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Technology cluster evaluation and growth factors: literature review

Marc Gagné, Shannon H Townsend, Isabelle Bourgeois and Rebecca E Hart

The pace of evolution of a technology cluster is determined by a variety of endogenous and exogenous factors related to its local and global environment. Extensively studied over the years, the factors that influence the growth of technology-based clusters can provide valuable indications about the capacity of clusters to achieve their objectives, attract new firms and become internationally competitive. Following an extensive literature review, the most prevalent factors that influence technology-based cluster growth were identified. These factors are those that must normally be present in order for a cluster to exist and to progress over time. This article outlines the method used to identify 12 recurring growth factors and discusses the use of these in the evaluation of technology-based clusters.

THE GROWTH OF technology clusters in industrialized nations has long been considered a key component of regional economic development. Technology clusters, typically understood as regional agglomerations of industrial firms and their service providers, have been characterized using numerous concepts. For example, early in the 20th century, Alfred Marshall was first to notice the geographical agglomeration of companies operating in the same industry. He attributed the phenomenon to the accumulation of knowledge in the area, the formation of a specialized labour pool, as well as to the attraction of support and supplier industries. He coined the term 'industrial district' to refer to such geographical concentrations of firms and related industries (Marshall, 1920).

A similar concept was introduced in France in the 1970s in reference to geographical agglomerations of industry that are formed through the activities of one or a few large companies. These companies may be large system integrators that attract suppliers of parts and components, or producers of essential inputs. The concept, named 'growth poles', was widely adopted in Western Europe where governments tried to build automobile, chemical or aerospace poles by attracting — often by subsidizing — large corporations to specific regions. In such poles, firms were linked together by the regional trade of parts, materials and components.

In the 1990s, an interest in the geographic component of industry was revived. Nobel Prize recipient Paul Krugman wrote that 'the geographic concentration of production is clear evidence of the pervasive influence of some kind of increasing returns' (Krugman, 1991: 5). Under such conditions, regions may be interested in implementing policies that nurture the development and growth of specific industries in pre-determined locations. Krugman's analysis provided theoretical justification for regional science, technology and innovation policies.

Since the 1990s, a considerable amount of research has been conducted on the development of technology clusters as well as the factors that increase the likelihood that these will be successful in fostering economic growth. Commonalities can be identified in research reports, which point to a narrowing of the knowledge base in this area. The present study sought to identify the factors most commonly thought to influence cluster growth in industrialized nations. The 12 factors identified through a literature review, and summarized here, provide a useful starting point for the analysis and

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comparison of cluster growth in different jurisdictions. These factors were derived and used as part of the Portfolio Evaluation of the National Research Council (NRC) Technology Cluster Initiatives in Canada, which took place in 2009. The article will first detail the methodology used to conduct the literature review, present the 12 factors identified in the documentation, and discuss possible implications for cluster-related policy, measurement and research.

Methodology

The evaluation of the NRC Technology Cluster Initiatives undertaken in 2008 and 2009 focused primarily on the assessment of the early impacts of 11 publicly funded cluster initiatives on the local economy and the development of regional clusters. Evaluators established early in the process that a review of the literature with respect to common cluster success and growth factors would be needed as part of the evaluation methodology. It was felt that such a review would allow evaluators to ground the study by determining criteria against which the growth potential of clusters could be assessed. As a result, academic literature, program evaluation material and policy documents were identified, reviewed and analyzed in order to identify the most common factors associated with cluster growth.

Identification of current and relevant documents

The identification of the most current and relevant documents was done by searching various databases and other information sources available via NRC's Canada Institute for Scientific and Technical Information.

A broad search of current social science databases, such as Digital Dissertations, Management and Organization Studies, Education and the Education Resources Information Center, was also conducted. Web searches using Google and Google Scholar were also undertaken to ensure full coverage of grey literature. Some of the key search terms used when reviewing databases and performing web searches included: cluster success; factor; characteristic; determinant; criteria; condition; performance; and growth.

Key documents related to cluster literature identified in previous evaluations undertaken by NRC on its cluster initiatives were also reviewed. Some included *The Cluster Greenbook* (Sölvell *et al*, 2003); *The Cluster Redbook* (Sölvell, 2008); *A Practical Guide to Cluster Development* (DTI, 2004), and *Clusters of Innovation: Regional Foundations of U.S. Competitiveness* (Porter, 2001).

Overall, the review process resulted in the identification of approximately 40 documents published between 1998 and 2008. Following a brief review of document abstracts, tables of content, and paper content, the most relevant 25 documents were retained. These documents were selected according to the quality of the information available and their direct links with the object of analysis (i.e. factors that influence the growth of technology clusters). Particular attention was paid to documents featuring science- or technology-based clusters given that the NRC is exclusively involved in such clusters.

The documents retained for analysis were categorized into two groups, namely scientific papers studying cluster growth factors and policy instruments targeting policy-makers and cluster managers. In both categories, case studies and narrative descriptions of successful and unsuccessful clustering experiences were the main methods used to generate findings. Although scientific rigour varied from one document to another, it was determined that the narrated experience of policy-makers and cluster managers could provide an interesting view of the factors that influence the growth of clusters. It was determined that, in order to be included in the final framework, each growth factor had to be supported by both scientific data and the experience of cluster managers or policy-makers. Therefore, the use of both sources of information (i.e. scientific papers and policy documents) was deemed to provide a sufficient level of confidence in the findings that were generated as a result of the literature review.

Document review process and results

An analytical grid was used to capture key data on the cluster growth factors identified in the literature. The information captured as a result of this systematic review process enabled the evaluation team to produce an exhaustive list and a comprehensive description of each factor. Although the document review resulted in the identification of a significant number of factors, only those most frequently cited as well as those deemed to have a critical influence on the growth of clusters were considered. In total, 12 factors were retained. These factors are those, according to the literature, that must normally be present for a cluster to exist and to progress over time.

In order to improve the validity of the results of the literature review, the list of factors retained was compared with the results of another literature review that was conducted by the United Kingdom's Department of Trade and Industry (DTI) in 2004. Although the DTI study used a different methodology (i.e. it counted the percentage of articles mentioning a series of '*success criteria*'), similar results were obtained by both studies. More specifically, it appears that of the 16 factors identified by the DTI study, nine were similar to the 12 factors identified in this study. Moreover, the five factors that were found by the DTI study to be the most frequently cited in the literature were also identified as critical factors in the present work, further validating the results of the work conducted by NRC.

It is relevant to keep in mind that the literature review was undertaken within the context of an evaluation of technology cluster initiatives, and that NRC's program activities were designed to support the development of some of these factors. Thus, each factor was linked to an appropriate core evaluation issue or question. In this manner, assessment of the status of each growth factor included in the framework presented here and the role of the NRC cluster initiatives in this change would help to determine the initiatives' performance against the program's expected outcomes as indicated in its logic model. The intent of this exercise was to facilitate the evaluation's objective judgment on the influence, if applicable, of NRC on the presence of these factors (e.g. development of a skilled workforce or the development of a specialized research infrastructure) or to assess the broader context in which NRC's cluster initiatives evolve (e.g. presence of an anchor organization or government support) in order to determine the growth potential of each of the clusters, which were determined to be at various stages of development.

Findings

Figure 1 summarizes the findings obtained as a result of the literature review. The growth factors retained as a result of the analysis were organized according to their contribution to four types of cluster capital: human; social; physical; and financial.

Each of the 12 growth factors identified through the analysis are presented in the sections that follow. These growth factors were used as foundational elements in the evaluation of NRC's technology cluster initiatives, which act in a larger cluster context (i.e. the technology cluster initiatives launched by NRC are meant to support the overall growth of the cluster). Examples from the evaluation's key findings are also presented to illustrate each growth factor in a concrete manner.

New graduates are hired by firms and institutions' spin-off companies, transferring knowledge and supporting innovation within the cluster. Highly specialized individuals are thought to pool in regions

Human capital

Human capital is defined by the OECD (2001) as the 'productive wealth embodied in labour, skills and knowledge' (electronic document). Two growth factors linked to human capital include a skilled workforce, and innovative technology and technology transfer. These two factors are closely linked, given that the development of knowledge and its transfer are linked to the capacities inherent in a skilled workforce.

Skilled workforce Access to a highly skilled workforce is consistently regarded as one of the most important factors supporting the growth of technology clusters (Wolfe and Gertler, 2004; DTI, 2004). In fact, the presence of a skilled labour force is one of the key factors thought to prompt the emergence of a cluster (Xu and McNaughton, 2006). It supports the attraction of firms to the region, as well as the retention of existing firms within the cluster (DTI, 2004).

The presence of specialized skills is an important feature defining a highly talented workforce. The

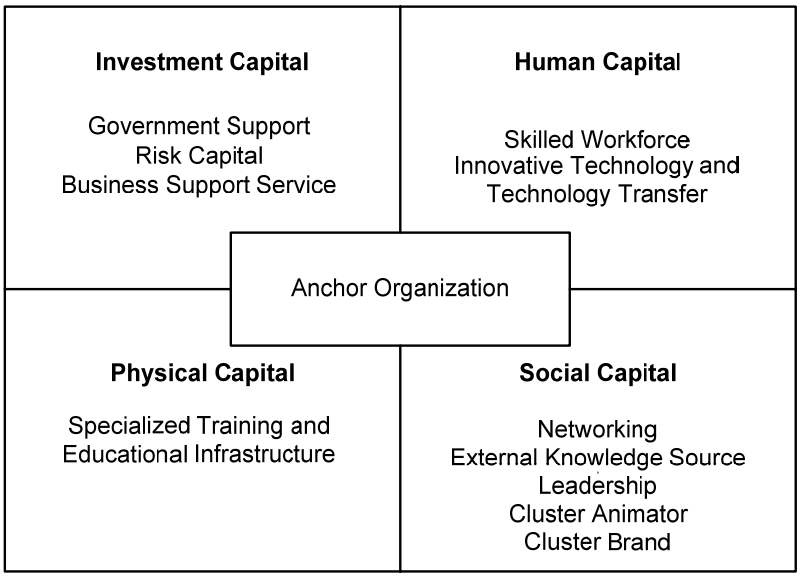

Figure 1. Cluster capital and cluster growth factors

presence of specialized skills differentiates it from a general workforce, which does not possess the same level of training or knowledge. Not only does a specialized workforce help attract and retain firms, it also plays a role in disseminating knowledge within the cluster. New graduates are hired by firms and institutions' spin-off companies, transferring knowledge and supporting innovation within the cluster (Wolfe and Gertler, 2004).

Highly specialized individuals are thought to pool in regions, which offers firms in that area an advantage over others without such local resources. Porter (2001) offers four explanations for the creation of labour pools:

- Specialized training institutions exist and create a mass of specialized workers;
- Groupings of local companies offer specialized training to their employees;
- External companies are attracted to the region because of the skilled workforce and bring their own trained staff; and
- Skilled individuals from outside the region move to the area because of the availability of employment opportunities in the field.

Silicon Valley illustrates a mix of these approaches, where Stanford and Berkeley played roles as educational institutions and where firms such as Hewlett-Packard and Intel also contributed to the development of the workforce:

> Our cases demonstrate that there are a number of different ways to achieve a supply of skilled labour and that it is the ultimate outcome (a highly skilled labour supply), not the particular mechanism (a university) that matters. (Bresnahan *et al*, 2001: 846)

The evaluation of the NRC technology cluster initiatives revealed that many of the clusters studied have built their workforce over time through aggressive recruitment of academic and technical staff to their respective regions and through their ongoing focus on training new generations of skilled workers.

Innovative technology and technological transfer Successful clusters promote innovative technologies and technology transfer by developing knowledge exchange networks, both formal and informal, and using research centers to drive innovative technologies.

The maturity of the technology platform was also found to contribute to the success of the cluster. For new, emerging and innovative technologies, there exists little competition from other regions. As a technology develops, more organizations outside the region enter the market as competitors, which can slow the growth of the cluster (Munn-Venn and Voyer, 2004). In fact, the evidence shows that product development and well-developed research structures, together with other forms of innovation, are vital for a dynamic cluster. Innovation maintains the cluster at the forefront of the market while a strong R&D base can provide the ideas and products for future development (DTI, 2004: 34).

As mentioned previously, both training institutions and a skilled workforce play roles in the transfer of knowledge within and into a region. In addition to these, other formal and informal networks within a cluster enable knowledge and technology transfer. These knowledge and technology exchanges are important to the collective learning of the cluster (Xu and McNaughton, 2006).

A cluster with several different types of research institutions (e.g. universities and publicly funded research centres, large firms with research facilities) provides firms with more options for exchange and knowledge acquisition and transfer. This provides more opportunities for firm interaction, researcher exchange, intellectual property development and commercialization. This will in turn foster commercialization and promote innovation within the cluster. It may also generate competition between research institutions, further accelerating knowledge generation and transfer within the region (Porter, 2001).

One notable example of innovative technology and technological transfer can be derived from the evaluation of NRC technology cluster initiatives. A particular case examined involved the collaboration of NRC, a local university and a private sector company in the development of a new product. The three parties collaborated together on the R&D activities required to develop the new product, and the intellectual property generated was transferred to the industrial partner for application and commercialization.

Social capital

Four growth factors have been associated with social capital. These include: networking; external knowledge sources or global pipelines; leadership and cluster animators. Social capital is recognized by Grootaert (1998: iii) as:

> the norms and social relations embedded in the social structures of societies that enable people to co-ordinate action to achieve desired goals.

Networking The ability of cluster stakeholders to form linkages with one another and to maintain their collaborations are essential to the formation and continued growth of technology clusters. Fostering linkages between cluster actors is one of the most important elements of any cluster development strategy, as not only does it enable continuous informal and formal communication between cluster actors, but also can be the means through which many cluster development activities are delivered (DTI, 2004). The presence of strong networks, characterized by close social interactions and a high level of trust and

knowledge-sharing (DTI, 2004; Wolfe and Gertler, 2004), is thought to be at the very core of cluster development, catalyzing intellectual exchange and knowledge transfer between firms and other stakeholders (Huggins, 2008; Lundequist and Power, 2002). Highly functioning networks within clusters can in fact be thought of as 'the gel that binds success over time' (DTI, 2004: 24).

Networking between clusters that focus on similar technologies has also recently been identified as another source of connection and knowledge-sharing. Huggins (2008) provides evidence from case studies suggesting that successful clusters are moving beyond their own network and building heightened critical mass through consolidation with other relatively proximate clusters. Huggins is careful to add, however, that these globalized networks do not reduce the importance of local network building in cluster formation and growth. Finally, the DTI also offers a warning to clusters keen on developing networks:

> Networks should not be encouraged for their own sake; they are a means to an end and not an end unto themselves. Unless they fulfill some need they will not survive. (DTI, 2004: 26)

All of the clusters studied in the NRC evaluation were found to engage in extensive networking activities, whether formal or informal. A notable example is one cluster where concrete efforts are made to link research with business through an innovation forum that enables the development of new relationships.

External knowledge sources or global pipelines Successful clusters have in common the performance of their firms. The literature suggests that a firm's performance is often determined by its ability to innovate, which is in part dependent upon its access to external sources of knowledge. In this regard, the cluster literature establishes a distinction between local sources of knowledge and what Bathelt *et al*l (2002) refer to as 'global pipelines', or sources of knowledge that come from outside the cluster. With respect to the former, local competitors (i.e. rival firms) and potential collaborators (e.g. universities, publicly funded research and development laboratories) are usually identified as the main sources of innovative ideas.

However, the literature also emphasizes the importance of external sources of knowledge available internationally. Successful cluster experiences reviewed in the literature share a common capacity to establish formal and informal channels of communication or formal and informal collaborations with foreign clusters and/or regions. Wolfe and Gertler (2004: 1090) found that in several clusters, 'a large component of the knowledge inputs to local production — at least in certain sectors — is drawn from well outside the region'.

Twinning was found to result in the development of collaborative research agreements, knowledge-sharing and international market opportunities for companies belonging to different clusters

Another benefit associated with the establishment of linkages with external sources of knowledge is the capacity for cluster firms and the cluster as a whole to respond to new ideas (Munn-Venn and Voyer, 2004). More specifically, it appears that open clusters, defined as those with linkages outside their own boundaries, are more likely to adapt to changing markets or major shifts in technology development.

Cluster twinning, which involves establishing some form of linkage or exchange with comparative clusters, was found to have occurred in a number of the clusters where Canadian-based clusters built relationships with international clusters focusing on similar technologies. Twinning was found to result in the development of collaborative research agreements, knowledge-sharing and international market opportunities for companies belonging to different clusters.

Cluster animator As discussed previously, the literature strongly emphasizes the critical role of networks in successful cluster evolution. Findings from the literature review indicate that the establishment of formal and informal networks is facilitated by the presence of a cluster animator. Several types of institutions such as universities, economic development organizations, public organizations, not-for-profit organizations or trade/sector organizations were found to act as network brokers between cluster firms and other cluster support organizations.

In a study commissioned by the Council on Competitiveness, Porter (2001) identifies the flow of information, ideas, and resources among firm and supporting institutions as one of the main benefits of cluster animators. Moreover, it appears that the animator can provide a structure for the management and the coordination of common activities in support of cluster development. These activities range from cluster strategic planning to the promotion of the region to outside firms or the development of technology roadmaps. From the perspective of Lundequist and Power (2002: 698), the value of having cluster animators resides in their ability to act as 'network brokers between sectors and individual interest'.

The capacity of the animator to mobilize the community toward a common goal is also noted by various authors. For Wolfe and Gertler (2004: 1085),

the existence of such organizations has the potential to improve the sustainability of the cluster by allowing a 'reflexive behaviour', which may lead to 'successful adaptation and resilience in the face of competitive challenge from abroad'.

In Canada, several technology cluster initiatives in which NRC is involved include not-for-profit or industry associations that play the role of cluster animator. These organizations tend to engage participants in networking activities and represent the cluster in other national or international fora.

Leadership Unlike cluster animators, who focus on the establishment and maintenance of networks, leaders provide direction and help to drive the strategic orientation and overall development of the cluster. Whether the leadership role is exercised by a single individual, a single company, an industry leader or an industry association, the majority of authors recognize the importance of the private sector in leading the development of clusters. For Porter,

> Private-sector leadership is often critical for success. Active government participation in a privately led effort, rather than an initiative controlled by government, will have a better chance of success. Companies can usually better identify the obstacles and constraints in their path than can government. (2001: 17)

In addition to providing a strategic direction to the cluster, leaders were also found to assume various functions in support of clustering, such as catalyzing the development of new or emerging industries, animating strategic visioning exercises, coordinating the cluster activities, and representing the interests of the private sector outside of the cluster (Wolfe and Gertler, 2004; DTI, 2004). The importance of leaders at the inception of cluster development is another recurring theme observed in the literature. Lundequist and Power noted that:

> what is crucial however is that a strong vision and leadership emerge early on and that a strategic and purposeful view of the [cluster] process be taken. (2002: 695)

In all of the clusters reviewed, NRC was found to play an important role in terms of mobilizing resources and people and inciting cluster development activities, especially in those considered to be nascent. In more established clusters, leadership roles have been held by various organizations or individuals, with some taking on roles of promoting and branding the cluster, as well as mobilizing and attracting resources to it.

Cluster brand A clear brand is noted as being a critical factor in strengthening the competitiveness of a cluster. Lundequist and Power (2002) suggest that branding has three main functions:

- It serves to strengthen the ability of the cluster to attract investments, venture capital, and skilled workers;
- It helps unite cluster actors under a shared vision, purpose and identity; and
- It helps to complement firms' marketing activities.

Who develops the brand and how the branding occurs can vary, although it is suggested that branding can be supported by public sector involvement, where government is able to communicate regional opportunities to a wider audience (Munn-Venn and Voyer, 2004).

In the NRC evaluation, cluster branding was found to vary across the clusters examined. In some cases, the cluster brand was attached to NRC whereas in others, the brand was connected to a large company acting as an anchor organization. In more established clusters, brands were attached to a scientific area or to an industrial sector rather than specific organizations.

Physical capital

Physical capital is defined as the infrastructure (i.e. laboratories, instruments or equipment) used in the creation of knowledge, technologies, and commercial products and processes. The key factor contributing to cluster growth identified in this area includes the presence of specialized training and educational infrastructure.

Specialized training and educational infrastructure The presence of specialized training and educational infrastructure provides a supply of qualified labour to firms in the cluster (Porter, 1998; Wolfe and Gertler, 2004). This contributes to the growth of local firms, as well as the attraction of firms to the region. Cluster networks enable training institutions to identify the needs of the region and orient their programs to respond to the needs of local firms. This helps ensure that the available labour force is well-suited to the requirements of cluster employers (DTI, 2004).

In addition to developing a future workforce, the specialized infrastructure offered at post-secondary institutions and R&D laboratories helps attract skilled individuals to the region (Munn-Venn and Voyer, 2004). Overall, universities have been identified as a key component of technology clusters' knowledge exchange network and as a driver for innovation.

Specialized training programs have been implemented in at least three of the 11 clusters reviewed in the NRC study to respond to the needs of each region for skilled workers. The combination of infrastructure held at both university and NRC facilities and participation of NRC researchers in the training of highly qualified personnel have led to identifiable successes in this area.

Investment capital

Within the scope of investment capital are associated government support, business support services and risk capital. Investment capital refers to the financial resources and business-related services available to cluster actors for the production of knowledge, technologies and commercial products and processes.

Government support Public sector organizations play a variety of roles in developing clusters. They contribute directly to cluster growth by building knowledge and research infrastructure, creating organizations that produce critical knowledge-based assets for the region, providing funding for basic or applied research, supporting the development of research networks, creating technology transfer organizations, and establishing science and technology parks to attract businesses (DTI, 2004; Lundquist and Power, 2002; Wolfe and Gertler, 2004). The public sector also contributes indirectly to cluster growth by providing a supportive policy environment focusing on regional development, science, regulations, and competition.

The most crucial role for government in cluster development is to develop an integrated strategy that includes some or all of these elements. The common feature of successful public sector intervention in cluster growth, according to the literature, is:

> a strong commitment from local and regional government bodies to deliver growth and sustainability (DTI, 2004: 51–52)

By its very nature, the evaluation of the NRC technology cluster initiatives focused on the role of government in creating and supporting technology clusters across Canada. Beyond the involvement of NRC, however, extensive federal and provincial government support was also identified in many of the clusters reviewed. Such support was provided through various partnerships and other financial arrangements. In a few cases, municipalities were also found to support cluster development.

Business support services The presence and availability of business support services were also identified in the literature as contributing to cluster growth and success. Business support services can be defined as:

> the kind of infrastructural knowledge resources found in the specialized legal, accounting and financial firms that are essential to the success of individual firms in the cluster. (Wolfe and Gertler, 2004: 1076–1077)

These types of services can take on different forms and include, among others, information and communications technology support, grant assistance, business advice and marketing and networking assistance. Generally, business support services are thought to facilitate improvements in firm performance by complementing their technical or scientific skills. Some of the specific business support services identified in the evaluation include competitive technical intelligence, law services, referrals to specialized business management services and financial assistance.

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Risk capital The availability of risk capital to support R&D investment is documented as an essential element contributing to the successful growth and expansion of cluster-related activities (Karlsson *et al*, 2005), particularly in R&D-focused clusters requiring continuity of investment over the long term (Munn-Venn and Voyer, 2004). Access to risk capital may include access to venture capital, business angels and investor networks, specialist resources and financing as well as other forms of public and private sector investing. Access to financial institutions and intermediaries including banks, lending and trading houses and other financial institutions have been identified as having a positive effect on cluster growth (DTI, 2004).

Cluster policy is seen to support the evolution of risk capital resources in a region given that the process of clustering is one of risk management. Clusters may *de facto* attract investment because they present lower levels of risk to the investment community. Policy-makers' attention to skill acquisition, entrepreneurship, improved market entry and regional incentives reduce risk within a cluster context, thereby promoting innovation and inciting investment activity.

Evidence suggests that policies to support risk capital investment in a region or cluster will be unsuccessful in the absence of other efforts or policies that support cluster building, such as entrepreneurialism, research and development (Bartzokas and Mani, 2004). Based on such evidence, an argument can be made that a congruence of policies and actions are needed in support of cluster development.

This particular growth factor was difficult to identify in many of the Canadian clusters studied. Several clusters have put in place strategies to support the availability of risk and early stage capital for innovation; however, its limited availability continued

to be sounded as a deterrent to growth. Many of the companies consulted for the evaluation expressed the importance of this factor in fostering ongoing industrial growth.

Multi-dimensional capital

One particular growth factor frequently identified as contributing to cluster success is the presence of an anchor organization. Given its diverse facets, an anchor may be considered to be a contributor to any form of cluster capital, including human, social, infrastructure or investment. For this reason it is positioned in the framework as being associated with all four forms of cluster capital.

Anchor organization Frequently, the case literature on cluster development has identified the presence of an anchor firm as being a core element, and in some instances, the defining factor that has given rise to the cluster. Anchor firms serve to attract both allies and competitors, as well as give rise to the creation of new companies (Munn-Venn and Voyer, 2004; Wolfe and Gertler, 2004). They also serve to incite the emergence of industry-specific value chains by spinning-off related technology firms, suppliers and consultants. Further, they support the long-term development of networks through relationships established and maintained among employees and business associates.

The potential to catalyze growth and anchor a region is not restricted to firms. Universities and public research and development facilities have also taken on such roles, in some instances purposely as part of a policy initiative or strategy, to incite the attraction of companies and development of clusters. They may also acquire the role of lead institution or anchor organization in the case of the demise of a private sector anchor. Such organizations are able to support the development of the local talent base, incubate and generate new firms, and attract larger private sector investment — including the attraction of larger firm investment (NRC, 2009).

Powell (2009) suggests that the strength of the anchor organization and its role in cluster growth is rooted in the fact that its position within the cluster provides it with the ability to 'recombine and repurpose diverse activity. The anchor institution protects the values of the local community' (Powell, 2009: 8). The research identified that cluster growth emerged where anchor tenants 'catalyzed further organization and network formation, rather than acting as a hegemonic power' (Powell, 2009: 23).

Within the context of the NRC evaluation, it was identified in numerous cases that there were present anchor organizations that served to focus local activity. In a number of established clusters, private sector anchor organizations were found to play a key role in attracting and retaining a skilled workforce and in creating a local demand for specialized services.

Implications for the evaluation and study of technology clusters

Following the establishment of an objective list of criteria against which the potential growth of clusters can be assessed, data and information on these 12 factors were collected for each of the 11 clusters in which NRC launched cluster support initiatives. The data and information used to conduct the assessment were collected through multiple lines of evidence including: community focus groups, semi-structured interviews, document review, and the review of administrative and performance data. For the most part, qualitative data and information were available. Although the data were sufficient to generate findings that helped address a portion of the evaluation issues/questions, several opportunities for improvement in the application and use of the growth factors for cluster evaluation or assessment are proposed. These may lead to a greater ability to assess cluster growth over time, according to these factors.

It is feasible for cluster evaluation in general that the identified growth factors could form the basis of a cluster growth factor scorecard, with an associated series of indicators for each factor. This scorecard would see the identification of indicators for each of the factors and define strategies for the collection of data — using both qualitative and/or quantitative methods — over time. Given the range of factors that need to be assessed, and the high variability in the accepted concepts and definitions of clusters, it is anticipated that data collection would involve multiple stakeholders or sources.

Further, the variable stage of development of the cluster, as per a cluster lifecycle model (Andersson *et al*, 2003), could be used as a basis for weighing the importance of each factor to the cluster and its growth. For instance, a cluster at a more latent stage may exhibit growth in government support as policy-makers seek to jumpstart cluster development. Comparatively, a cluster at a later developing stage may be expected to exhibit more growth in the area of cluster-branding, and the establishment of external knowledge sources and global pipelines.

An aspect not sufficiently identified in the literature to be included in the selected factors, but which may nonetheless warrant further investigation, is that of the effects of entrepreneurialism, which was identified by the DTI study as an important factor supporting a cluster's evolution. The presence of actors who are capable of taking calculated risks, and who have the capacity to absorb the innovative technology created by institutions that act as research and innovation catalysts, was identified as a determinant of the growth of some of the clusters that were examined. Thus, the role of new and developing firms, as well as spin-off activity, could be examined more closely in evaluations and related studies.

The assessment of technology clusters through the use of the growth factors framework could also be complemented in the future by focusing on the

The assessment of technology clusters through the use of the growth factors framework could also be complemented by focusing on the creation and at-traction of firms to the region, as well as the com-petitiveness of local companies

creation and attraction of firms to the region, as well as the competitiveness of local companies. An emphasis on these results, above and beyond growth related to each of the factors, will indicate the degree to which growth factors are supporting and contributing to cluster strength (Munn-Venn and Voyer, 2004).

Conclusion

The literature review conducted as part of an evaluation of the NRC technology cluster initiatives yielded a list of the 12 most prevalent factors of cluster growth. These are the factors that research has shown to be most often present when clusters grow and succeed over time — sometimes lengthy periods of time. As a means of improving the robustness of future evaluations, it is proposed that the development of a cluster factor scorecard, against which data would be collected over time for each factor, would provide an opportunity to assess cluster change and evolution. The use of performance data pertaining to cluster firms is also proposed as a complementary means of understanding the level of development of technology clusters.

In summary, the literature proved to be a valid source of information in support of the evaluation process where criteria against which to assess the impact of publicly funded initiatives on cluster growth could be established.

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