php?articleNum=98 (accessed: 2013/02/28).

Ansell, Chris and Alison Gash. (2012). Stewards, mediators and catalysts: Toward a model of collaborative leadership. The Innovation Journal: The Public Sector Innovation Journal 17 (2), article 7.

Baglieri, Daniela, Cinici, Maria C. and Vincent Mangematin. (2012). Rejuvanating clusters with 'sleeping anchors': The case of nanoclusters. Technovation 32, 245-256.

Baptista, R. (1998). Clusters, Innovation and Growth: A Survey of the Literature. In Swan, G.M.P., Prevezer, M. And Stout P. The Dynamics of Industrial Clustering: International Comparisons in Computing and Biotechnology. Oxford: Oxford University Press.

BC Biotech (now: LifeSciences BC). (2005). Annual Report 2004 – 2005. Available at: http://www.lifesciencesbc.ca/files/PDF/publications/BC_Biotech_AR_05.pdf (Accessed: 2012/03/20).

BC Ministry of Health Services. (2010). The Drug Review Process in B.C. – Overview. Available at: http://www.health.gov.bc.ca/pharmacare/outgoing/drugrevproc2.pdf (Accessed: 2012/05/23).

Bell, M. and Albu, M. (1999). Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries. World Development 27, 1715–34.

Brenner, Thomas, Cantner, Uwe, Fornahl, Dirk, Fromhold-Eisebith, Martha and Claudia Werker. (2011). Regional Innovation Systems, Clusters and Knowledge Networking. Papers in Regional Science 90 (2), 245-249.

Cohen, W.M. and Daniel A. Levinthal. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly 35, 128-152.

Cohen, W.M. and Daniel A. Levinthal. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly 35, 128-152.

Cooke, P., De Laurentis, C., Tödtling, F. And Michaela Trippl. (2007). Regional Knowledge Economies, Markets, Clusters and Innovation. Edward Elgar: Cheltenham, UK/ Northampton, MA.

Cooke, P., De Laurentis, C., Tödtling, F. And Michaela Trippl. (2007). Regional Knowledge Economies, Markets, Clusters and Innovation. Edward Elgar: Cheltenham, UK/ Northampton, MA.

Desjardins, Louise and Darren King. (2011). Expectations and Labour Market Outcomes of Doctoral Graduates from Canadian Universities. Tourism and Centre for Education Statistics Division. Available at: http://www.statcan.gc.ca/pub/81-595-m/81-595-m2011089-eng.pdf (Accessed: 2012/05/20).

Dosi, G., Llerena, P. and M.S. Labini. (2006). The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'. Research Policy 35, 1450-1464.

Dossou-Yovo and Diane-Gabrielle Tremblay. (2012). Public policy, intermediaries and innovation system performance: A comparative analysis of Quebec and Ontario. The Innovation Journal: The Public Sector Innovation Journal 17 (1), article 3.

Etzkowitz, H. 2003. Innovation in Innovation: The Triple Helix of University-Industry-Government Relations. Social Science Information 42, 293-337.

European Commission. (1995). Green Paper on Innovation. Brussels.

Feldman, M. P., and J. Francis. (2004). Homegrown Solutions: Fostering Cluster Formation. Economic Development Quarterly 18(2), 127-137.

Ffowcs-Williams, I. (2004). Cluster Development: Red Lights & Green Lights. Regional Science Association International, Australia and New Zealand Section. Available at: http://www.desertknowledge.com.au/dka/documents/IFW%20Cluster%20development%20red%20and%20green%20lights%200404.pdf (Accessed: 2011/09/10).

Fowlie, Jonathan. (2012). B.C. sets sights on 47,000 international students. Government earmarks $5 million for scholarships and internships over next four years. The Vancouver Sun May 27 2012. Available at: http://www.vancouversun.com/sets+sights+international+students/6687992/story.html (Accessed: 2012/05/28).

Gagné, M.,Townsend, S. H., Bourgeois, I. and R. E. Hart. (2010). Technology cluster evaluation and growth factors: literature review. Research Evaluation 19 (2), 82-90.

Gertler, Meric S. and Uyen Quach. 2005. Biomedical Innovation Systems: A Comparative Analysis of Six Canadian Regions. Munk Centre for International Studies, University of Toronto. Available at: http://tinyurl.com/chqv2kb (accessed 2013/04/01).

Giuliani, Elisa. (2005). Absorptive Capacity: Why do some clusters forge ahead and others lag behind? European Urban and Regional Studies 12 (3), 269-288.

Government of Canada. (2009). Mobilizing Science and Technology to Canada's Advantage, Progress report. Available at: http://www.ic.gc.ca/eic/site/ic1.nsf/vwapj/STProgressReport2009.pdf/$file/STProgressReport2009.pdf (Accessed: 2012/05/13).

Gualini, Enrico. 2004. Regionalization as 'Experimental Regionalism': The Rescaling of Territorial Policy-making in Germany. International Journal of Urban and Regional Research 28 (2), 329-352

Halkier, Henrik. 2010. Regional Policy in Transition – A Multi-level Governance Perspective on the Case of Denmark. European Planning Studies 9 (3), 323-338.

Holbrook, J. Adam, Salazar, M., Crowden, N., Reibling, S., Warfield, K. and N. Weiner. 2003. The biotechnology cluster in Vancouver. Centre for Policy Research on Science and Technology, Simon Fraser University, Vancouver. Available at: http://blogs.sfu.ca/departments/cprost/wp-content/uploads/2012/06/0306.pdf (accessed: 2013/04/06).

Holbrook, J. Adam. 2006. Quantifying the Vancouver Biotech Cluster. Centre for Policy Research on Science and Technology, Simon Fraser University, Vancouver. Available at: http://blogs.sfu.ca/departments/cprost/wp-content/uploads/2012/06/0409.pdf#page=25&zoom=auto,0,258 (accessed: 2013/04/05).

Hon, Dee. (2008). QLT Inc: A Place called Hope. BC Business, September 3, 2008. Available at: http://www.bcbusinessonline.ca/bcb/top-stories/2008/09/03/place-called-hope (Accessed: 2012/05/21).

Ingstrup, M. and Torben Damgaard (2010). Cluster Development through Public Sector Facilitation. Available at: http://www.uia.no/no/content/download/193664/3466398/file/Session9_Ingstrup%26Damsgaard.pdf (Accessed: 2011/09/12).

Jenkins, Tom, Dahlby, Bev, Gupta, Arvin, Leroux, Monique, Naylor, David and Nobina Robinson. (2011). Innovation Canada: A Call to Action. Available at: http://rd-review.ca/eic/site/033.nsf/vwapj/R-D_InnovationCanada_Final-eng.pdf/$FILE/R-D_InnovationCanada_Final-eng.pdf (Accessed: 2012/05/02).

Kaiser, R. (2003). Innovation Policy in a Multi-Level Governance System, The Changing Institutional Environment for the Establishment of Science-based Industries. In Edler, J., Kuhlmann, S. & Behrens, M. (Eds.), Changing Governance of Research and Technology Policy, The European Research Area. Cheltenham, Northampton: Edward Elgar Publishing, 290-311.

Khuan, Sim Ping. 2012. S'pore ranked most innovative country in Asia. Channel NewsAsia Singapore, 03 July 2012. Available at: http://www.channelnewsasia.com/stories/singaporebusinessnews/view/1211446/1/.html (accessed: 2013/02/28).

Lai, A.Y. (2011). Organizational Collaborative Capacities in Disaster Management: Evidence from the Taiwan Red Cross Organization. Asian Journal of Social Science 39, 446–468.

Lee, Bernard. 2012. Driving innovation in Singapore. The Straits Times, 3 March 2012. Available at: http://www2.smu.edu.sg/news_room/smu_in_the_news/2012/sources/ST_20120303_1.pdf (accessed: 2013/02/28).

LifeSciences BC. (2007). Submission to the British Columbia Conversation on Health, Open Letter from the Chair of Life Sciences British Columbia. Available at: http://www.lifesciencesbc.ca/files/PDF/LSBC_COH_Submission__Sept__27_2007_Final.pdf (Accessed: 2012/05/20).

Lonmo, Charlene and Chuck McNiven. (2007). Selected Results of the Biotechnology Use and Development Survey 2005. Working Paper, Science, Innovation and Electronic Information Division (SIEID), Ottawa. Available at: http://www.statcan.gc.ca/pub/88f0006x/88f0006x2007006-eng.pdf (Accessed: 2012/05/8).

Matthews, Judy. (2002).Clusters of innovative firms: absorptive capacity in larger networks? Australian and New Zealand Academy of Management Conference, La Trobe University Victoria.

Mesquita, L. F. (2007). Starting cover when the bickering never ends: rebuilding aggregate trust among clustered firms through trust facilitators. Academy of Management Review 32 (1), 72-91.

Mytelka, L. and Farinelli, F. (2003). From Local Clusters to Innovation Systems', in J.E. Cassiolato, H.M.M. Lastres and M.L. Maciel (eds). Systems of Innovation and Development. Evidence from Brazil. Cheltenham: Edward Elgar, pp. 249-72.

Narula, Rajneesh. (2004). Understanding Absorptive Capacities in an 'Innovation Systems' Context: Consequences for Economic and Employment Growth. Danish Research Unit for Industrial Dynamics (DRUID) Working Paper No. 04-02. Copenhagen Business School and University of Oslo.

Nature. 2011. Spotlight on Singapore. 16 November 2011, doi:10.1038/nj0362. Available at: http://www.nature.com/naturejobs/science/articles/10.1038/nj0362 (accessed: 2013/02/28).

Niosi, Jorge. (2000). Regional Systems of Innovation: Market Pull and Government Push. In: Holbrooke, Adam and David A. Wolfe. Knowledge, Clusters and Regional Innovation. School of Public Policy: Montreal, Quebec, p.39-59.

OECD. 2009. OECD Territorial Reviews - Copenhagen, Denmark. Available at: http://www.oecd.org/gov/oecdterritorialreviewscopenhagendenmark.htm (accessed: 2013/02/20).

Pennings, Johannes M. (1981). Strategically Interdependent Organizations. In: Paul Nystrom and William O. Starbuck (eds.). Handbook of Organization Design. New York: Oxford.

Porter, M. (1998). Clusters and the new economics of competition. Harvard Business Review 76, 77-91.

Provan, Keith G. And Patrick Kenis. (2007). Modes of Network Governance: Structure, Management, and Effectiveness. J-PART 18, 229-252.

Pugh, Cedric. 1986. Budget Innovation in Singapore. Asia Pacific Journal of Management 3 (3), 157-175.

Raines, Philip. (2003). Cluster behaviour and economic development: new challenges in policy evaluation. Int. J. Technology Management 26 (2/3/4), 191-204.

Rosa, Julio and Antoine Rose. (2007). Report on Interviews on the Commercialization of Innovation. Working Paper, Science, Innovation and Electronic Information Division (SIEID), Ottawa. Available at: http://publications.gc.ca/collections/collection_2007/statcan/88F0006X/88F0006XIE2007004.pdf (Accessed: 2012/05/12).

Smith, R., J. McCarthy, and M. Petrusevich (2004) Cluster or Whirlwind? The New Media Industry in Vancouver, in Wolfe, D. and Lucas, M. (Eds.), Clusters in a Cold Climate: Innovation Dynamics in a Diverse Economy. Montreal and Kingston: McGill-Queen's University Press, pp. 195-221.

Stoerring D, Christensen J L .2008. Clusterpreneurs – Promoting High-Tech Clusters in Low-Tech Regions. Working Paper No 12, Department of Business Studies, Aalborg University.

Sydow, J., Lerch, F., Huxham, C. and Paul Hibbert. (2011). A silent cry for leadership: Organizing for leading (in) clusters. The Leadership Quarterly 22, 328-343.

Uhrbach, Mark. (2009). Innovation in the Canadian Manufacturing Sector: Results from the Survey of Innovation 2005. Working Paper, Science, Innovation and Electronic Information Division (SIEID), Ottawa. Available at: http://publications.gc.ca/collections/collection_2009/statcan/88F0006X/88f0006x2009002-eng.pdf (Accessed: 2012/05/3).

Vancouver Economic Commission. (2012). Life Sciences. Available at: http://www.vancouvereconomic.com/page/life-sciences (Accessed: 2012/03/22).

Wardale, Dorothy. 2008. A Proposed Model for Effective Facilitation. Group Facilitation: A Research and Applications Journal, Number 9, 2008.

Wolfe, David A. and Tijs Creutzberg. 2003. Community Participation and Multilevel Governance in Economic Development Policy. Paper prepared for the Panel on the Role of Government Toronto, August 2003.

World Economic Forum. (2012). The Global Competitiveness Report 2011–2012. Available at: http://www3.weforum.org/docs/WEF_GCR_Report_2011-12.pdf (Accessed: 2012/01/28).

Tables and Figures

Table 1. Collaborative Capacity Framework (based on Lai 2011).

Collaborative Capacity Framework	**Basic elements**	***Collaborative activities***
Purpose	Leadership	*Identification of leadership role*
	Shared Vision	*Mission statement/agreement*
	Network membership	*Connection to a broader functional network*
Structure	Formal and Informal Procedures	*Memorandum/interagency planning document*
	Clear Roles	*Agreed and informed policy guidelines*
Communication	Information Links	*Formal agreements/ personal connections*
	Active Communication	*Communication technology, e.g. boundary-free information platform*
Resources	Knowledge and Skills	*Knowledge-based modes using techniques such as pre-planning, role plays, on-job training, drills and exercises, and simulation for collaborating managers*
	Financing Powers	*Collective financial pool*

Table 2. Absorptive Capacity Framework (based on Giuliani 2005).

Absorptive Capacity Framework	**Basic elements**	***Absorptive activities***
Intra-cluster knowledge system	Knowledge spillovers	*Stakeholders links*
	Social relations	*Collective learning processes*
Extra-cluster knowledge system	Extra-cluster knowledge sources	*Linkages to those sources*
	Interface between the external linkages and the intra-cluster knowledge system	*Acquiring new knowledge from extra-cluster sources and transferring knowledge to intra-cluster firms*

Table 3. Collaborative and absorptive capacity in the BC cluster

Collaborative Capacity Framework	**Basic elements**	**Collaborative activities**	**Yes**	**In Progress**	**No**
Purpose	Leadership	*Identification of leadership role*			x
	Shared Vision	*Mission statement/agreement*			x
	Network membership	*Connection to a broader functional network*			x
Structure	Formal and Informal Procedures	*Memorandum/interagency planning document*	x		
	Clear Roles	*Agreed and informed policy guidelines*			x
Communication	Information Links	*Formal agreements/ personal connections*	x		
	Active Communication	*Communication technology, e.g. boundary-free information platform*			x
Resources	Knowledge and Skills	*Knowledge-based modes using techniques such as pre-planning, role plays, on-job training, drills and exercises, and simulation for collaborating managers*			x
	Financing Powers	*Collective financial pool*			x

Absorptive Capacity Framework	Basic elements	Absorptive activities	Yes	In Progress	No
Intra-cluster knowledge system	Knowledge spillovers	*Stakeholders links*	x		
	Social relations	*Collective learning processes*		x	
Extra-cluster knowledge system	Extra-cluster knowledge sources	*Linkages to those sources*		x	
	Interface between the external linkages and the intra-cluster knowledge system	*Acquiring new knowledge from extra-cluster sources and transferring knowledge to intra-cluster firms*		x	