Graytek
Management Inc.

ICT/LIFE SCIENCES CONVERGING TECHNOLOGIES CLUSTER STUDY:

A Comparative Study of the Information and Communications, Life Sciences, and Converging Next Generation Technology Clusters in Vancouver, Toronto, Montreal and Ottawa

Prepared for:

ICT and Life Sciences Branches of Industry Canada and the National Research Council

Prepared by:

**Graytek Management Inc. in Association with
Dr. Roger Voyer, Dr. Jorge Niosi, Franco Materazzi and Neelam Makhija**

Final Report

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EXECUTIVE SUMMARY

PROJECT OVERVIEW

A **qualitative** analysis of the information and communications technologies (ICT), life sciences and their converging next-generation technology clusters in Vancouver, Toronto, Montreal and Ottawa.

KEY OBJECTIVES

- **Improved policy development.** To provide the federal government and other stakeholders with relevant information to improve policy decisions and the design of new initiatives intended to accelerate cluster development and growth.
- **Improved communications.** To help break down silos between the ICT and LS sectors by presenting the study findings to sector leaders and stakeholders in each of the four cities and facilitating a discussion around implementation of the study recommendations. Results will also be presented to senior managers and officers involved with these sectors at the federal level in Ottawa.

METHODOLOGY

The study used a previously-validated analytical framework to build an understanding of current cluster capacity and operational dynamics and included:

- Conducting extensive literature review
- Mapping approximately 200-500 key ICT and 100-200 life sciences companies per city
- Interviewing approximately 10 key stakeholders per city
  ⇒ Obtain top of mind perspective
  ⇒ Review success factors using preliminary spider diagrams
  ⇒ Ask what they would like to see from government
- Assessing cluster dynamics and performance
- Comparing results across sectors and cities (Note: US comparisons for biotech are based on indicators for research and commercialization developed by the Brookings Institute).

OVERVIEW OF CLUSTER CAPACITY

Vancouver

- ICT Cluster
  ⇒ ~1,000 companies, ~30,000 people
  ⇒ Telus is largest employer by far (~10,000 in 2003)
  ⇒ Few large companies, many small service providers

⇒ Key strength in wireless and new media areas
⇒ Largely focused on emerging markets

- Life Sciences Cluster
  ⇒ ~90 companies, >1,900 people with another 1,400 in public institutions
  ⇒ Dominated by small and medium-size enterprises (SMEs) in health area
  ⇒ Growing base of non-health biotechnology companies
  ⇒ Small number of local medical device companies
- Converging Technologies
  ⇒ Key strength in bioinformatics, but few companies

Toronto

- ICT Cluster
  ⇒ ~9,000 companies (~4,000 core), ~200,000 people
  ⇒ Dominated by multinational enterprises (MNEs)
  ⇒ Little manufacturing, except local assembly
  ⇒ Many small service providers
  ⇒ Really 3 clusters (Downtown, Markham, Mississauga)
- Life Sciences Cluster
  ⇒ ~400 companies, >30,000 people
  ⇒ Pharma dominated by MNEs
  ⇒ MNE Manufacturing increasingly going off-shore
  ⇒ R&D focused on emerging biotech (health) activities, mostly SMEs
  ⇒ Diverse and unfocused medical device activities, mostly SMEs
- Converging Technologies
  ⇒ Some activities in all converging technology areas but largely unfocused

Montreal

- ICT Cluster
  ⇒ >2,500 companies, ~110,000 people
  ⇒ Many MNEs and large companies mainly in the services area
  ⇒ Traditional manufacturing area restructuring, services stable, software and new media strong
  ⇒ Emphasis shifting to emerging markets
- Life Sciences Cluster
  ⇒ ~275 companies, ~21,000 people
  ⇒ Dominated by MNEs in health area
  ⇒ Key strengths in pharmaceuticals and biotechnology
  ⇒ Substantial number of medical device companies
- Converging Technologies

⇒ Some focus on bioinformatics and biomaterials

Ottawa

- ICT Cluster
  - ⇒ ~1,500 companies, ~64,000 people
  - ⇒ Nortel still the largest player (~6,000 people), many MNEs (~70)
  - ⇒ Services accounts for ~60% of cluster companies and government is major customer
  - ⇒ Key strengths in wireless and photonics, shifting focus to emerging markets
- Life Sciences Cluster
  - ⇒ ~100 companies, ~4,200 people (Ottawa-Gatineau)
  - ⇒ Mostly early stage companies
  - ⇒ One large firm, MDS Nordion (~750 employees)
  - ⇒ Large research base (~45 institutions)
  - ⇒ Focus on health, bioproducts, converging technologies (including medical devices), and life sciences services
- Converging Technologies
  - ⇒ A focus on biophotonics, but few companies

CROSS CLUSTER COMPARISONS

Canadian Comparisons

- All four metropolitan areas have substantial capabilities in their clusters overall
- ICT clusters are larger than Life Sciences clusters by about an order of magnitude
- Relative critical mass
  - ⇒ ICT - Toronto strongest, followed by Montreal, Ottawa and then Vancouver
  - ⇒ Life Sciences - Montreal and Toronto are comparable & complementary
  - ⇒ Life Sciences - Vancouver is stronger than Ottawa but both are fragile
- Few converging technology firms and lack of focus
  - ⇒ Greatest diversity appears to be in Toronto

US Comparisons (Biotechnology)

- Significantly below top 9 US clusters, compare favourably to next 42 US clusters
- Toronto & Montreal are strongest contenders, Vancouver is performing above its size, Ottawa is a distant fourth
- Commercialization performance is better than research performance (Canadian clusters do more with less)
  - ⇒ Commercialization is strong in new company creation but weak in company growth

KEY FINDINGS AND RECOMMENDATIONS

Cluster Development Overall

- **The importance of cluster diversity.** All four metropolitan areas have attained a considerable level of diversity. This has helped to make the clusters more resilient during the technology downturn.
  ⇒ The transferability of technical skills has helped mitigate the impact of the downturn in one technology area by providing new opportunities in other areas;
  ⇒ The breadth of knowledge and skills is enabling the development of emerging markets and converging technology opportunities.

  It is important that policy makers encourage cluster diversity as an important element of cluster sustainability rather than focusing on specific industries.

> *Key Recommendation:*
>
> ***1. Support the development of integrated cluster strategies that cover the full range of technology industries. An emphasis should be placed on supporting clusters that are deemed strategically important in terms of contributing to exports and thus to Canada's prosperity.***

- **The need for coordinated and sustained leadership and support.** Leadership and support vary considerably across the clusters and are for the most part fragmented and not sustained. In order to compete globally, it is necessary to mobilize and coordinate resources around common goals and objectives. Leadership must come from within the cluster and be supported at the provincial level. The federal government can mobilize coordinated action around significant projects sustained by long-term funding commitments.

> *Key Recommendation:*
>
> ***2. Identify and support one, or more, substantial projects aimed at accelerating cluster development in each key Canadian technology cluster. A particular emphasis should be placed on projects aimed at emerging market and/or converging technology opportunities.***

- **The need to grow larger companies – the commercialization dimension.** Growing companies (SMEs) that already exist is more important than spinning off more companies. This requires:
  ⇒ **Developing the right skills mix.** To grow companies an increase in management, marketing and commercialization skills is required.

⇒ **Ensuring availability of substantive and sustained financing.** Securing adequate financing is clearly a major challenge facing virtually all technology companies across the entire commercialization spectrum..

⇒ **Development of early market credibility.** Finding early customers is an important aspect of developing a technology company, particularly when addressing emerging market opportunities where revenue potential is typically less well defined.

Key Recommendations:

3. Work through the appropriate skills councils and universities to develop and fund programs to increase the pool of executive management talent, marketing professionals and commercialization experts capable of growing technology companies.

4. Develop a broad approach to increasing the availability of substantive and sustained financing support for technology companies. As a minimum, this approach should consider:

4.1. Providing incentives to entrepreneurs, particularly serial entrepreneurs, to grow successful companies over time rather than selling out at the earliest opportunity.

4.2. Providing incentives to VCs to make long-term commitments to investing in companies from start-up through subsequent growth stages.

4.3. Increasing mobility of capital, particularly labour sponsored funds, across Canada.

4.4. Increasing the size of available capital pools for investing in technology companies (e.g., through changes in pension fund rules).

5. Develop approaches to supporting early market development by technology companies. As a minimum, this approach should consider:

5.1. Extending the existing Scientific Research & Experimental Development (SR&ED) Program tax credits to include activities related to confirmation of commercial product viability.

5.2. Encouraging the procurement of locally developed products and helping promote such products in international markets.

With Respect to ICT

- **Dealing with ICT as a mature sector.** ICT is a mature sector dominated by a small number of large global companies surrounded by an array of smaller niche players and component suppliers. In Canada, the large companies are increasingly foreign multinational enterprises and they are dominant players in all of the clusters studied except Vancouver. The multinational enterprises need to be encouraged to develop stronger local roots, particularly in the R&D and commercialization/production areas to ensure that they remain in the cluster. The multinational enterprises are also in a position to assist local companies by developing supplier relationships, something that is generally not evident at present.

> ***Key Recommendation:***
>
> ***6. Recognize the growing importance of ICT multinational enterprises and encourage them to increase their long-term commitment to Canada. Policy initiatives should also be applicable to large indigenous ICT companies. Specific actions should include:***
>
> ***6.1. Encouraging local R&D through use of procurement levers.***
>
> ***6.2. Encouraging R&D linkages with local academia.***
>
> ***6.3. Encouraging local partnerships, particularly supplier development partnerships, through use of incentives and procurement levers.***
>
> ***6.4. Encouraging more commercialization and production in Canada. Product mandates for Canada should be encouraged.***

- **Exploiting ICT's role as an enabler.** The importance of ICT as an enabler of broad economic development has surpassed that of ICT as an economic sector in its own right. Much of the ICT R&D taking place in the clusters studied is in the area of emerging market opportunities, particularly those related to provision of infrastructure, content and applications targeting enabled sectors. Many of the spin-offs and start-ups, as well as some of the medium-sized companies, are targeting ICT-enabled, emerging market opportunities. This makes it increasingly difficult to view ICT as a coherent sector and future success will require much stronger linkages between the ICT sector and other sectors of the economy. In this regard, ***it is important to facilitate ICT technology development and lever ICT skills capacity at the interface between the ICT sector and other sectors of the economy.***

> ***Key Recommendation:***
>
> ***7. Shift the ICT policy emphasis from a sector orientation to one that is more focused on ICT as a broad enabler of economic development. Specific actions should include:***
>
> ***7.1. Increased coordination and collaboration between sector analysts and***

policy makers (the current study is a good example of this in the case of the ICT and Life Sciences sectors).

7.2. Encouraging increased coordination and collaboration between ICT industry associations and associations representing other sectors of the economy. A good starting point is to develop value chains that map the linkages between ICT and the enabled sectors as well as mapping cluster companies onto such value chains.

7.3. Supporting cross-sector initiatives aimed at developing partnerships between ICT companies and companies in other sectors. The emphasis should be on product and market development partnerships involving substantial joint R&D activities that are intended to strengthen both the enabled company and the ICT participant(s), particularly with a view to growing larger ICT companies.

7.4. Supporting continuing development of the ICT skills base to better position the sector to launch next generation technologies into the enabled sectors.

With Respect to Life Sciences

- **Integrating the three components.** The three main components of the Life Sciences clusters (i.e., pharmaceuticals, medical devices and biotechnology) operate largely in silos with very few linkages among them.

Key Recommendation:

8. Strengthen linkages between the pharmaceuticals, medical devices and biotechnology components of the Life Sciences sector. Specific actions should include:

8.1. Encouraging the merging of industry associations into a single entity to support the development of clusters at the level of life sciences per se, not at the component level. This would facilitate interactions among firms in the three components.

8.2. Mobilizing local, provincial and federal governments support for the formation of consortia and projects that integrate the three components.

8.3. Setting in place demonstration projects within the hospitals to encourage linkages and demand pull.

- **Focusing on Top Tier Clusters.** According to this analysis, Montreal and Toronto's biotechnology clusters currently have the critical mass to compete and/or collaborate most effectively with the nine leading US biotechnology clusters. The depth of their research capabilities and their related industrial diversity give Montreal and Toronto more staying power. Vancouver is a robust challenger with considerable commercialization capacity; Ottawa has a strong research base but needs to build its commercialization capacity.

> ***Key Recommendation:***
>
> ***9. Make the top tier Life Sciences clusters more competitive by mobilizing local, provincial and federal governments to ensure that the necessary capabilities and incentives are in place so that these clusters increase their potential to compete and cooperate internationally, to attract investment, skilled people and firms.***

- **Stimulating Alliances between Pharmaceutical Firms and Biotechnology Firms.** Canadian biotechnology firms are small and, because financing difficulties, often sell their intellectual property rather than exploiting it themselves.

> ***Key Recommendation:***
>
> ***10. Develop a support program to stimulate the formation of R&D alliances between biotechnology firms and Canadian-based pharmaceutical firms. One approach could be a program where government supports biotechnology firms by providing funds that match those provided by pharmaceutical firms***

- **Consolidating Biotechnology Firms.** It is difficult to grow the many small biotechnology firms in Canada due to their small size.

> ***Key Recommendation:***
>
> ***11. Develop federal and provincial programs to encourage the consolidation of small biotechnology firms. A first step would be to identify firms that work in the same areas using similar molecular platforms to determine if there is sufficient synergy for consolidation.***

- **Developing a Local Supplier Base in Vancouver and Ottawa.** As a cluster grows there is an opportunity to create a strong local supplier base so that fewer goods and services have to come from the outside.

Key Recommendation:

12. ***That industry associations, local, provincial and federal governments explore ways of aggregating local demand in order to help develop a local supplier base. A first step would be to identify the needs of Vancouver and Ottawa biotechnology firms to ascertain which areas provide market opportunities for local suppliers.***

With Respect to Converging Technologies

The need to focus resources. To compete with converging technology clusters in other countries, this study concludes that it is necessary to focus on Canada's top tier Life Sciences and ICT clusters rather than spreading support more broadly for emerging clusters.

Key Recommendations:

13. ***Leverage Montreal and Toronto's existing ICT and Life Sciences strengths. Specific actions should include:***

    13.1. ***Mobilizing resources to identify one, or more, key converging technology projects that would help accelerate cluster development. Participants in this process should include key executives from leading ICT and Life Sciences companies in the cluster.***

    13.2. ***Arranging sustained funding and support for the key project(s) identified.***

14. ***Assess the potential of Vancouver and Ottawa to become globally competitive by leveraging their emerging strengths in bioinformatics and biophotonics, respectively. Specific actions should include:***

    14.1. ***Determine the business case for establishing a world-class bioinformatics centre in Vancouver that leverages existing strengths in the BC Cancer Agency.***

    14.2. ***Determine the business case for establishing a world-class biophotonics centre in Ottawa that leverages existing photonics strengths in the ICT sector.***

- **The need to consider converging technologies more broadly.** The study considered nanotechnology as an ICT and Life Sciences converging technology but found that converging technology activities are also taking place in the area of biomaterials (another Materials Science technology).

> ***Key Recommendation:***
>
> ***15. Future discussions on policy development regarding converging technologies should also include representation from Advanced Materials and Nanotechnology.***

- **The need for policy coordination.** Industry support is typically organized along sector lines (e.g., ICT, Life Sciences, etc.) and converging technology issues tend to be dealt with from a sector perspective. With convergence rapidly becoming a reality in a variety of technology areas, it is important to begin the transition towards addressing issues related to converging technologies per se. At the federal level, this could start with a secretariat within Industry Canada and later broaden out to include other departments and levels of government.

> ***Key Recommendation:***
>
> ***16. Federal and provincial governments create a focus within their structures for converging technologies; possibly a secretariat to facilitate consensus development in the immediate future. Over time this secretariat could evolve into a more robust entity.***

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INTRODUCTION

BACKGROUND

A key priority of the Government of Canada's innovation and commercialization strategy is to support the development of globally competitive industrial clusters. There is a strong indication from market reviews that industrial clusters play an important role in the overall economic development of Canada. Consequently, the intent is to accelerate the development of existing technology clusters where Canada has the potential to develop world-class expertise and to identify emerging clusters with strong growth potential.

The purpose of this project was to complete a **qualitative** cluster study of Information & Communication Technologies (ICT), Life Sciences and their converging next generation technologies (e.g., bioinformatics, biophotonics, biosensors, nanotechnology, biochips, medical robotics, medical wireless devices) in four major Canadian metropolitan areas (i.e., Vancouver, Toronto, Montreal and Ottawa).

The project objectives were to:

- Develop an improved understanding of ICT/Life Sciences and their converging next generation technology clusters in terms of state of evolution, strengths/weaknesses and key opportunities;
- Provide a comparative analysis of four leading Canadian clusters, as well as comparisons with selected US biotechnology centres using recognized methodologies;
- Help break down silos between sectors and stimulate discussion of community needs and aspirations;
- Suggest realistic scenarios for sector growth; and
- Help accelerate cluster development by informing policy decisions and the design of new initiatives.

This is a summary report which outlines the approach used in cluster analysis, provides comparative results for each of the four Canadian metropolitan areas[1]; compares biotechnology development in each of the four Canadian metropolitan areas with similar developments in leading US clusters; draws overall conclusions from the study; and proposes concrete recommendations for policy and cluster development.

[1] Separate detailed report modules exist for each of the four metropolitan areas studied.

APPROACH

A framework-based approach (see Appendix C for further details and definitions of terms) was used. It consisted of:

- Assessing cluster capacity by building a detailed understanding of the cluster and its support infrastructure at the firm level;
- Understanding the operational dynamics of the cluster through the use of an analytical framework based on generally recognized and accepted success criteria;
- Adding substance and credibility to the analysis through an interviewing process involving key cluster participants and opinion leaders (particularly heads of organizations representing broad stakeholder constituencies);
- Framing the policy issues in a readily understandable and accessible manner; and
- Facilitating communications and breaking down silos throughout the process.

The geographic scope of the study was Vancouver (Lower Mainland), Toronto (Greater Toronto Area), Montreal (Montreal Metropolitan Community) and Ottawa (Ottawa-Gatineau).

The sector scope of the study was the ICT sector as defined by the 1997 NAICS codes used by Statistics Canada in producing special aggregations for the ICT sector. In terms of Life Sciences, the sector scope included research and development in the Life Sciences, and biopharmaceutical and medicine manufacturing (this is the definition used in the Brookings[2] and previous BC studies). As well, the Life Sciences scope included medical devices and non-health biotechnology. Tele-health and e-health companies are typically classified as ICT services companies and were included under the ICT component of the study.

It should be noted that, for the most part, secondary information sources were used for this study. These data sources varied extensively in terms of completeness, accuracy and consistency. The data used was originally collected at varying points in time over several years. Attempts were made to confirm the currency of the data by comparing to alternative sources where possible. However, the primary purpose of the data collection was to provide a reasonable understanding of the cluster at a point in time in order to facilitate broad cluster/policy analysis.

As well, leaders in each cluster were interviewed to obtain a subjective appreciation of the dynamics of each cluster.

---

[2] *Signs of Life: The Growth of Biotechnology Centres in the US.* The Brookings Institution Centre on Urban and Metropolitan Policy (2002).

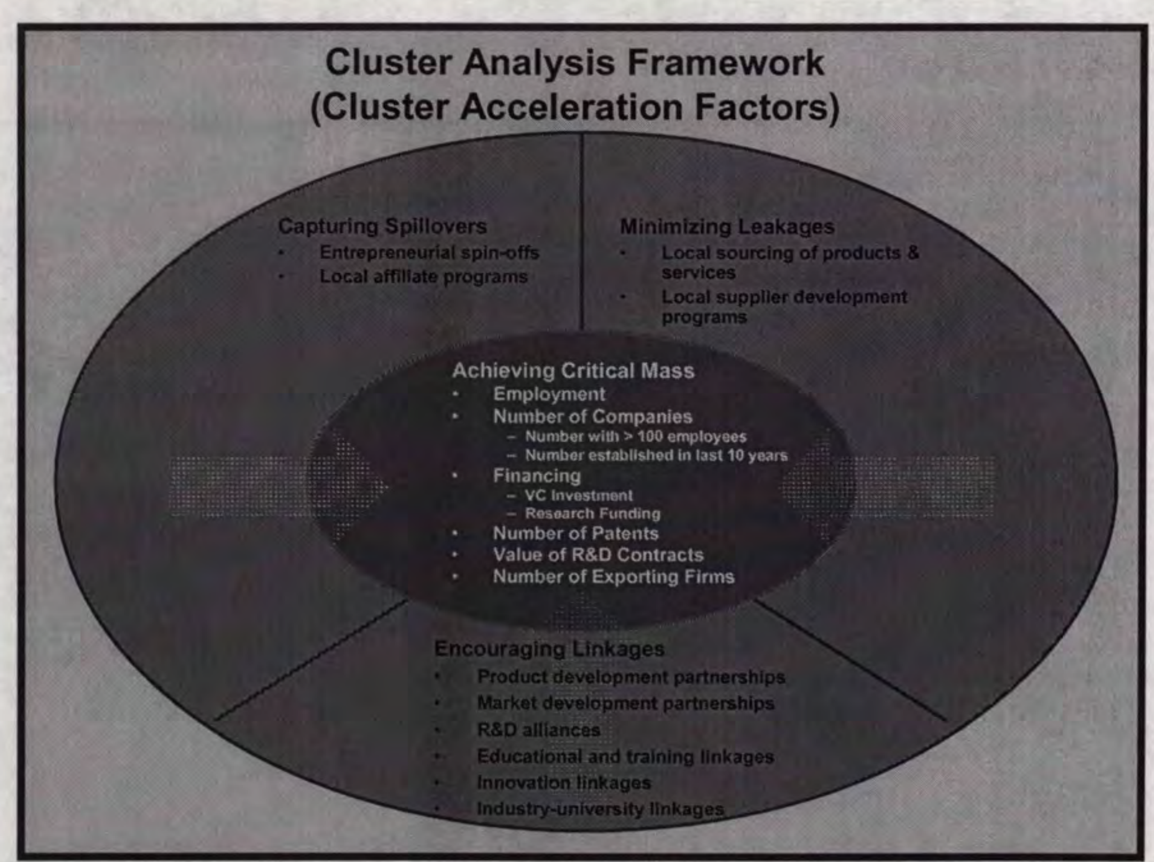
In addition to assessing the four Canadian clusters and comparing them with each other, the study also compared the biotechnology activities in the four clusters with biotechnology centres across the US. As with a previous Vancouver study, the data and methodology used in the *Signs of Life* study was replicated and adapted to include data from the four Canadian clusters. The author of *Signs of Life*, Joseph Cortright was contacted by Industry Canada and the study was replicated for this use with his knowledge.

ORGANIZING FRAMEWORKS

Two organizing frameworks were used to analyze the information and present the results; four factors contributing to building critical mass and eight characteristics of cluster dynamics and success[3].

Cluster development can be accelerated in a number of ways that need to work together at the level of the cluster. Following is an overview of the key cluster acceleration factors and cluster performance indicators.

[3] See Appendix C for a more complete description of these frameworks and the underlying cluster methodology.

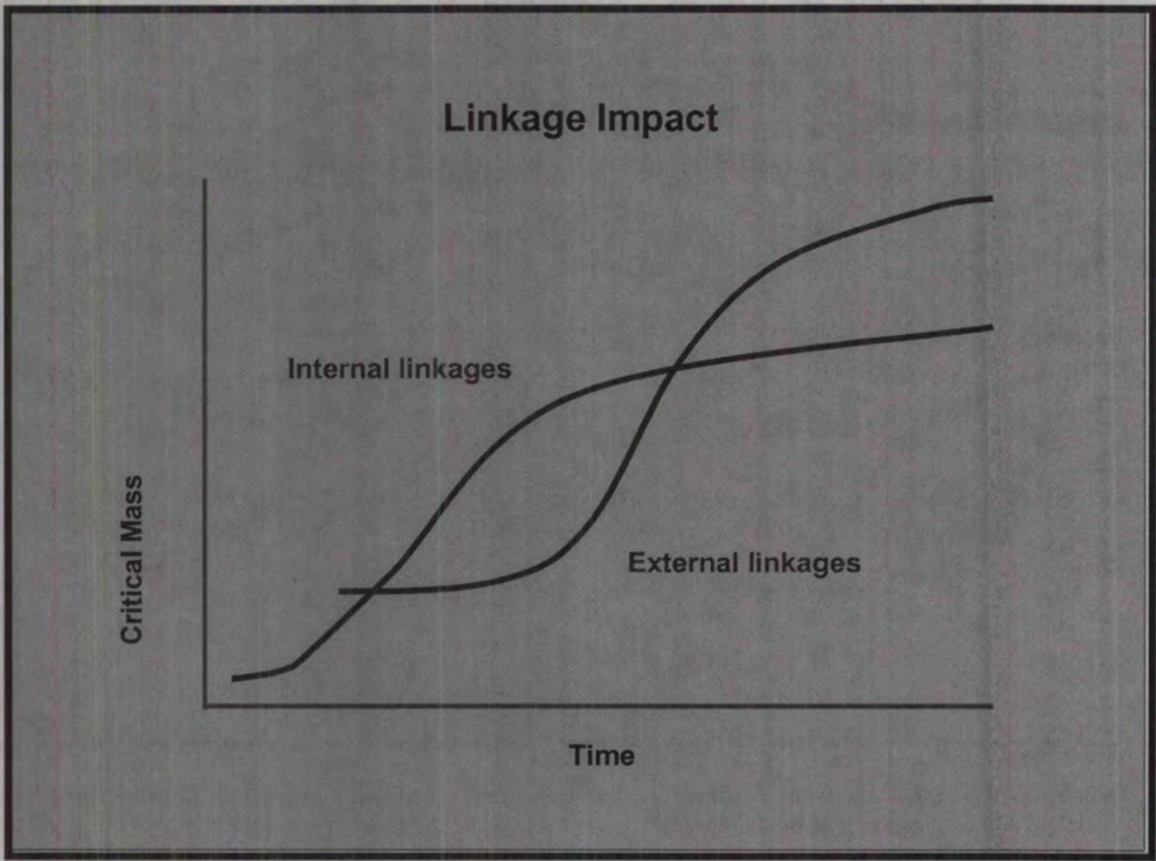


It should be noted that employment is often used as a proxy for measuring and reporting on critical mass. This is a convenient high-level indicator for depicting cluster capacity at a point in time. In order to understand the potential for accelerating cluster growth looking forward in time, a richer set of metrics is required.

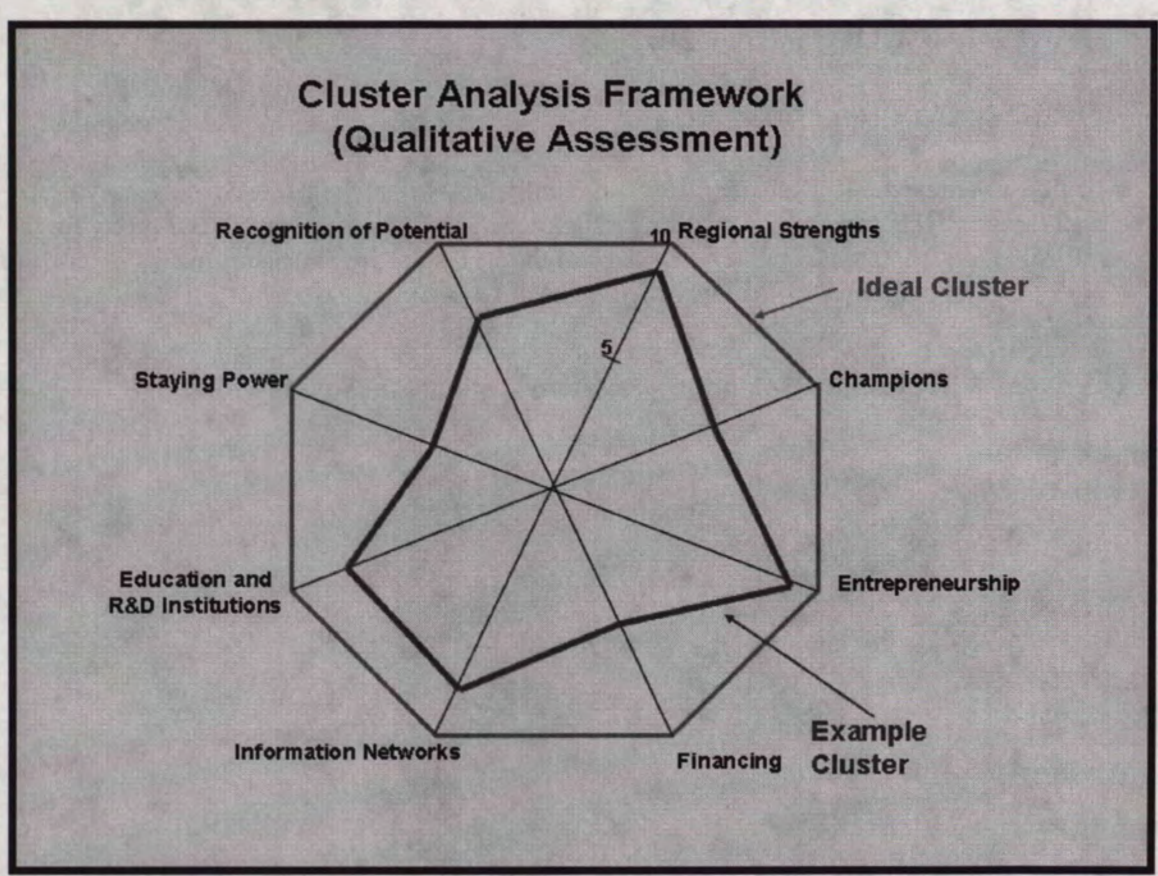
It should also be noted that local linkages are more important at the early stages of cluster development in terms of contributing to building critical mass sufficient to establish cluster credibility. In these early stages firms establish linkages mainly with the local infrastructure (e.g., universities, laboratories, industry associations, funding agencies). As firms grow they begin to establish external linkages (e.g., with clients, competitors, suppliers, investors) and tend to become more prominent in terms of their contribution to building critical mass of the cluster in the longer term. The cluster becomes more widely recognized and comes to be called a 'traded[4]' cluster because of its external commercial relationships (e.g., exporting

[4] Traded industries are those that are typically concentrated in specific geographic areas (clusters) and sell to markets beyond the local region.

firms, inward investment). The impact of linkages on critical mass over time is illustrated in the following diagram.



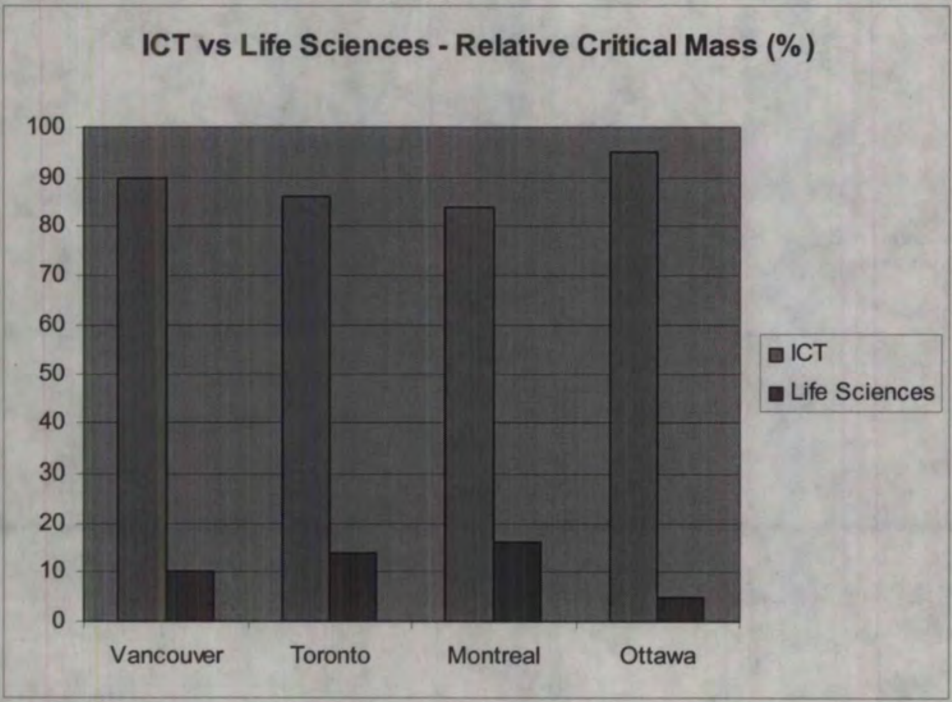
The eight characteristics of success need to work together at the level of the cluster. Following is the cluster analysis framework that was used to show the relative performance of the cluster to an ideal and compare the performance of one cluster to another. It can also show how the performance of the cluster changes over time.


Cluster Analysis Framework
(Qualitative Assessment)
Recognition of Potential
10
Regional Strengths
Ideal Cluster
5
Staying Power
Champions
Education and
R&D Institutions
Entrepreneurship
Information Networks
Financing
Example
Cluster

CANADIAN COMPARISONS

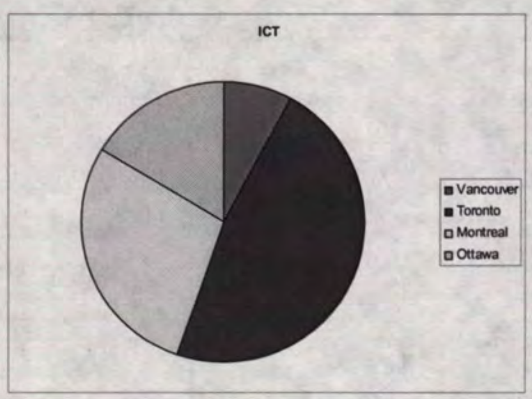
OVERALL COMPARISONS

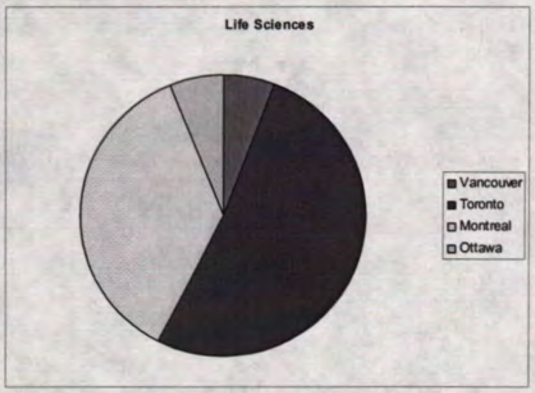
In all four cities, the ICT clusters are substantially larger than their Life Sciences counterparts. This can be seen in the chart below which uses employment as a proxy for critical mass. It illustrates the relative sizes of the ICT and Life Sciences clusters in terms of percentage of combined critical mass within each city.



Again, using employment as a proxy for critical mass, the following charts illustrate the relative critical mass of each of the four ICT clusters and each of the four Life Sciences clusters respectively.

RELATIVE CLUSTER SIZES – ICT AND LIFE SCIENCES





ICT CLUSTER COMPARISONS

Cluster Acceleration Factors

Following is a summary analysis of the four clusters based on key factors for accelerating cluster growth. The summary provides an indication of each cluster's current status relative to performance indicators for each factor.

Cluster Acceleration Factors	ICT Cluster			
	Vancouver	Toronto	Montreal	Ottawa
Achieving Critical Mass	• Employment: ~56,000[5] (~30,000)	• Employment: ~185,000	• Employment: ~110,000	• Employment: ~64,000
	• Companies: ~5,600[6] (~1,000 core) • Few MNEs	• Companies: ~9,000[7] (~3,500 core) • Dominated by MNEs	• Companies: >2,500 • Many MNEs	• Companies: ~1,500 • Many MNEs

[5] This is total for province. Number in () is Graytek estimate for Vancouver ICT employment.

[6] This is total for province. Number in () is Graytek estimate of core ICT companies in Vancouver.

[7] This includes very small firms and incorporated individuals. Number in () is Graytek estimate of core ICT companies in the GTA.

Cluster Acceleration Factors	ICT Cluster			
	Vancouver	Toronto	Montreal	Ottawa
	• Mostly <100 employees • Many new entrants	• Many >100 employees • Many new entrants	• Many >100 employees • Some new entrants	• Many >100 employees • Many new entrants
	• Financing: had all but dried up, showing some signs of improvement			
	• Patents: strong, particularly wireless	• Patents: not clear	• Patents: not clear but declining	• Patents: not clear
	• R&D contracts: little evidence	• R&D contracts: little evidence	• R&D contracts: some (Ericsson)	• R&D contracts: little evidence
	• Exporting firms: not available			
Capturing Spillovers	• Spin-offs: many (mainly universities)	• Spin-offs: many (mainly corporate)	• Spin-offs: some (mainly corporate)	• Spin-offs: many (mainly corporate & research labs)
	• Affiliate programs: not evident			
Minimizing Leakages	• Local sourcing : some (e.g., wireless)	• Local sourcing: some	• Local sourcing: mainly manufacturing	• Local sourcing: some (e.g., via Breconridge)
	• Local supplier development programs: not evident			
Encouraging Linkages	• Strong in wireless • Strong between universities and spin-offs	• Not generally evident • Some university-corporate, corporate-corporate, and corporate-supplier linkages	• Not generally evident • Some university-corporate, and corporate-customer linkages	• Mainly in telecom and photonics areas

Achieving Critical Mass

Vancouver. Employment is strong in the ICT cluster and there are a large number of companies, with many recent entrants. However, only a relatively small number of companies (probably not much more than 50) have more than 100 employees. VC investment has all but dried up in the last few years, although there are some signs that this is changing. Research funding has been stable but likely not sufficient. The number of patents is high, particularly in the wireless area where some 375 patents have been filed. There is little evidence of substantial R&D contracts being awarded.

Toronto. Employment is strong in the ICT cluster and there are a large number of companies, with many recent entrants. There are a large number of companies that have more than 100 employees, with the largest companies being predominantly multi-nationals. A number of the larger companies have retrenched during the downturn and in some cases closed their Toronto offices. VC investment has all but dried up in the last few years, although there are some signs that this is changing. Research funding has been stable but likely not sufficient. It is not clear how many patents have been filed. There is little evidence of substantial R&D contracts being awarded and there is concern that the current move to offshore R&D will impact the long term sustainability of the cluster.

Montreal. Employment is strong in the ICT cluster and there are a large number of companies, with many large indigenous companies (~35 in the sample profile) and a similar number of multinationals. The larger companies are concentrated in the intangible services area, predominantly telecommunications services and ICT professional services. The new media area is still small but viewed as strategically important and has a world class reputation. While the manufacturers have retrenched during the downturn and in some cases closed their Montreal operations, the services side has remained strong. VC investment has all but dried up in the last few years and is a major obstacle to cluster growth. Patenting in ICTs has declined by at least 20% since 2000. ICT R&D appears not to be extensive and mostly takes place in the private sector, primarily by Ericsson, and Ericsson has supported many university research projects.

Ottawa. Employment is strong in the ICT sector and there are a large number of companies with many new entrants as fallout from the economic downturn. Since existing markets have yet to rebound, many of these new entrants are addressing emerging market opportunities, including converging biotechnology areas. It is these emerging market opportunities that will likely provide the basis for long-term growth and sustainability.

In Sum: All four clusters have achieved substantial critical mass albeit by differing means and to varying extents. For example, the Vancouver cluster is based on a large number of small companies and considerable technical diversity. The Toronto cluster is built around the presence of many foreign multi-nationals and a large local market. The Montreal cluster is built around traditional manufacturing activities and the presence of some large ICT services companies. Ottawa has been built around a substantial telecommunications industry and a large local market (i.e. government).

All of these clusters are vulnerable to industry and market shifts, including the collapse of the telecommunications market (e.g., Ottawa and Montreal); offshoring of manufacturing, and increasingly R&D (e.g., Montreal and Toronto); the uncertainties of emerging markets (e.g., Vancouver and Ottawa); the uncertainties caused by an increasing presence of multinationals (e.g., Ottawa); and the financing difficulties endemic to the sector.

With the ICT sector in considerable turmoil and transition, substantial support is required to ensure that a healthy and vibrant sector emerges. Broad policy support is required in such key areas as:

- Commercialization support to stimulate growth of companies to 100 employees and beyond;
- Support for the development of executives capable of growing companies;
- Incentives to encourage multi-nationals to engage more extensively in R&D activities in Canada;
- Addressing the financing crisis inhibiting growth of the ICT sector; and
- Development of stronger linkages between industry and universities (particularly in the area of emerging technologies).

Capturing Spillovers

Vancouver has been very successful in creating entrepreneurial spin-offs, particularly from the universities, but the number appears to have slowed down, except perhaps in the software area. There is less evidence of established companies supporting spin-offs through affiliate programs.

Toronto appears to generate many entrepreneurial spin-offs, mostly from employees of established companies. These appear to be somewhat as a result of corporate downsizing and/or employee dissatisfaction rather than as a result of innate entrepreneurship. The universities also create spin-offs but the vast majority of graduates appear to gain employment with established companies. There is little evidence of established companies supporting spin-offs through affiliate programs, although some larger players appear to make targeted investments in existing local companies.

Montreal appears to be generally weak in terms of generating entrepreneurial spin-offs. The large majority of such spin-offs are from employees of established companies and the sense is that university spin-offs only account for about 20% of the total. In part this has been due to a lack of entrepreneurial culture, a situation that has apparently been changing significantly in recent years. Government support has been an important catalyst and this is now threatened with the change in government.

Ottawa has been very successful in creating entrepreneurial spin-offs, particularly from the major telecommunications companies (e.g., through the now defunct Newbridge and Nortel affiliate programs). There has also been significant spin-off activity through the national research laboratories (e.g., CRC). There is less evidence of university spin-offs in the ICT area.

In Sum: All four clusters have demonstrated an ability to capture spillovers. This has been predominantly from established companies, although there is significant evidence of university spin-offs, particularly in Vancouver.

In clusters where the entrepreneurial culture is strong (e.g., Vancouver and Ottawa), a key opportunity for ICT cluster development is to focus on the quality of the spin-offs rather than the quantity of new companies created. This could be achieved by placing an emphasis on providing increased commercialization support particularly to companies that demonstrate technology leadership, market understanding and management capability.

In clusters where the entrepreneurial culture is weaker (e.g., Toronto and Montreal), a key opportunity for ICT cluster development is to focus on creating a more attractive entrepreneurial environment that encourages company formation, particularly by university graduates.

In all cases, there is an opportunity to provide incentives to larger companies, including multi-nationals, to develop affiliate programs for supporting spin-offs of non-core activities.

Minimizing Leakages

Vancouver shows little evidence of local sourcing of products, and services or local supplier development programs, except perhaps in the wireless area where a survey showed that 46 of 67 wireless companies indicated that they collaborate with an average of eight companies or associations.

Toronto shows little evidence of local sourcing of products or of local supplier development programs, although the sheer size of the cluster suggests that some amount of this activity is undoubtedly taking place. There does appear to be a wide range of supporting services available and such service providers are active in the major associations. A central issue is the general lack of knowledge of the companies in the cluster and their capabilities.

Montreal provides evidence of a fair amount of local sourcing of products due to the nature and extent of the manufacturing area (i.e. a concentration of firms providing design engineering and contract manufacturing). The decline in manufacturing indicates that the nature of the business opportunity in this area is changing and that the focus of such companies needs to shift to activities where customer proximity is important (e.g., tailor-made, just-in-time manufacturing and new product introduction). The new media area is vibrant, the change of government not withstanding, and the full value chain is covered within the Montreal Metropolitan Community (MMC) (e.g., software platform, middleware, multimedia content, specialized consultants). There does appear to be a wide range of supporting services available and such service providers are active in the major associations. Language and culture considerations undoubtedly encourage local supplier relationships in these areas. Overall there appears to be little awareness and synergy among the various parts of the cluster (e.g., hardware, telecommunications services, new media).

There is evidence that the **Ottawa** ICT cluster is fairly mature and is supported by a broad range of products and services covering all aspects of the product life cycle, with the possible exception of adequate sales and marketing support. Breconridge appears to be a good example of a local company that is providing manufacturing services on an outsourced basis and helping re-vitalize manufacturing activities in the cluster.

In Sum: All four clusters have at least the potential for substantially minimizing leakages both within the cluster and between the cluster and local markets. A key pre-requisite is increased awareness of cluster capabilities through a reliable, and up-to-date, company database (e.g., the Ottawa Technology Database) and a mapping of such companies onto industry value chains (e.g., the wireless value chain developed by Wireless Innovation Network BC (WinBC)). Similarly, the annual surveys done by Doyletech on sourcing opportunities are a valuable way of raising awareness.

Since much of the ICT opportunity is in enabling other industries, it would make sense to link ICT value chains to the value chains of such industries. Value chain and sourcing opportunity mapping can be used as tools to help minimize leakages. Association activities need to be more tightly focused on encouraging local sourcing of products both within the ICT sector and across other sectors of the economy.

Encouraging Linkages

Linkages and partnerships can take many forms, including product development partnerships; market development partnerships; R&D alliances; educational and training linkages; innovation linkages; and industry-university linkages.

Vancouver. It appears as though these linkages are strongest in the wireless area where collaboration with companies and associations is widespread. University linkages are also strong across the ICT sector for companies that spin-out of the universities.

Toronto. These linkages are not evident in Toronto, except for university linkages with a few large companies (e.g., Nortel and Bell Canada). Some large companies have supplier and investment linkages with local firms, but for the most part appear to take a Canada-wide perspective rather than a cluster perspective on such linkages. There appear to be some linkages between ICT firms and companies in other sectors.

Montreal. These linkages are not evident in Montreal, except for university linkages with a few large companies (e.g., Ericsson) and the recently announced International Institute of Telecommunications (a private sector pre-competitive R&D consortium). There appear to be some supplier linkages between ICT firms and companies in other sectors, as evidenced by the nature and extent of the contract design engineering and manufacturing activities.

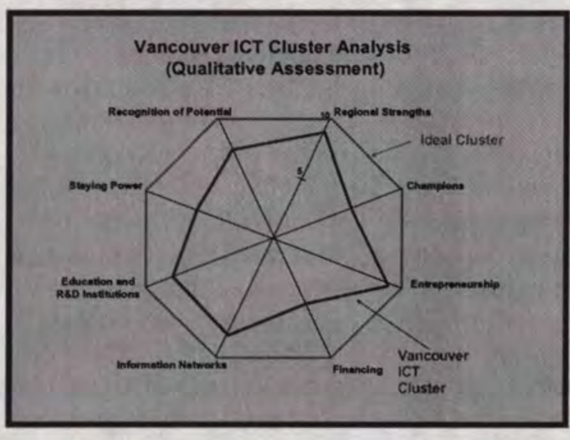
Ottawa. These linkages are most evident in the traditional areas of Ottawa's ICT strengths (e.g., telecommunications and photonics), these are areas where relationships have developed over time and cluster behaviour is well established. Industry/university linkages are not as well developed, except perhaps in the photonics area, and the focus of university research is in the Life Sciences area rather than areas of established ICT cluster strength. Linkages between multi-national ICT companies and local companies are not evident. Similarly, linkages between local ICT companies and the federal government are not evident except in the professional services area.

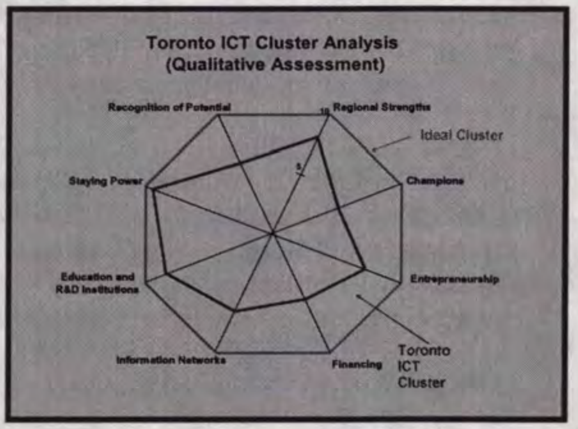
In Sum: Given the importance of ICT as an enabler of other sectors, a key opportunity is to encourage linkages between companies in the ICT sector and companies in other sectors. Sectors of importance vary by cluster (e.g., finance, automotive, manufacturing, retail and health in Toronto; aerospace, transportation and distribution in Montreal; and government in Ottawa). In addition, in several clusters, Life Sciences is also an important sector and provides significant opportunities for developing linkages (e.g., bioinformatics linkages in Vancouver and biophotonics linkages in Ottawa). Similarly, emerging new media industries provide opportunities for linkages with the ICT sector (e.g., Montreal and Toronto).

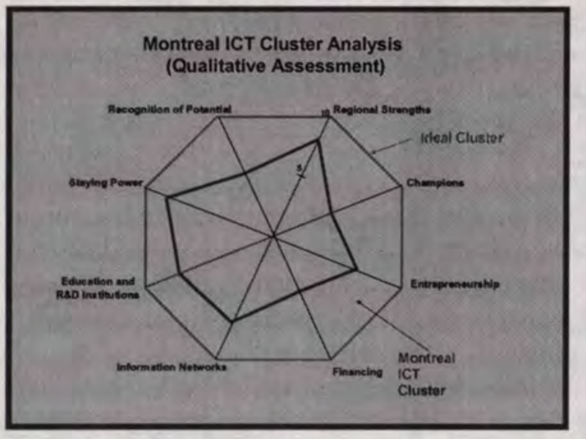
The proximity of Ottawa to Montreal also provides opportunities for Ottawa firms developing enabling technologies to establish linkages with the manufacturing, aerospace and business sectors of Montreal.

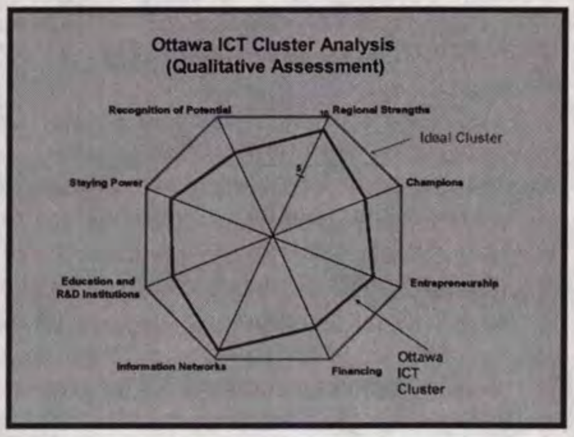
Cluster Success Factors

Following is a qualitative analysis of the four clusters based on eight characteristics of success that need to work together at the level of the cluster. The charts below provide a relative comparison of the operational dynamics of the four clusters and are intended to indicate areas where cluster behaviour is contributing to/inhibiting cluster growth. Care should be taken in interpreting these results as the individual clusters vary significantly in terms of size and composition.









Overall Cluster Behaviour

Vancouver The Vancouver ICT cluster is a diversified cluster with a reasonable level of critical mass, sufficient to survive the economic downturn over the last couple of years reasonably intact. The cluster is again showing signs of growth.

Toronto There is some question whether the behavioural dynamics of ICT firms in the Greater Toronto Area (GTA) is indicative of one cluster or three (i.e., Toronto, Markham and Mississauga), while others question whether the ICT firms actually exhibit cluster behaviour characteristics at all. However, the ICT sector in Toronto has shown resilience during the recent economic downturn and still has substantial potential for growth despite changing industry dynamics.

Montreal The ICT cluster in Montreal is mature with significant critical mass. However, the cluster is also in transition with new areas of expertise and growth rapidly emerging. In general terms, the manufacturing area is in decline and is re-structuring itself to meet merging opportunities. It has not exhibited significant cluster behaviour in the past. The new media area is the new growth area, building on Montreal strengths in animation, graphics and film production. Other areas (e.g., ICT professional services, telecommunications services, and software) have slowed down like elsewhere in the world but will probably resume growth. However the telecommunication equipment and software sectors are structurally weak. The non-manufacturing areas tend to exhibit stronger cluster behaviour patterns.

Ottawa While the Ottawa ICT cluster is considered mature, it is still substantially smaller than Silicon Valley by an order of magnitude, and therefore does not have the same level of critical mass as its southern counterpart. Also, compared with Silicon Valley, Ottawa is a more specialized cluster, with telecommunications equipment, chips and software playing a central role. Nevertheless, the cluster was able to weather the 2001 economic downturn despite being hit hard due to the collapse of the telecommunications industry worldwide.

In Sum: Cluster behaviour appears to be the strongest in Ottawa and Vancouver and is fairly well-developed in both clusters. In Toronto, cluster behaviour is less evident and tends to vary geographically within the GTA (e.g., it is particularly strong in Markham and less so in Toronto). In Montreal, cluster behaviour is relatively undeveloped at present (although this seems to be changing) and tends to vary by industry (e.g., it is strongest in the emerging new media area).

Recognition of Potential

Vancouver. Recognition of potential appears to have increased substantially with the recent change of government. There appears to be a significant commitment to the development of high-technology clusters, including ICT, but little evidence of constructive policies so far. Provincial level support appears to be taking a province-wide perspective and there is no clear definition of a Vancouver (or Lower Mainland) cluster. There is little evidence of concerted municipal support for developing the high-technology industries in general, and the ICT sector in particular, with the possible exception of the Vancouver Economic

Development Commission which acknowledges advanced technology as one of nine important economic sectors and helped form Leading Edge BC. It is interesting to note that according to Morgan Sturdy, former Chairman of the BC Technology Industries Association (BCTIA), public perception of ICT as the strongest driver of the economy dropped from 46% to 29% after the technology meltdown.

Toronto. Recognition of potential is relatively weak in the GTA, particularly in the City of Toronto. Recognition is strongest with the mayors of Markham and Mississauga and among the ICT business leaders themselves. While the ICT sector is a relatively large employer in the cluster, at an estimated 7.3% of the workforce in 2000[8], it is not at the heart of the economic base and hence does not gain the same recognition as other sectors of the economy. The somewhat distributed and diffuse nature of ICT sector activities and the fragmentation of economic development support in the GTA also work against increased recognition.

Montreal. Recognition of potential has been very strong at all levels of government, particularly the provincial level, since the mid-1980s. Provincial recognition has been less evident since the change in government. At the municipal level recognition has been fairly strong with the mayors of Laval and the former mayor of St. Laurent. There is no overall vision for the ICT sector in the MMC.

Industry recognition is strong by ICT executives who are very cognizant of the potential for the ICT cluster, non-ICT executives are less aware. While the ICT sector is a relatively large employer in the cluster, at an estimated 110,000 jobs overall, it does not gain the same recognition by the general population as other sectors of the economy. Montreal is recognized worldwide for its new media industry.

Ottawa. Recognition of potential appears to be very strong, particularly among the business community, as well as federal and municipal politicians. The city has a strong vision and includes an emphasis on high-technology clusters as part of its overall economic development plan. In reality this has not translated into action and support for clusters has diminished following the economic downturn. There is also the perception that the federal government does not fully exploit this potential through concerns about appearing to favour Ottawa over other regions of the country. Similarly, there is a perception that Ottawa has been treated by the Province as somewhat of a distant cousin to Toronto, again resulting in not fully realizing the potential, although this may change with the new government. Recognition appears to be lower in Gatineau than Ottawa because of the interest for a more diversified economy.

In Sum: Recognition of potential for ICT as a sector is fairly strong at the federal level for all four clusters, although ICT has not received the same level of support as other sectors of late (e.g., the automotive sector). It is apparent from the study that the future of the sector is

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[8] Source: Statistics Canada, Cat #11-622 MIE No. 003, page 27.

increasingly linked to its role as an enabler of other sectors of the economy. A key opportunity for the federal government is to substantially increase awareness of the enabling potential of ICT and translate this increased awareness into coordinated cross sector policies and initiatives.

Recognition at the provincial level is quite varied. It is particularly strong in BC following the change of government while it has declined significantly in Quebec also since the change of government. In Ontario, recognition for ICT seems quite weak, particularly as compared to Life Sciences sector, and there appears to be no overall strategy, and a lack of sector specific support programs, for ICT in the Province.

At the municipal level, recognition is certainly strongest in Ottawa, where cluster thinking has been integrated into the economic development plan for the City of Ottawa. Recognition is significantly less in the other clusters, except in isolated cities within the larger clusters (e.g., Markham and Mississauga). A key issue is the limited financial resources to provide cluster support at the municipal level.

Industry level recognition is generally fairly strong within the ICT sector in all clusters but less so in other sectors and among the population at large. Recognition suffers in clusters where ICT is not one of the leading economic drivers in the region.

A key opportunity is for the federal government to help stimulate broad recognition of potential in a variety of ways, including:

- establishing major ICT research facilities that leverage cluster strengths, particularly in areas of emerging and converging technologies;
- supporting initiatives aimed at encouraging increased use of ICT as an enabler in other sectors of importance to the key clusters;
- ensuring that ICT plays a significant role in supporting major infrastructure initiatives in the clusters; and
- generally supporting the development of comprehensive ICT cluster strategies at the provincial/municipal levels.

Regional Strengths

All four clusters have very well developed regional strengths.

Vancouver is widely acknowledged as one of the best places in the world to live. Physical infrastructure is well developed, in terms of both telecommunications and air transportation links, with good air transportation links to Asian markets. Proximity to Whistler is also a factor in increasing awareness of the region for visiting executives. The provincial government has been responsive in terms of making BC a good place to do business.

Toronto is viewed as a vibrant multicultural city that continues to attract a strong influx of new residents. The physical infrastructure is generally very strong with the exception of the transit system, and associated traffic gridlock, which has not kept pace with the needs of a growing major city. Toronto is the financial centre of Canada and the GTA forms a large part of the economic heartland of the country. This provides a stabilizing influence that allows the ICT sector to thrive and grow.

Montreal is also viewed as a vibrant multicultural city that is particularly attractive to European firms interested in doing business in North America. The physical infrastructure is generally very strong and the city has a well developed transit system as well as good domestic and international air, road, rail and sea links. Montreal has an extraordinary quality of life, a critical mass of companies, quality universities, a low cost of living and ease of doing business. The linguistic laws protecting French are sometimes seen as having a negative impact.

Ottawa is particularly strong in terms of physical infrastructure. A large federal government presence is also an asset in a variety of ways, including the physical presence of the CRC and the NRC, as well as justifying, in large measure, the direct air link to Heathrow. The new airport terminal enhances the image of Ottawa as a world-class city, although the number of international air links from Ottawa could still be increased. A strong base of high-technology companies is an important regional asset. Overall, Ottawa is a medium-sized city with a very good quality of life and provides an attractive environment for high-technology workers to live and raise their families.

In Sum: While all four clusters have well developed regional strengths, this is under increasing threat as the clusters grow. Urban sprawl and inadequate/ageing transportation infrastructure are of particular concern in varying degrees in all four clusters. A key opportunity is to link support for infrastructure development more closely to cluster development strategies.

Champions

Vancouver. Industry champions are evident in the Vancouver area but they do not have sufficient stature to be widely recognized and highly regarded across Canada. Since the wireless cluster is in a state of relative infancy, specific wireless champions are less evident and it is likely that future champions have yet to emerge. The same is true in the new media area. The biggest champion is the Premier, Gordon Campbell.

Toronto. Champions are generally not evident in Toronto. The mayors of Markham and Mississauga generally act as ICT champions for their own cities but no one speaks for the GTA as a whole. ICT business leaders are generally known within the sector and are perceived as champions by some sector participants. However, they generally lack the stature and profile within the business community as a whole to be viewed as champions more broadly. ICT is now viewed as a mature sector and the original business leaders are no longer active, or have moved on. Champions have not yet emerged from the new generation of leaders.

Montreal. Champions are relatively scarce in Montreal. There are a few high profile champions such as Serge Godin, Lionel Hurtubise and Lorne Trottier, but nowhere near enough. The former premier, Bernard Landry, was clearly a champion but, with the change of government, organizations such as Montreal International are left with the task of re-kindling the drive to achieve world-class recognition.

Ottawa. Industry champions are prevalent in the Ottawa area, although many of the earlier high-profile champions appear to be no longer as visible. A second tier of industry champions is very much in evidence and are often involved in, or running, sub-cluster groups in particular technology areas (e.g., wireless, software). A new generation of champions is just starting to emerge although they have yet to achieve the stature and recognition of their predecessors. No such legacy exists in Gatineau (except for Franz Plangger).

In Sum: Champions are an area of weakness in all clusters, except perhaps Ottawa. Where champions have existed in the past, they have often retired or moved on and a new generation of champions is only now starting to emerge in some clusters. One gets the sense of a sector that no longer generates the same level of enthusiasm and commitment as it did prior to the downturn; a sector that is still re-grouping; and a sector where the dynamism and vibrancy brought about by key champions is only now starting to re-kindle.

A key opportunity is to help attract such champions through well-funded research chairs; recruiting high profile former CEOs to run major ICT research facilities; encouraging the recruitment/repatriation of high profile industry executives, and/or providing incentives to successful entrepreneurs to become serial entrepreneurs (rather than retiring) and enhance their stature as role models.

Entrepreneurship

Vancouver. Entrepreneurship appears to be alive and well on the Lower Mainland, particularly in the wireless and new media industries where most companies are recent entrants. This is despite the apparent lack of substantive support for entrepreneurship in a city the size of Vancouver. The challenge is harnessing the entrepreneurial drive and turning the many start-ups into viable businesses.

Toronto. Entrepreneurship flourishes in the GTA with the formation of new start-ups continuing apace. However, there is a general sense that entrepreneurship support is somewhat limited and uncoordinated leaving many entrepreneurs to fend for themselves. It also appears that Toronto lacks a strong entrepreneurial culture. Rather, there is a feeling that reluctant entrepreneurs are forming companies due to changing business circumstances rather than entrepreneurial passion.

Montreal. Entrepreneurship has not always been part of the culture of the MMC. This has changed significantly in recent years and there is now a strong entrepreneurial spirit. Entrepreneurship is encouraged by government, universities and industry. There is fairly good support for entrepreneurs but still a lack of serial entrepreneurs.

Ottawa. Entrepreneurship is alive and well in the Ottawa cluster, although not necessarily in the traditional telecommunications area, and support for entrepreneurship is strong. The acquisition of Skystone in 1997 by CISCO was a seminal event that changed the culture of Ottawa and resulted in the strong entrepreneurial spirit in evidence today. The challenge is harnessing the entrepreneurial drive and turning the many start-ups into viable businesses.

In Sum: Entrepreneurship is very strong in Vancouver, almost to the point of being an obsession. In Ottawa, a major shift towards an entrepreneurial culture appears to have taken place over the last few years. Similarly, a growth in entrepreneurship in Toronto is evident in recent years, although perhaps more reluctantly than in Ottawa. Montreal has a less well developed entrepreneurial culture, although there is evidence that this has changed significantly of late.

A key opportunity is to re-enforce the importance of entrepreneurship through increased recognition of entrepreneurs; providing greater support for entrepreneurs throughout the innovation cycle; and stimulating entrepreneurial spin-off activity from universities.

Financing

Vancouver. Financing is apparently in plentiful supply, although investors are somewhat cautious following the recent telecommunications downturn and appear to be looking for established companies with demonstrable products. Seed and start-up financing is less evident (i.e. the first $1-2 million) and this is somewhat problematic. There is some evidence that investment interest is shifting from ICT to the emerging bio-tech sector.

Toronto. Financing is a major problem at this time, particularly in terms of seed and early stage investments. Angels and VCs alike appear to have stepped back from the ICT sector. They are typically only funding companies with well thought out business plans and demonstrable early business success. The economic recovery should help restore investor confidence if it continues to take hold. However, rebuilding the ICT investment pipeline will likely take a considerable effort.

Montreal. Financing is a major problem at this time across the board. Investors have been discouraged by the ICT downturn and are tending to favour other sectors such as biotechnology. The government previously played a major role in providing financial support for the sector and this has now been called into question, causing considerable uncertainty. Overall, the investment community is taking a cautious position with regard to ICT investments.

Ottawa. Financing is clearly the Achilles heel of the cluster. Even though Ottawa put itself on the investment map during the high-technology bubble, there is insufficient financing available at all levels of company development. Consequently, many of the entrepreneurial start-ups that emerged from the economic downturn are not expected to survive and the overall number of companies in the cluster is expected to decline. The challenge will be in securing longer term financing for the stronger companies in the cluster. Consolidation through acquisition is continuing apace. Gatineau firms have access to a little more government support to SME's, as well as a greater availability of venture capital from Montreal based venture capital groups.

In Sum: This is clearly the major weakness in all four ICT clusters across the board and particularly for the first $1-2 million of investment capital.

There are many views on how to address this issue but the overall message, that the federal government needs to play an important role, was clear. Key opportunities for the federal government include:

- Increasing the level of commercialization support at least through to proof of market;
- Improving tax incentives for early stage investments (e.g., exempt capital gains on start-ups if re-invested in similar businesses);
- Increasing mobility of capital within Canada, particularly with respect to labour sponsored funds; and
- Generally increasing the size of the capital pools within Canada for ICT investments.

Information Networks

Vancouver is strong when it comes to information networks, particularly formal information networks. BCTIA appears to provide the leadership in this regard and appears to be successful in promoting a technology culture. WinBC membership appears to be growing rapidly and the Vancouver Enterprise Forum (VEF) attracts good turnouts to its events, but overall the information networks appear somewhat fragmented. New Media BC currently includes over 130 new media companies. Vancouver is generally a very supportive high-technology community with many informal networking events and opportunities to rub shoulders, some think too many.

Toronto has strong formal information networks, particularly serving the major ICT concentrations in Markham and Mississauga, as well as the growing base of new media companies in downtown Toronto. There is also evidence that informal networking activities are strong in the new media area. At this time there appears to be a lack of effective pan-GTA information networking support aimed at increasing the profile and cluster dynamics of ICT in the GTA as a whole.

Montreal has a range of formal information networks, but lacks apparent coordination among them. Some areas such as manufacturing lack formal information networks and consequently are missing a key ingredient required to stimulate cluster behaviour. Montreal International is stepping in to strengthen information networks within the MMC.

Ottawa is certainly very strong when it comes to information networks, particularly formal information networks. Ottawa Centre for Research and Innovation (OCRI) is widely recognized as an excellent role model when it comes to facilitating and supporting the widespread dissemination of information among the high-technology community. In some ways, OCRI has become too successful and institutionalized. However, smaller, less formal networks have emerged to meet specific sub-cluster networking interests under the overall OCRI umbrella. Gatineau does not participate as it should in these networks.

In Sum: Information networks are very strong in Ottawa (a Canadian role model in this regard) and, to a lesser extent Vancouver. They are reasonably strong in Toronto and Montreal, albeit somewhat fragmented and inconsistent across geographies and industries within the cluster.

The challenge facing all clusters is to grow larger ICT companies that stay in Canada (acquisition by a foreign multi-national is not necessarily a problem as long as the company continues to maintain and grow its operations in Canada).

A key opportunity for growing ICT companies in Canada is to increase awareness of companies and capabilities within the cluster. A good database of company capabilities is a starting point. This needs to be accompanied by greater coordination of activities among the leading associations in the cluster (This is already happening in Ottawa and starting in other clusters). Targeted events aimed at introducing companies to other companies with similar business interests and with related multi-nationals is one approach to making the information networks more effective.

Another opportunity for growing ICT companies is to encourage the procurement of locally-developed products and to help promote such products in international markets.

<u>Education and R&D Institutions</u>

Vancouver appears to be well served by educational and R&D institutions and the University of British Columbia (UBC) is considered world-class. The universities appear to be adequately satisfying the needs of the sector in terms of technical skills, and capacity is continuing to increase. The weakness is in the area of applied skills, particularly in terms of management, marketing and commercialization. There appears to be substantial R&D occurring through the universities, which have traditionally had partnerships with the NRC to deliver their programs in the cluster. Consequently, the cluster has the potential to develop strong R&D linkages between the universities and the private sector. However, the perception is that such linkages are still relatively undeveloped at present. This is an area that warrants a more detailed examination in order to better understand how to exploit this potential.

Toronto is well served by a range of educational institutions and the University of Toronto (U of T) appears to have world-class status. These institutions seem to be meeting the majority of the ICT sector's current needs, although there is some concern that programming may not be keeping pace with the pace of technological change. There is also concern that the supply/demand balance may revert to a shortage as ICT sector growth accelerates following the downturn. University-based research is seen as strong although the extent of commercialization is a concern. Some support is also provided by other R&D institutions such as Ontario Centres of Excellence.

Montreal is well served by a range of educational institutions, including four universities, and McGill appears to have world-class status. The strength of these institutions is a major asset when attracting firms, particularly European firms, to the MMC. These institutions seem to be meeting the majority of current needs of the ICT sector although there is some concern about the lack of applied ICT skills. University-based research is seen as strong although the extent of commercialization is a concern. There is evidence of inter-university collaboration to address this commercialization issue.

Ottawa appears to be well served by Education and R&D Institutions in terms of quality and quantity of graduates. However, there are still plenty of unemployed experienced people available to meet many of the current needs thus lessening the demand for new graduates at present. University research tends to focus on Life Sciences rather than ICT and is spread too thin. There is a general lack of applied ICT research and industry linkages. There are plenty of research laboratories in Ottawa and these form an important element of the ICT cluster. Gatineau firms have somewhat the same access to federal labs but the Université du Québec en Outaouais does not offer any major engineering (except in software) or science programs.

In Sum: All four clusters appear to be well-served in terms of Education and R&D Institutions. The key issues here are an apparent mismatch between university priorities and industry requirements, particularly:

- The lack of applied skills in terms of management, marketing and commercialization; and
- A perceived lack of university/industry research linkages.

A key opportunity is for the federal government to take a leadership role in addressing the skills issue (e.g., through the Software Human Resource Council) and in fostering research linkages through focusing its research presence in the clusters (e.g., NRC) to more closely match industry needs.

Staying Power

Vancouver. The ICT cluster overall is viewed as being quite strong and diverse and has weathered the downturn fairly well. While manufacturing was hit hard, services continued to expand. Software experienced difficult times for a couple of years (except games). The wireless industry is an emerging area with a great deal of long-term potential as is the new media industry. The increased recognition of potential coupled with longer term policies aimed at stimulating cluster growth and the emergence of additional champions will likely be the keys to achieving the commitment required to develop the staying power required for long-term success.

Toronto. The ICT sector has substantial staying power due to the number and diversity of companies and the underlying strength of the local economic base in the cluster. Even at a time when large companies and multinationals were pulling back, the overall level of ICT business activity remained strong. The main threat to sustainability on the horizon is the significant trend to offshoring. This currently includes much of the former manufacturing activities and is extending to software development. As countries such as India and China move up the value chain, some are predicting that much of the R&D activity, or at least the development activities, will shift to these countries. On the other hand, Toronto is making progress as a nearshore destination for ICT services. According to McKinsey Global Institute, Canada did $3.7 billion in nearshoring in 2001 and several major Indian ICT service firms have opened operations in Toronto to service the North American market (e.g., TCS, Wipro and Infosys).

Montreal. The ICT sector in Montreal has substantial staying power due to the number and diversity of companies and the underlying strength of the local economic base in the cluster. Even at a time when the traditional manufacturing area has been in significant decline, the overall level of ICT business activity remained strong. The new media area, including animation, gaming, 3-D graphics, digital arts and digital media appear to be poised for substantial growth and the manufacturing area is in the process of restructuring to become more relevant to changing markets.

Ottawa. Ottawa has shown remarkable staying power in light of the economic downturn which hit Ottawa harder than many high-technology centres centers due to its specialization in the hardest-hit sector, namely telecommunications. This staying power can be attributed largely to individual entrepreneurialism, as well as an increase in government hiring. It is interesting to note that the cluster essentially weathered the downturn and has started to recover without any substantial government assistance. The challenge is to continue this recovery in light of difficult financial markets.

In Sum: All four clusters have demonstrated substantial staying power and generally weathered the economic downturn fairly well. The contributing factors to this resilience vary somewhat between clusters but generally include elements of technological diversity (particularly Vancouver and to some extent Ottawa and Montreal); strong local markets (particularly Toronto and Ottawa); and the inertia of good people committed to the quality of life afforded by all four clusters.

The challenge is to provide an environment conducive to growing larger ICT companies that stay in Canada and encourages multi-nationals to continue, and expand, their operations (particularly R&D) in Canada.

There are widespread suggestions as to how to achieve this but they generally fall into several categories:

- Encourage entrepreneurs, particularly serial entrepreneurs, to grow successful companies over time rather than selling out at the earliest opportunity;
- Provide incentives to venture capitalists (VCs) to make long term commitments to investing in companies from start-up through subsequent growth stages;
- Increase the pool of executive management talent capable of growing such companies (e.g., increase the support for management and business skills training through the education system; provide incentives to successful entrepreneurs to become serial

entrepreneurs; encourage the recruiting/repatriation of high profile executives from abroad);

- Encourage the procurement of locally developed products and help to promote such products in international markets; and
- Use government policy and procurement levers to encourage multi-nationals to increase their long-term commitment to Canada.

LIFE SCIENCES CLUSTER COMPARISONS

Cluster Acceleration Factors

Following is a summary analysis of the four clusters based on key factors for accelerating cluster growth. The summary provides an indication of each cluster's current status relative to performance indicators for each factor.

Cluster Acceleration Factors	Life Sciences Cluster			
	Vancouver	**Toronto**	**Montreal**	**Ottawa**
Achieving Critical Mass	• ~90 companies • >1,900 employees with another 1,400 in public institutions • A few large indigenous firms • Mostly SMEs <100 employees	• ~400 companies • >30,000 employees • A few large indigenous firms • Several MNEs • Many SMEs <100 employees	• >270 companies • >21,000 employees • A few large indigenous firms • Some MNEs • Many SMES <100 employees	• >100 companies • > 3,500 employees • 1 large indigenous firm • Few MNEs • Many SMEs <100 employees
Capturing Spillovers	• Spin-offs (mainly from universities)	• Spin-offs from universities and firms	• Spin-offs from universities and firms	• Spin-offs (mainly from universities)
Minimizing Leakages	• Need to develop supplier base	• Diversified supplier base	• Diversified supplier base	• Need to develop supplier base
Encouraging Linkages	• No pharma presence	• Few linkages among pharma,	• Few linkages among pharma,	• No pharma presence

Cluster Acceleration Factors	Life Sciences Cluster			
	Vancouver	Toronto	Montreal	Ottawa
	• Links between universities and biotech firms	biotech and medical devices firms • Links between biotech firms and universities	biotech and medical devices firms • Links between biotech firms and universities and other public labs	• 1 large indigenous medical devices firm with no local linkages • Links between universities and govt. labs and biotech firms

Achieving Critical Mass

The **Vancouver** life sciences cluster is populated mainly by small firms. A strategy needs to be set in place that will stimulate the growth of these firms. A strategy that integrates five BC clusters (i.e., ICT, wireless, new media, fuel cells, and biotechnology) is being developed. Elements of such a strategy could include setting in place a competitive business environment and procurement of drugs and equipment by the provincial government and the hospitals.

Since **Toronto** has a concentration of large pharmas, they could be encouraged to establish alliances with smaller biotechnology firms. The pharmas bring managerial and marketing expertise as well as money that can help the smaller biotechnology firms grow. Local procurement of drugs and medical devices can also stimulate the growth of firms.

Montreal needs a strategy that links research to commercialization. Montreal International has proposed a life sciences strategy. An element of that strategy would be to foster alliances between large pharmas and biotechnology firms. Other elements could include government procurement of drugs and medical equipment and demonstration projects in hospitals for medical devices.

Ottawa could pursue the initiatives set out in the Biotechnology Cluster Strategy document[9] and make strategic infrastructure investments in emerging areas. This strategy is part of a

[9] Ottawa and Eastern Ontario Biotechnology Cluster, *Biotechnology Cluster Innovation Program: Part 2, BIOTECHNOLOGY CLUSTER STRATEGY,* DRAFT, March 23, 2004.

broader activity, sponsored by the Ontario Government, to develop biotechnology strategies in 11 communities across the province.

In Sum: Strategies to stimulate the growth and the number of firms are at various stages of development in the four clusters. Ottawa is well on the way to developing and implementing a strategy. Vancouver has begun to grapple with an integrated strategy while Toronto's strategy might emerge from the Ontario Government's recent activity mentioned below (see Recognition of Potential, Toronto). Montreal International has proposed a life sciences strategy that it is promoting.

Capturing Spillovers

Vancouver has done very well in capturing spillovers from the research infrastructure in health-related biotechnology. To diversify the cluster and make it more stable, more attention needs to be paid to non-health sectors such as agriculture, aquaculture, environment and forestry, which are emerging. The non-health firms have the possibility of interacting closely with the relevant industrial sectors in BC (e.g., forestry, agriculture).

Toronto has significant capabilities in genomics and proteomics on which to build. These capabilities also offer possibilities to capture spillovers in bioinformatics. MaRS could become the principal instrument for capturing spillovers.

Montreal has significant capabilities in neurobiology, oncology, cardiovascular diseases, virology, epidemiology and immunology on which to build. To encourage the capture of spillovers in these and other areas the proposed Biocentre could be set in place to have a capability similar to that emerging at MaRS in Toronto. The Canada Health Infoway program could be revised so as to stimulate developments at the interface between the delivery of health information electronically and biotechnology.

Ottawa has a well-developed ICT cluster which can be used to build a converging technologies cluster that incorporates life sciences and medical devices. A 'technology broker' function could be set in place within universities to spot market opportunities, including those in converging areas. Since the cluster is well endowed with federal government laboratories, policies could be set in place to facilitate the transfer of technology from these laboratories.

In Sum: All four clusters have demonstrated an ability to capture spillovers. In biotechnology, spillovers come mainly from the universities. Mechanisms are being set in place to stimulate the transfer of technology out of the universities (e.g., MaRS in Toronto) and others have been proposed (e.g., Biocentre in Montreal; technology broker in Ottawa, which resembles such approaches in other jurisdictions). The UBC University-Industry Liaison Office (Vancouver) has been particularly successful in spinning-off firms based on university research results.

There is an opportunity to capture spillovers at the interface between ICT, medical devices and biotechnology. The ICT and medical devices clusters in the four metropolitan areas, which have developed over a long period of time, are major assets in the move towards developing converging technologies. The challenge is to break down the barriers between these three elements.

Minimizing Leakages

Vancouver needs to focus on developing the support infrastructure locally (e.g., clinical trial services) as much as possible. By aggregating demand for supporting goods and services, some local opportunities are likely to arise.

In **Toronto** MaRS offers the possibility of providing supporting services locally that are needed to stimulate the growth of biotechnology firms.

In **Montreal** the Biocentre would help to minimize leakages by putting in place support infrastructure. As well, there could be new training programs in areas such as bioprocessing.

Ottawa should maximize the use of local and regional suppliers.

In Sum: As the smaller clusters (i.e., Vancouver and Ottawa) grow, they will see the opportunity to put in place various supporting services. Major investments in infrastructure, such as MaRS and Biocentre, will be focal points for the development of support services.

Encouraging Linkages

Alliances could be promoted to encourage the consolidation of smaller firms in the **Vancouver** and **Toronto** clusters.

In **Montreal,** linkages could be encouraged between the well-established pharma and medical devices firms, and the biotechnology firms, to develop converging technologies and products.

Ottawa could link up more closely to the Montreal Life Sciences Cluster. Universities and firms could establish local links with MDS Nordion, the only indigenous major life sciences 'anchor tenant' in the cluster. In some areas, such as agriculture, manufacturing and the research base in growth areas (e.g., biopharma, biofuels), all the elements of the value chain could be linked more closely. Gatineau firms and agencies could establish closer ties with Ottawa-based firms and institutions. This emerging cluster still has to establish strong internal linkages that help to build critical mass before it is able to forge credible external linkages.

In Sum: Clusters are defined by their capabilities and local linkages. The life sciences clusters studied all have capabilities, some more than others (see below). But what about local linkages? They seem to be lacking by and large. Consider the following;

- Clusters are made up of capabilities in pharmaceuticals, biotechnology and medical devices. These three components are very different from each other and do not appear to interact closely.

- Branded pharmaceutical firms in Canada are, by and large, subsidiaries of multinational firms. Strategic decisions are made elsewhere. A recent study has made proposals to bring Canadian capabilities to the attention of the headquarters of big pharmas and to establish better linkages between the pharmas and these Canadian capabilities.[10]
- Biotechnology firms are mainly indigenous, rather small and emerging. They have a variety of molecular platforms to address specific diseases, which makes linkages among them difficult. Moreover, they do not interact easily with the large pharmaceutical firms that have an independent existence. There are, however, strong linkages with the universities from which most of them have emerged.
- Medical devices firms cover a wide spectrum of activities (e.g., from lab supplies to x-ray machines) and this makes it difficult to identify common threads that could create some cohesion. Moreover, they do not interact closely with either the big pharmas or the biotechnology firms.

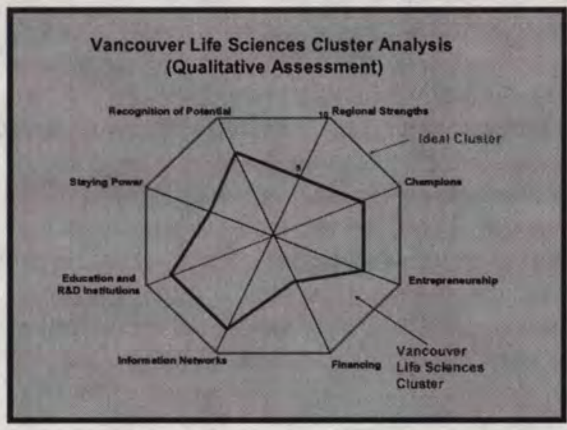
Given this dynamic, how are linkages to be created within and among the three elements of the life sciences cluster? Some approaches have been suggested above. As well, the focus could shift to the sub-cluster level where specific components can come together to create synergies. This is the case in Laval (Montreal), for example, where a focus is emerging on veterinary vaccines; and in Ottawa where a number of projects have been proposed that will create some 'glue' among players around specific objectives.

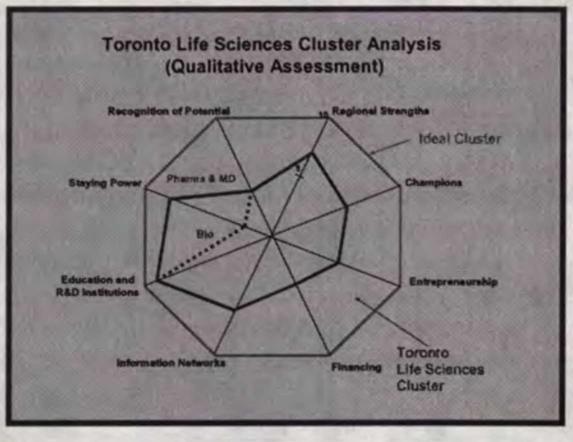
The newly formed Life Sciences Forum could go some way towards forming linkages between biotechnology and pharmaceutical firms in Canada.

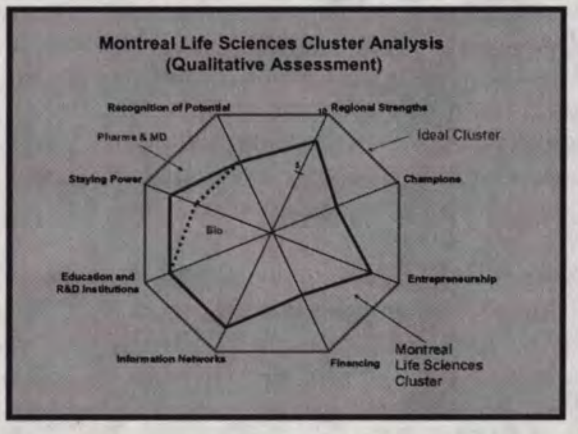
Cluster Success Factors

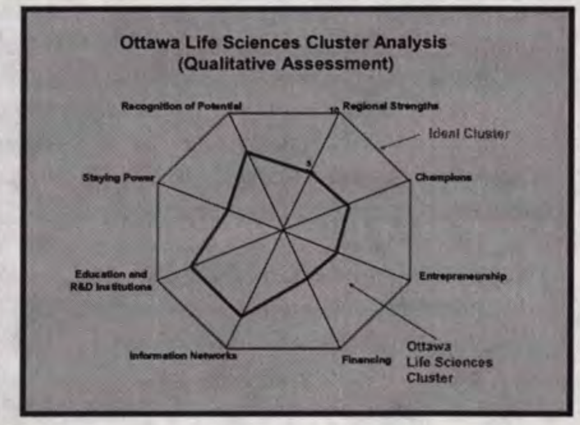
Following is a qualitative analysis of the four clusters based on eight characteristics of success that need to work together at the level of the cluster. The charts below provide a relative comparison of the operational dynamics of the four clusters and are intended to indicate areas where cluster behaviour is contributing to/inhibiting cluster growth. Care should be taken in interpreting these results as the individual clusters vary significantly in terms of size and composition.

[10] Secor, *Realizing the Full Benefits of the Canadian Innovation-Based Pharmaceutical Industry*, prepared for Merck Frosst Canada, May 2003.









Overall Cluster Behaviour

Vancouver has an emerging biotechnology cluster populated with SMEs. There is no local pharma presence to interact with the biotechnology firms. It is a fragile cluster with one dominant firm, QLT, responsible for 87% of cluster revenues.

Montreal has diversified capabilities in the three cluster components, biotechnology, pharmaceuticals and medical devices. The potential for R&D driven cluster development is well-recognized and there are activities in place to promote the development of the cluster.

Toronto, like Montreal, has diversified capabilities in the three components of the cluster. However, the dynamics of the cluster appear to be more 'laisser-faire'. The establishment of MaRS could give more focus to cluster development.

Ottawa is an emerging biotechnology cluster. There is also a relatively significant medical devices component. There is no local pharma presence. However, there is a major anchor tenant, MDS Nordion, which could be harnessed to drive the development of the cluster. To do this, a first step would be to identify Nordion's needs that could be met locally. Then, as a second step, projects would have to be set in place that would respond to those needs. These projects could range from building new research capabilities at the universities to establishing new supplier firms or new capabilities within existing supplier firms.

In sum: The Vancouver and Ottawa clusters are situated in smaller municipalities and appear to have more profile and cohesion than the Montreal and Toronto clusters which are situated in large conurbations with a lot of activities competing for attention. However, Montreal appears to be better at raising the profile of its cluster than Toronto.

When comparing cluster dynamics in the above diagrams, Toronto and Montreal are directly comparable because both clusters have pharmaceutical, medical devices and biotechnology firms. Similarly, Vancouver and Ottawa can be compared to each other because neither has pharmaceutical firms.

Recognition of Potential.

The potential of the life sciences clusters in the smaller metropolitan areas of **Vancouver** and **Ottawa** seems to be more recognized by the local leadership. This could be due, at least in part, to the fact that they represent a more significant proportion of new economic activity locally. However, there is concern that recognition may not translate into activity. For example, the budget of the Ottawa Life Sciences Council, the cluster's principal advocate, was cut back by the municipality.

In **Montreal**, the potential was well recognized by the previous provincial government but the current government has been removing its support from new economy sectors so recognition of potential has slipped at the provincial level. However, there is strong support at the local level through the mayors of Montreal and Laval, for example, as well as through the Life Sciences Committee of Metro Montreal, made up of about 30 key decision-makers.

In **Toronto**, recognition is difficult to obtain outside the life sciences community because the cluster represents only a very small proportion of overall economic activity (e.g., about 1% of total employment). The Ontario Government's Biotechnology Cluster Innovation Program to help 11 communities to develop biotechnology strategies and programs, and the establishment of MaRS, may improve the profile of the cluster within the local leadership.

In sum: Recognition of potential can fluctuate over time depending on the interest and priorities of the leadership; Vancouver and Toronto appear to be in the ascendancy while Montreal and Ottawa have suffered setbacks.

Regional Strengths

Montreal seems to have better developed regional strengths than the other clusters. It hosts the largest research oriented life sciences cluster in Canada (see Appendix A). The MMC has a strong industrial base; well-developed research capabilities that have the ability and support to commercialize research findings including business incubation, financial support in the form of tax incentives, and access to the largest concentration of venture capital for the life sciences in Canada.

A major strength of **Toronto** is the diversity of its industrial capabilities related to Life Sciences and the extensive research capabilities of the GTA's universities and hospitals. However, while these capabilities cover the overall value-chain, they remain disparate. The GTA is without much of a feeling of community and without a core identity and clear leadership.

Vancouver's major asset is its setting and quality of life, which is a major attractor of skilled people. Since the Life Sciences cluster is only emerging, there is a lack of maturity and limited industrial strength; almost all the firms are SMEs. As well, Vancouver lacks major pharmaceutical firms that can partner with biotechnology firms. Vancouver firms tend to sell their intellectual property, or enter into agreements with larger firms elsewhere.

Similarly, **Ottawa** has an emerging Life Sciences cluster which has a significant medical devices component. The cluster also has a major 'anchor tenant', MDS Nordion, a converging technology firm, which, however, does not have any linkages to the R&D capabilities in the cluster. The well-developed ICT cluster is a major asset that will help position the Life Sciences cluster in converging technology areas. The cluster has major R&D capabilities in its universities and federal government laboratories. Despite the fact that Ottawa ranks quite high on the research funding, it is underperforming relative to other Canadian universities in terms of licensing income and spin-off activity[11]. Ottawa-Gatineau is also known for its quality of life which attracts skilled people.

In sum: Montreal and Toronto have diversified capabilities, which are their strengths. Vancouver and Ottawa do not have such diversification but are focused on their emerging biotechnology sectors to develop strengths based on existing research capabilities. They also promote their quality of life as major assets to attract skilled people.

Champions

Interviewees in Vancouver seem to feel that they have more champions. Interviewees in other Life Sciences clusters felt less well endowed with champions.

Vancouver's Life Science cluster seems to be very dynamic and people are well informed. This could be due, at least in part, to the fact that it is a small cluster that has concluded that it can do more with less; that is, it has exhibited a high degree of commercialization from the relatively modest research base when compared with US biotechnology clusters[12].

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[11] PricewaterhouseCoopers, Ottawa and Eastern Ontario Biotechnology Cluster, *Biotechnology Cluster Innovation Program: Part 1, REGIONAL INNOVATION PROFILE,* DRAFT, March 10, 2004.

[12] Vancouver Economic Development Commission *et al., Vancouver: A North American Biotechnology Centre,* October 2002.

In sum: All four clusters have champions; either individuals or industry associations. While these champions promote and support activities locally, none appear to have the international stature needed to attract foreign investment and skilled people.

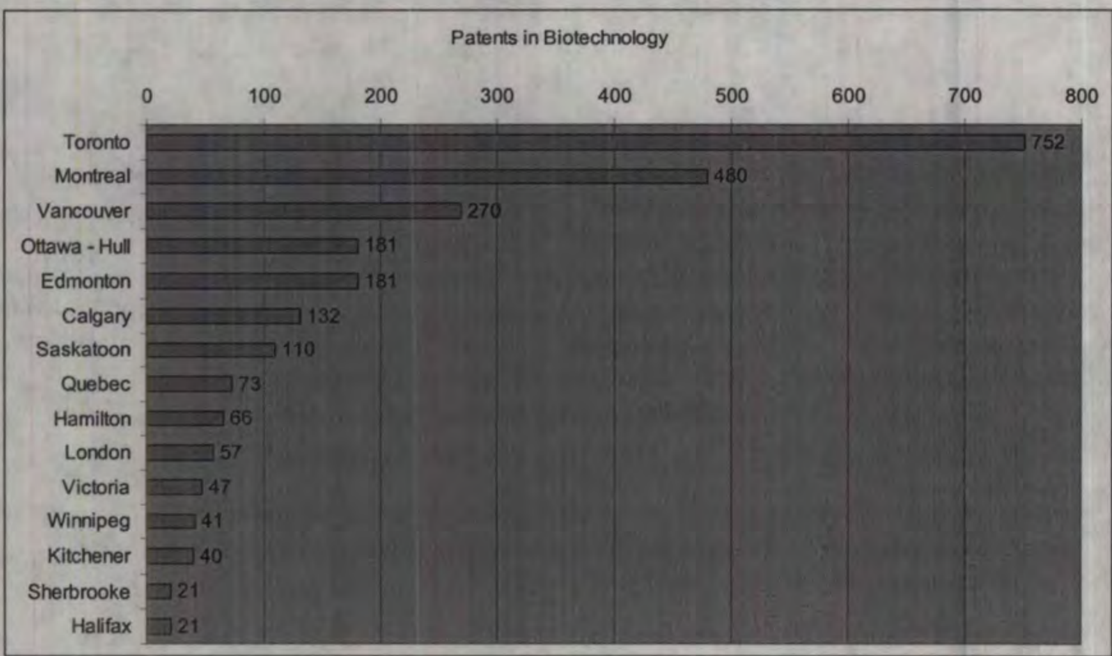
Entrepreneurship

Interviewees in Montreal and Vancouver felt that their clusters have a high level of entrepreneurship, while interviewees in Toronto and Ottawa felt that their clusters have a lower level of entrepreneurship.

One indicator of entrepreneurial dynamics is patent counts, especially in the emerging biotechnology segment of the life sciences clusters. The chart below shows that for the period 1990 to 2003, in absolute terms, Toronto dominated, followed by Montreal, Vancouver and Ottawa tied with Edmonton. The definition of biotechnology used in this chart is a broad one that includes enabling technologies such as processes, testing/measurements and apparatus as well as the usually recognized sectors such as human health, agriculture/aquaculture, environment, food processing and natural resources.

If CMA size is taken into account (i.e. population) then the order becomes Ottawa, Toronto, Vancouver and Montreal, which is the reverse order to the perceptions of the interviewees. Using population as a common denominator may be too broad an approach since entrepreneurship occurs at the level of the firm, especially within small firms.

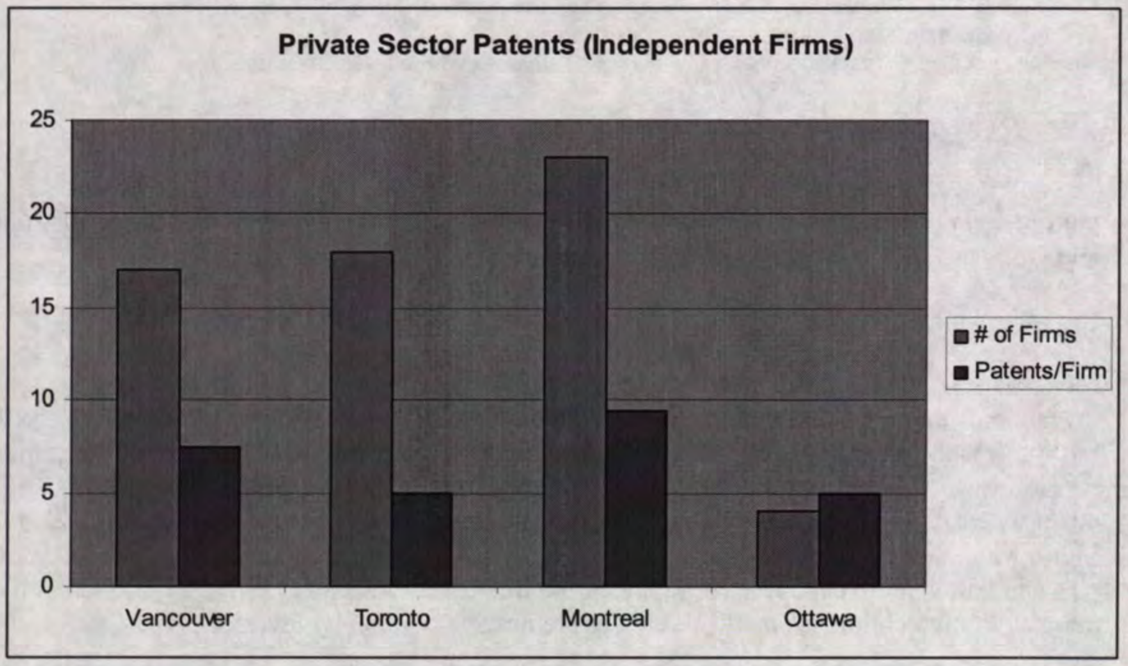
US BIOTECHNOLOGY PATENTS BY CMA (1990-2003)



Source: Science-Metrix; Benchmarking of Canadian Biotechnology Patents at the National and International Levels, 1990-2003; Prepared for the Canadian Biotechnology Secretariat (USPTO data).

Many small Canadian firms have been established in recent years and a different picture emerges when the patenting activity of these firms is separated from the larger, well established, foreign-owned firms as shown in the chart below. If the average patenting activity of these independent firms is taken as an indicator of entrepreneurship, then the pattern is more in keeping with the perceptions of interviewees as to the level of entrepreneurship in their respective clusters with Montreal in the lead followed by Vancouver.

PATENTING ACTIVITY OF INDEPENDENT FIRMS IN BIOTECHNOLOGY AND PHARMACEUTICALS (1995-2004)



Source: Dr. Jorge Niosi, Appendix A (USPTO data)

Another indicator of entrepreneurial dynamics is the number and value of research alliances that biotechnology firms establish with international pharmaceutical firms. The table below presents this information for the 31 research alliances established during the period 1999-Aug. 2004. The table indicates that Vancouver had the largest number of alliances with the resulting highest value, followed by Montreal.

NUMBER AND VALUE OF BIOPHARMA RESEARCH ALLIANCES BETWEEN 1999 AND AUGUST 2004

	Vancouver	Toronto	Montreal	Ottawa
Number of Alliances	14	7	10	0
Value ($M)	$511 (12)	$91 (3)	$190 (8)	$0

Data Source: Peter Winter (See "US Comparisons" section, table "Biotechnology Research and Commercialization Activity by Canadian Cluster", note e)
Note: the numbers in brackets indicate the number of alliances whose $ value was disclosed.

All four clusters have organizations that support entrepreneurship.

In sum: An analysis of patenting activity appears to support the views of interviewees re entrepreneurship; i.e. Montreal and Vancouver seem to be more entrepreneurial than Toronto and Ottawa. The research alliances information supports this observation.

Financing

Metro **Montreal** was the Canadian leader in 2002, attracting more venture capital investments than its closest competitors, Vancouver and Toronto, combined. More than $170 million was invested in Montreal in 2002. However, this represents a 17% decline from the previous year. This substantial activity in venture capital is a result of the high rate of business creation between 1991 and 2001, when more than 70 biotech firms were founded in Metro Montreal. For the third consecutive year, Metro Montreal attracted more than 30% of all Canadian venture capital investments in the life sciences sector[13]. Financing goes mainly into health biotechnology; medical devices are not as favoured by investors. The Quebec Government is cutting its financial support of new economy sectors. This is affecting the ability of Quebec-based firms to get financing.

Toronto is Canada's principal financial centre. There are various sources of capital, some of which are dedicated to the Life Sciences. Canadian firms and multinational firms have different views on financing issues. Canadian firms feel that there are not adequate sources of investment capital available in Canada. Firms turn to the US for financing because of the large pools of capital that are available. On the other hand, US multinational firms which have a presence in the GTA, see the Canadian business environment as competitive. They

[13] Montreal International, *The Metro Montréal Life Sciences Industry*, 2003.

can benefit from a lower costs structure due to the exchange rate as well as from generous R&D tax credits.

In **Vancouver**, companies seeking financing in the $1-5m range often have not achieved the market credibility required by investors. To get more significant funding (e.g., more than $10 million) it is necessary to go to the US because Canadian capital pools are not large enough. Funding of medical device projects is even more difficult because the opportunities are not well understood by the investment community.

Ottawa has a long history of financing high-technology firms and a sophisticated venture capital community has developed. However, only about 26% of local angels have indicated a strong interest in investing in the biotechnology area[14]. This could be due, in part, to the fact that investors are more familiar with the ICT sector. However, since 2000, despite the general downturn in technology financing, financing in regional life sciences ventures went up by almost a factor of five to reach $50 million in 2003. The major sources of financing for life sciences lie outside the cluster, mainly in the USA.

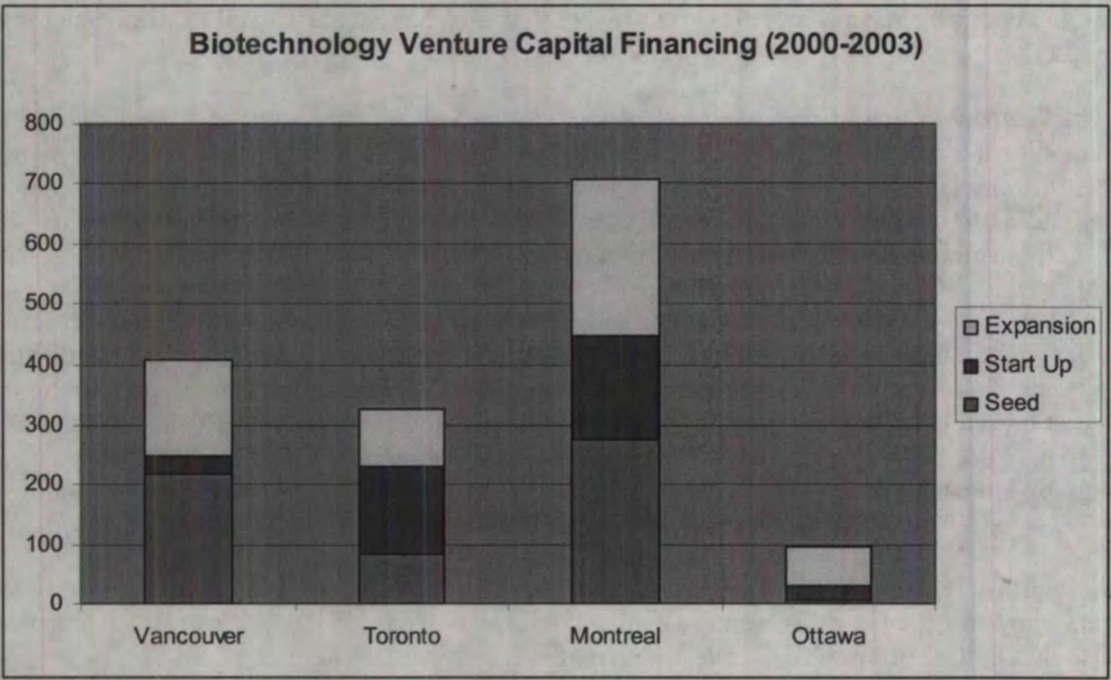
Financing remains a key problem across clusters. Because of the rapid growth in start-ups in recent years, the Canadian venture capital community would like to see some consolidation so that larger entities with a better chance of success could be funded.

One way of appreciating the dynamics in the four clusters is to examine the financing of the biotechnology element of each cluster, which is the newer sector of activity. Some of this information is given in the table below. For more details see Appendix B.

During the 2000-4 period, venture capitalists invested $2.1 billion in Canadian biotechnology. Over two-thirds of that amount was invested in four clusters: Montreal, Vancouver, Toronto and Ottawa in that order. The distribution is shown below. The following observations can be made;

- Vancouver had its major funding in seed financing with expansion in second place;
- Toronto had almost 50% of its financing in the start-up category;
- Montreal had a bimodal distribution in seed and expansion financing;
- Ottawa had most of its financing in the expansion phase.

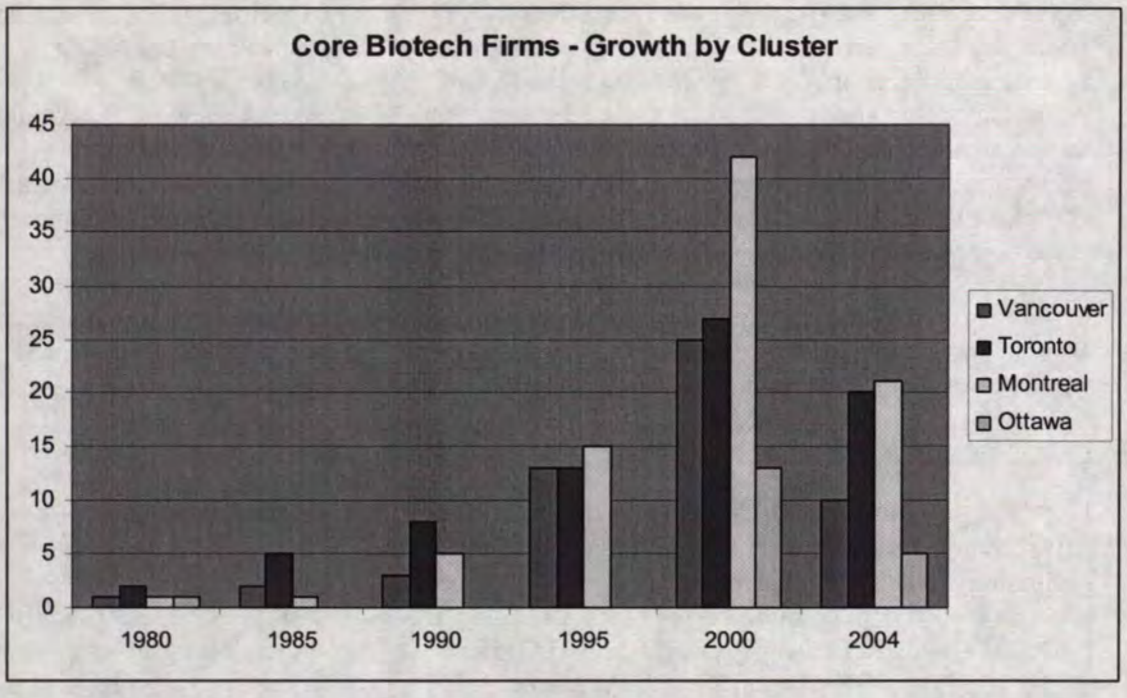
[14] PricewaterhouseCoopers, Ottawa and Eastern Ontario Biotechnology Cluster, *Biotechnology Cluster Innovation Program: Part 1, REGIONAL INNOVATION PROFILE,* DRAFT, March 10, 2004.



Source: Dr. Jorge Niosi, Appendix B (based on data from Mary Macdonald and Associates)

These trends indicate that, if venture capital is taken as a measure of the stage of the cluster, Vancouver looks like a young and emerging cluster, Toronto as a mature one, Montreal has both young and mature companies, and Ottawa seems a rapidly maturing cluster with little renewal. (See Appendix B for details)

In sum: All four clusters felt that financing is a major issue, especially for the biotechnology segment. Like the ICT sector, Life Sciences were affected by the economic downturn of 2000-01. As can be seen from the following chart, the growth in number of biotechnology firms, for example, declined after the downturn.



Data Source: Peter Winter

Information Networks

In **Toronto**, there are the following principal groups: The Toronto Biotechnology Initiative (TBI) which appears to be the prime body that facilitates networking for the Toronto Life Sciences community; the newly formed Biotechnology Council of Ontario (BCO) which will be one voice for all the jurisdictions in Ontario; the MaRS incubation facility which could become an important focus for networking; and the Association of Ontario Medical Manufacturers, established in 1995, which has some 50 or so members, represents the medical devices sector and is located in the Innovation Synergy Center in Markham.

In **Montreal** there are several groups including Montréal International, BioQuébec and the Association of Health Technologies Industries (AITS). At the national level there is Rx&D. There are also two important trade shows, Biomedex and Biocontact.

Vancouver has information networks at both the general (e.g., BC Biotech) and specialized levels (e.g., VanBUG in bioinformatics). The Life Sciences community is relatively small so that people know each other and are well aware of what is happening.

In **Ottawa,** the Ottawa Life Sciences Council (OLSC) is the principal networking body. The emphasis of OLSC activities has shifted from design to assembly in the design/assembly/manufacturing cycle – this is essentially a move from value creation to value capture.

A problem with these organizations is that their focus is on their specific clusters, which does not facilitate interactions between clusters to stimulate the development of converging technologies. In the medical devices area some firms even prefer to belong to high-technology associations such as the Canadian Advanced Technology Alliance (CATA) and the Information Technology Association of Canada (ITAC). There is a need for more interaction and possible consolidation of these entities. As well, a recent Conference Board of Canada report indicated that early-stage clusters are more likely to report that community-based organizations are more helpful than mature-stage clusters[15].

In sum: Montreal and Vancouver seem to have excellent information networks, while Toronto and Ottawa do not appear to be as well endowed with such networks. All clusters have entities that encourage networking through their projects and events.

Education and R&D Institutions

The **Vancouver** area has significant educational and R&D institutions. The universities (UBC, Simon Fraser University (SFU)) and colleges (British Columbia Institute of Technology (BCIT)) produce the skilled people. There are specialized university-based research groups with good ties to the hospitals. There are some 'star' researchers. The UBC University-Industry Liaison Office (UBC-UILO) has the best commercialization track record in Canada; about 70% of local biotech firms emerged from UBC. This is in keeping with the fact that the Vancouver university patenting index is much higher than those in the other jurisdictions (see below). While the biological capabilities are well developed, those in chemistry need to be built up.

Montreal has four universities and 125 public and para-public research centers and more than 8,200 researchers. These organizations include universities, research institutes, centres, networks, groups, laboratories, units, and chairs (see below). The areas of research that stand out are neurology, bioneurology, oncology, cardiovascular, virology, epidemiology and immunology. The universities have some 30 'star' researchers who are pivotal to the advancement of biotechnology. Montreal universities have the best patenting record in absolute terms and the second best in relative terms (see below).

Toronto is well endowed with relevant educational and research institutions within two universities (U of T, York) and its hospitals. For example, the University of Toronto has the largest faculty of medicine in North America. The Hospital for Sick Children has Canada's largest computing facility dedicated to biological research in its Bioinformatics Computing Centre. The output of peer-reviewed publications coming out of this complex (eight teaching hospitals and U of T), as listed in Medline, is greater than every medical center in the world

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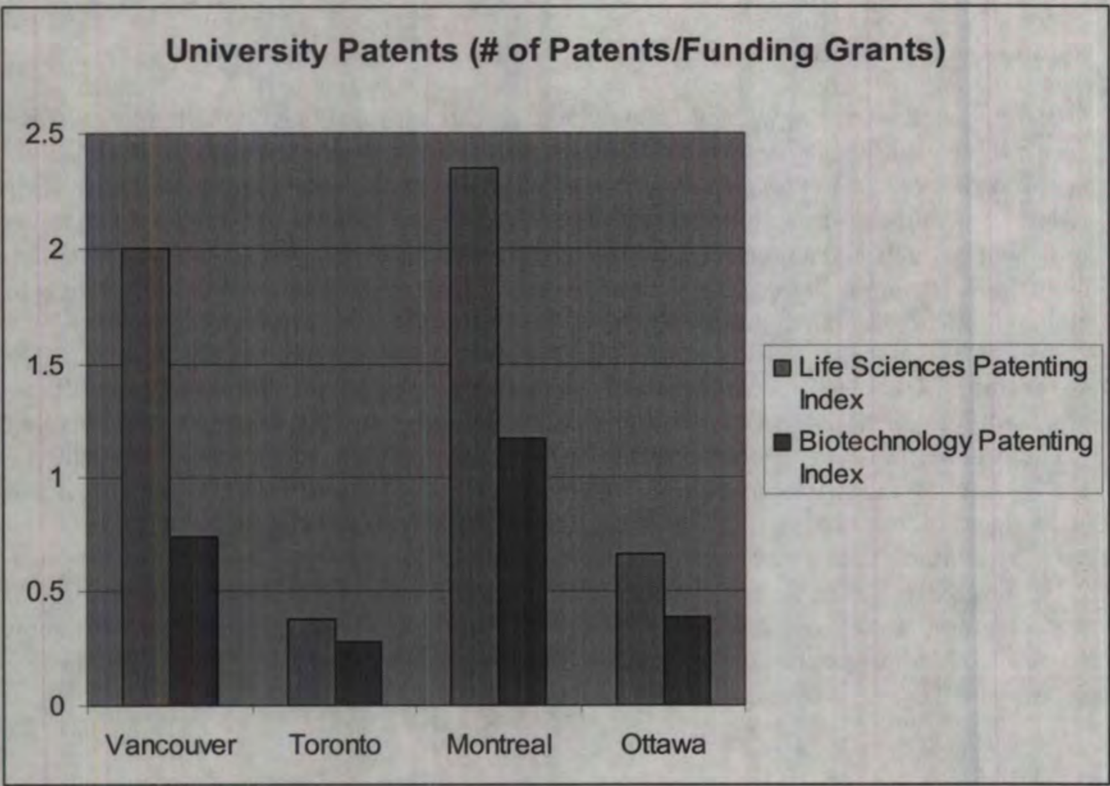
[15] Trefor Munn-Venn and Roger Voyer, *Clusters of Opportunity, Clusters of Risk*, Conference Board of Canada, August 2004, p. 14.

except Harvard. There are some 30 'star' researchers. Hamilton's McMaster University also has internationally recognized research capabilities in its medical faculty.

Ottawa is well-endowed with educational and research institutions. In the human health sector there is university-based research expertise in areas such as cancer, cardiovascular, health care services, neuroscience and stem cells. There are a few 'star' researchers. The federal government research institutions in the cluster are well placed to support emerging thrusts in biofuels and converging technology domains such as bioinformatics. Currently, there are 6-10 spin-offs from the cluster's research base. However, a major challenge is to commercialize research and grow firms.

Patenting of University Research: The universities are major players in spinning off biotechnology firms. To get a sense of this potential, the patenting activity of the universities in each cluster, which is related to the ability to commercialize research results, was reviewed and a patenting index was developed. The total university patents in both life sciences in general and biotechnology in particular, for the period 1995-2004, were put on a comparable basis by relating them to the size of the relative university research activities as expressed by CIHR/CFI/NIH[16] grants in each cluster. The year 2003 for research funding was chosen as being representative since this data was available for the US comparisons. The index shows that Vancouver universities are in the lead, followed by Montreal universities with the Ottawa and Toronto universities further behind.

[16] Canadian Institutes of Health Research/ Canada Foundation for Innovation/ National Institutes of Health

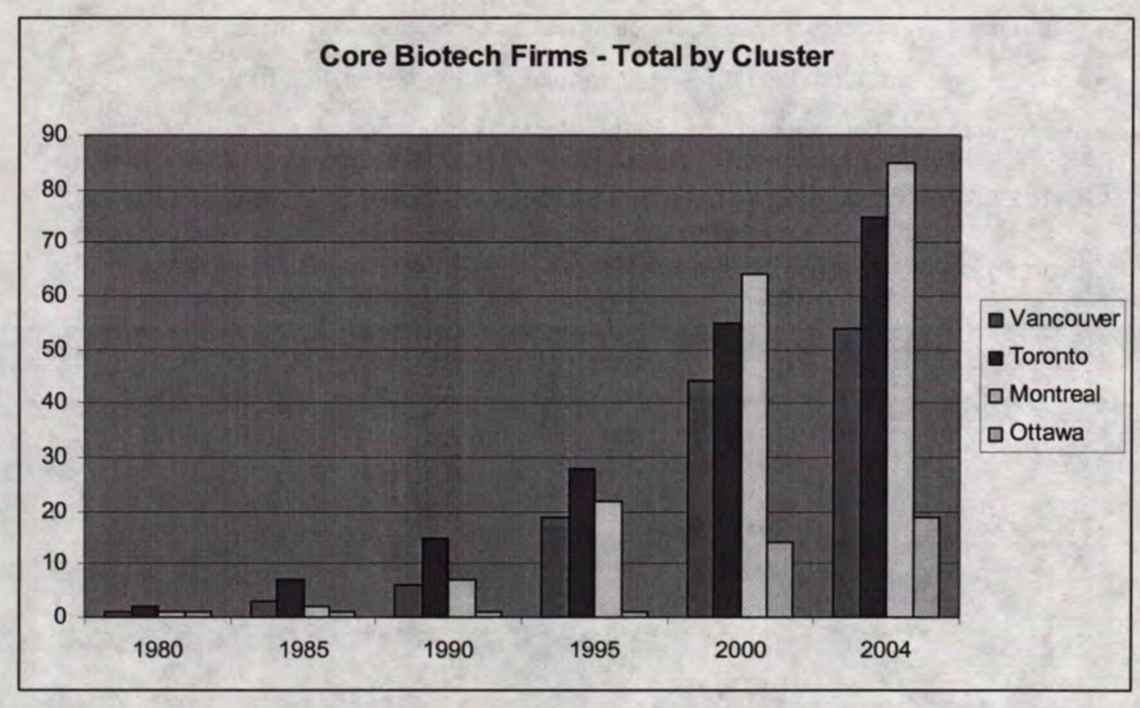


Data Sources; Patents, Dr. Jorge Niosi, Appendix A (USPTO data); Research Grants, CIHR/CFI, private communication; NIH from NIH web site

In sum: All four clusters believe that they have strong educational and research capabilities; somewhat less so in Ottawa. As can be seen from the table entitled "Biotechnology Research and Commercialization Activity by Canadian Cluster" in the "US Comparisons (Biotechnology)" section of this report, Ottawa universities receive fewer CIHR grants.

Staying Power

The Life Sciences clusters in Montreal and Toronto have more staying power because they have well-established pharmaceutical and medical devices sectors and a well-developed support infrastructure. However, their biotechnology sectors are just emerging and are therefore more fragile. There is also fragility in the Ottawa and the Vancouver clusters because these clusters are mainly populated by small emerging biotechnology firms and infrastructure is limited. The cumulative growth of emerging biotechnology firms in the four clusters is shown in the following chart. As can be seen most firms are less than 10 years old. It is also interesting to note that Montreal overtook Toronto by the year 2000.



Data Source: Peter Winter

Summary

This analysis indicates the following:

- Even though Toronto and Montreal's Life Sciences clusters include pharmaceutical, biotechnology and medical devices capabilities, they cannot be said to be integrated clusters because there are few linkages among the three components;
- Montreal has diversified capabilities and appears to be the most developed and well-rounded cluster overall;
- Vancouver appears to be the most dynamic biotechnology related cluster;
- Toronto has diversified capabilities and the dynamics are largely 'laisser-faire'; and
- Ottawa is still at the emerging stage in biotechnology but has a relatively significant medical devices component.

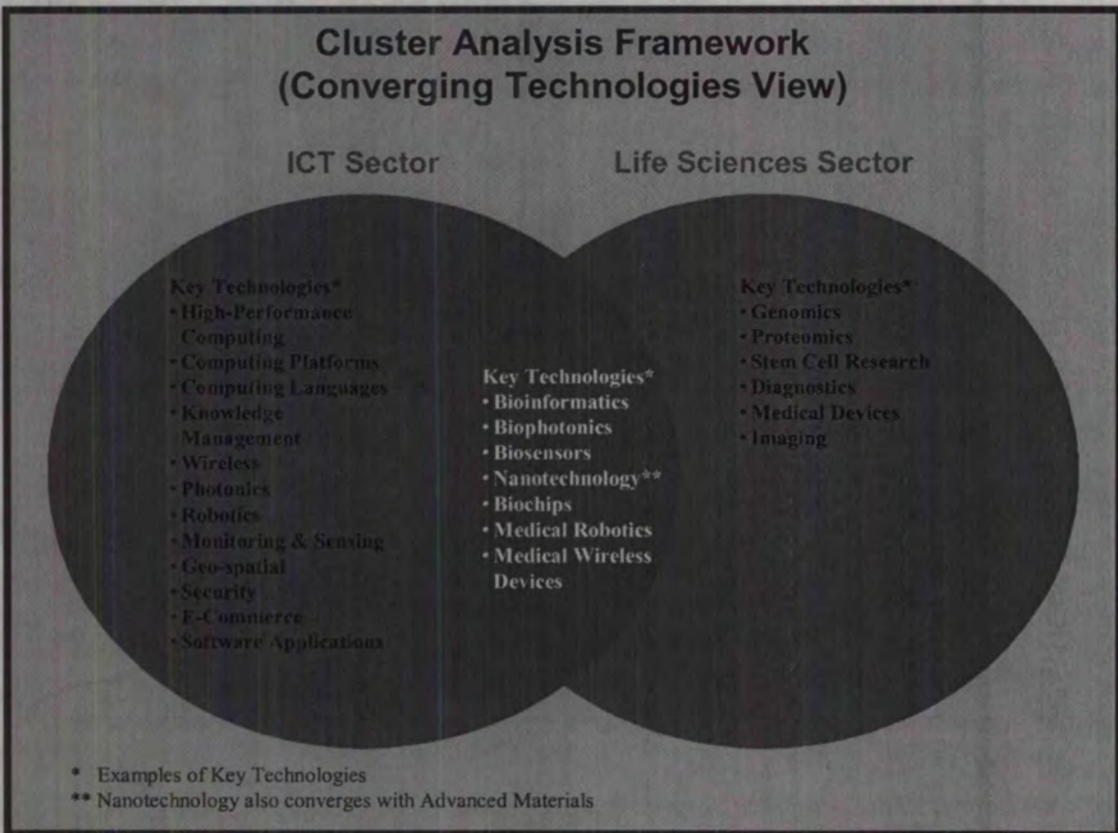
Following are some key opportunities to accelerate the development of these clusters:

- Encourage contacts between the life sciences clusters and other high-technology clusters. This will require conferences and projects so that players in various clusters can become more familiar with each other;
- Encourage the development of the local supplier base;
- Set in place demonstration projects within the hospitals to encourage demand pull;

- Stimulate alliances between pharmaceutical and biotechnology firms;
- Develop a commercialization strategy aimed at growing existing firms; and
- Encourage the consolidation of small biotechnology firms

CONVERGING NEXT GENERATION TECHNOLOGY SECTORS COMPARISONS

Converging Technology Areas



A key area of focus of this study, as shown in the chart above, is on specific emerging converging technology areas including, bioinformatics, biophotonics, biosensors, nanotechnology, biochips, medical robotics, and medical wireless devices. These emerging areas lie beyond the interests of the traditional pharmaceutical firms. The emphasis has been on identifying companies whose products have both a bio and an ICT component, are active (e.g., eye movement by user) rather than passive (e.g., submitting to an X-ray) in terms of their technology application and are invasive (e.g., nano-robot) rather than non-invasive (e.g., ECG) in their bio/ICT interaction.

A recent report has put the world market for products at the bio-high technology interface at $30-40 billion (US) by 2010[17].

Summary of Converging Technologies

The table below presents a summary of the number of converging technology companies identified in this study. All in all, there are very few converging technology companies in Canada at the present time. Even Silicon Valley, California, only has some 100 converging technology firms at this time[18]. However, several of these firms are large firms with financial and technical depth (e.g., Hewlett-Packard, IBM, Xerox PARC, Intel).

Converging Technology	Cluster				
	Vancouver	Toronto	Montreal	Ottawa	Total
Bioinformatics	• Companies: LS (4) • Research: Extensive • Networking: Strong	• Companies: ICT (6), LS (2) • Research: Some	• Companies: LS (9) • Research: Some	• Companies: ICT (2), LS (5) • Research: Some	• Companies: ICT (8), LS (17)
Biophotonics	• Companies: ICT (2), LS (3) • Research: Some	• Companies: ICT (1), LS (2)	• Companies: LS (2)	• Companies: ICT (3), LS (1) • Research: Extensive • Networking: Some	• Companies: ICT(6), LS (8)
Biosensors	• Companies: ICT (2), LS (4)	• Companies: ICT (12), LS (3)	• Companies: ICT (1), LS (1) • Research: Some	• Companies: ICT (2), LS (1)	• Cpmpanies: ICT(17), LS(9)
Nanotechnology	• Companies: ICT (1), LS	• Companies: ICT (1)			• Companies: ICT (1), LS

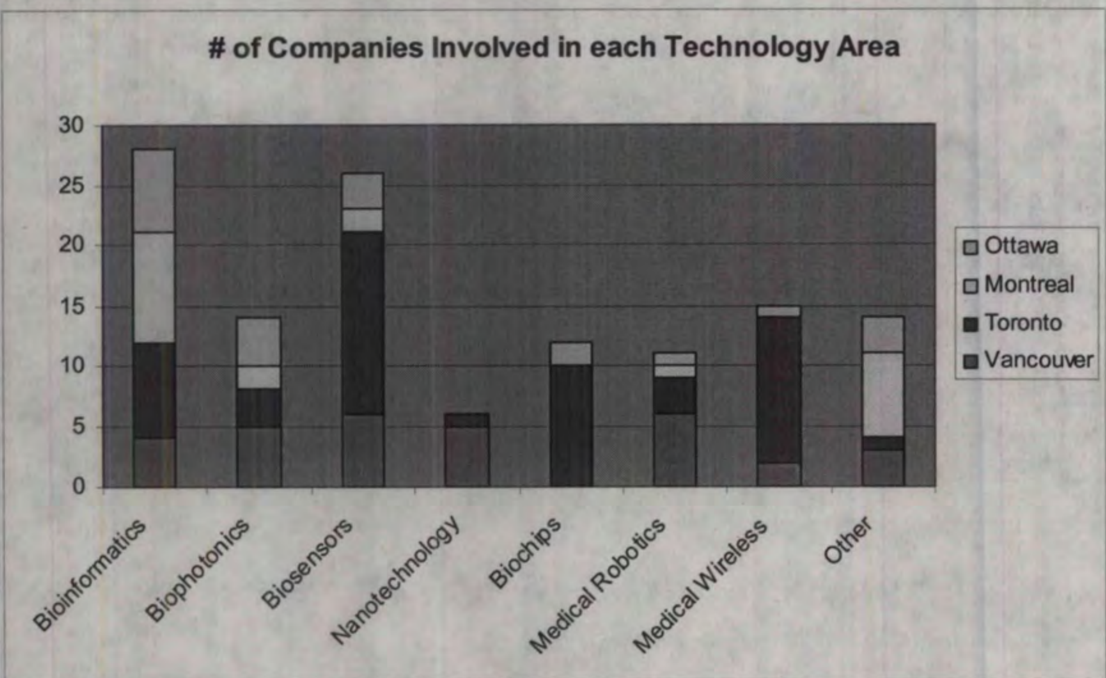
[17] Silicon Valley Joint Venture, *Preparing for the Next Silicon Valley; Opportunities and Choices*, June 2002.

[18] http://www.jointventure.org/initiatives/nsv/MapsofTechnologyConvergence/maps.html

Converging Technology	Cluster				
	Vancouver	Toronto	Montreal	Ottawa	Total
	(4)				(4)
Biochips		• Companies: ICT (10)		• Companies: LS (2)	• Companies: ICT(10), LS (2)
Medical Robotics	• Companies: ICT (4), LS (2)	• Companies: LS (3) • Research: Some	• Companies: LS (1) • Research: Some	• Companies: LS (1) • Research: Some	• Companies: ICT (4), LS (7)
Medical Wireless Devices	• Companies: ICT (2)	• Companies: ICT (12)		• Companies: ICT (1)	• Companies: ICT (15)
Other	• Companies: ICT (1), LS (2)	• Companies: LS (1)	• Companies: LS (7)	• Companies: ICT (2), LS (1) • Research: Some	• Companies: ICT (3), LS (11)

Notes: Some companies are involved in multiple converging technologies and are included in several categories

The following chart provides a summary of the number of companies identified by the study in each technology area.



Overall Assessment

Vancouver

There is some recognition of potential for converging technologies and increasing interest at the industry/association level. However, there is little evidence of company formation at this time. Significant research yielded about 20 converging technology companies scattered across various areas of converging next generation technologies but no real focus at this time.

The one promising area is bioinformatics where there is strong research activity, particularly associated with the UBC-Bioinformatics Centre. A Bioinformatics User Group (VanBUG) run out of the UBC Bioinformatics Centre currently has about 200 members.

While there is some support for bioinformatics, the main challenge is that bioinformatics is an open source community. Companies shy away from open source code because, essentially, there is no IP. The software cannot easily be sold since it can be downloaded from the web. Some companies have a business model that bundles the software with support. Rosetta is an example of a company that has created a niche market based on proprietary software. It is a large scale enterprise solution to gene expression analysis.

Other challenges facing bioinformatics development include:

- Lack of bioinformatics undergraduate programs. As a result, bioinformatics people have invented their own program, a double major in computer science and bio-chemistry/life sciences;
- Lack of a national network in order to increase critical mass (bioinformatics is currently managed at a regional level); and
- Absence of a bioinformatics funding agency.

Toronto

There is general lack of recognition of the potential for converging technologies and little apparent interaction between the ICT and Life Sciences communities. There is little evidence of company formation at this time and significant research yielded about 20 converging technology companies scattered across various areas of converging next-generation technologies. There appears to be some focus in the biosensors area and to a lesser extent in the biochip area. Much of the converging technology activity appears to be originating from the ICT, rather than the Life Sciences, community. Of particular note is a major IBM investment in Protana (formerly MDS Proteomics) in the area of bioinformatics.

There is some research activity in the bioinformatics area through the hospital research network (e.g., the Blueprint Initiative and the Centre for Computational Biology) but little evidence of coordinated research action. Similarly, there is some research activity in the medical robotics area through the Microarray Centre, again attached to the hospital research network.

In general, there is no evidence of specific support for converging technologies at the association level.

Montreal

There is general lack of recognition of the potential for converging technologies and little apparent interaction between the ICT and Life Sciences communities. There is little evidence of company formation at this time and significant research yielded about 20 converging technology companies across the various converging technology areas. There appears to be some focus in the bioinformatics area and also in the biomaterials area. Much of the converging technology activity appears to be originating from the Life Sciences, rather than the ICT, community.

There is some research activity in the bioinformatics area through McGill and the University of Montreal but little evidence of coordinated research action. Similarly, there is some research activity in the medical robotics and the biosensors areas through Concordia and McGill.

Ottawa

There is clearly recognition of potential for converging technologies and increasing interest at the industry/association level, particularly from the Life Sciences side. In that respect, the OLSC identifies convergence as one of four key Life Sciences clusters and defines convergence more broadly in terms of product categories, including health informatics, medical devices and medical equipment. OLSC has formed a special interest group in the biophotonics area.

However, there is little evidence of company formation at this time. Significant research yielded about 20 converging technology companies scattered across various areas of converging next generation technologies (closer to 45 companies, if you take the broader OLSC definition of convergence). There is some company focus in the bioinformatics area and some research focus in the bioinformatics and photonics areas, which includes biophotonics. In general, photonics companies are struggling and there is some interest in finding new opportunities in the biophotonics area.

Other areas of Ottawa strength (e.g., wireless and software) appear to be showing little interest in converging technology areas at this time, with the exception of a very few companies (e.g., QNX on the software side).

There is a major opportunity in the medical device area with MDS Nordion, the cluster's anchor tenant. It is a converging technology company that could be harnessed to drive the development of capabilities in intersecting domains.

Bioinformatics

There is an interest in bioinformatics in all four clusters and some potential for developing capabilities in this area.

The greatest opportunity appears to be to encourage the development of Vancouver as a world-class bioinformatics centre. Such a centre would build on the strengths of the existing Bioinformatics Centre, as well as substantial strengths in the area of genomics (UBC) and proteomics (UVic). It would also leverage the 30 years of history in cancer treatment in the province assembled by the BC Cancer Agency. The presence of a major NRC research facility located in Vancouver could provide the necessary impetus to transform the existing bioinformatics capacity into a viable economic cluster.

Biophotonics

There is an interest in biophotonics in all four clusters and some potential for developing capabilities in this area.

The greatest opportunity appears to be to encourage the development of Ottawa as a world-class converging technologies centre, focusing on biophotonics as identified in the Biotechnology Cluster Strategy (March 23, 2004) which proposed an Applied BioPhotonics Corporation (ABC). Such a centre would build on the strengths of existing photonics and biotechnology strengths, as well as incorporating existing wireless and software strengths where possible. OLSC and OCRI should lead this initiative aimed at implementing the approach presented in the Biotechnology Cluster Strategy report (i.e. the ABC).

Biosensors

There is an interest in biosensors in all four clusters and some potential for developing capabilities in this area. The largest concentration of firms appears to be in Toronto, while the only identified research appears to be in Montreal. Overall, there is significant Canadian strength in the sensing area but little cluster focus in development of biosensor technology.

Nanotechnology

There is little evidence of interest in nanotechnology as an ICT/LS converging technology other than by a few companies in Vancouver and one in Toronto.

Biochips

There is little evidence of interest in biochips other than in Toronto, and to a lesser extent Ottawa (particularly i-STAT), where a small number of companies are involved in this technology.

Medical Robotics

There is an interest in medical robotics in all four clusters and some research activity in Toronto, Montreal, and Ottawa.

Medical Wireless Devices

There is an interest in medical wireless in Vancouver, Toronto, and Ottawa. There is little evidence of company formation other than in Toronto where a small number of companies are involved in this technology.

Other

There is some interest in other converging technologies (e.g., biomaterials in Montreal, and software tools in Ottawa) but little evidence of significant company formation.

Summary

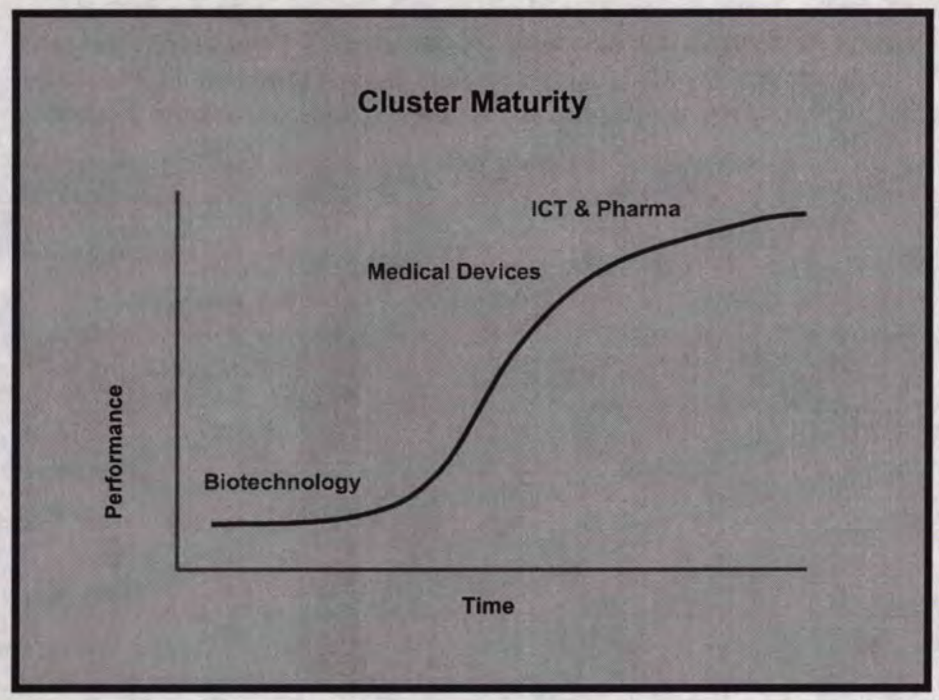
High-technology clusters typically follow a maturity life-cycle in which cluster performance progresses over time (see cluster maturity diagram below). ICT clusters are the longest established clusters and are currently at the high end of the performance curve, as are pharmaceutical clusters, while biotechnology clusters are the youngest and are still at a relatively low position on the performance curve. Medical devices clusters, which typically include some level of ICT component, and at times some biotechnology component, have also become well-established and are somewhere above the mid-point on the performance curve.

At this time, emerging converging technology areas are not on the cluster maturity radar screen. The key opportunity is to leverage the strengths of the established ICT clusters in order to grow substantial biotechnology clusters through the use of advanced ICT enabling technologies. While the ICT sector may sense opportunities that would enable cluster renewal, the needs are better known within the biotechnology community; bridging this gap is the challenge. This is difficult, not only because of the different scientific base and culture of each sector, but also because of the different dynamics of clusters at various stages on the performance curve;

- ***Early-Stage clusters*** are largely focused on the development of knowledge as opposed to the development of revenue. Clusters at this stage can often remain below the radar as the growth of firms and employment is typically not very dramatic.
- ***Growth-Stage clusters*** are characterized by a rapid influx of firms and people attracted to the emerging opportunities. Clusters at this stage are highly visible as the number of firms and the growth of employment increase dramatically.
- ***Mature-Stage clusters*** continue to grow but less rapidly—both in terms of employment and the number of firms arriving in the cluster. The firms that do arrive at this stage are often major players and some consolidation is not rare.
- ***Renewal- or Decline-Stage clusters*** sit in the balance. They can either reinvent themselves or fade from relevance. Decline occurs as markets shift either to new products or to alternative sites. Technological discontinuity is a major threat because it can render employees' skills, scientific and technical expertise, and supplier bases irrelevant. Shared interest at this stage is focused on survival[19].

[19] Trefor Munn-Venn and Roger Voyer, *Clusters of Opportunity, Clusters of Risk*, Conference Board of Canada, August 2004, p. 14.

While these stages overlap, what we are dealing with is trying to match three mature/renewal stage clusters (ICT, pharmaceuticals and medical devices) with an early-stage cluster (biotechnology).



Potential opportunities have been identified in the areas of bioinformatics (Vancouver) and biophotonics (Ottawa). While there are likely potential opportunities in other converging technology areas, these are not mature enough to be able to discern particular opportunities at this time.

Awareness of the potential for converging technologies is high in Vancouver where an integrated cluster strategy covering both ICT and LS clusters is currently being developed. This is helping to mobilize stakeholders and build interest. Awareness of the potential for converging technologies is also high in Ottawa, where the OLSC has taken the lead on promoting converging technology activities, particularly in biophotonics. Awareness of the potential for converging technologies is low in Toronto and Montreal and there is no evidence of specific support for converging technologies at the association level in either cluster.

In general, there appears to be a lack of concerted collaboration between the ICT and Life Sciences sectors to develop and exploit cluster potential in converging technology areas. Leadership for converging technologies is often coming from the Life Sciences side (e.g., Vancouver and Ottawa) but overall wealth generation and financing for high-technology in general is still largely on the ICT side. There are clearly still untapped opportunities to leverage existing ICT strengths in several converging technology areas (e.g., wireless strengths in the medical wireless devices area, software strengths in the bioinformatics area).

It appears that a useful approach would be to increase awareness (particularly within the ICT community) of the converging technology activities currently taking place (at the research and company level) and determine the level of interest in establishing special interest groups, through leading associations in the clusters, to develop a focus for converging technology activities. Perhaps funding of a joint industry/university project would be a way of getting the ball rolling. One model is the Applied BioPhotonics Corporation being proposed in Ottawa[20].

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[20] Ottawa and Eastern Ontario Biotechnology Cluster, *Biotechnology Cluster Innovation Program: Part 2*; BIOTECHNOLOGY CLUSTER STRATEGY, DRAFT, March 23, 2004, p. 51.

US COMPARISONS (BIOTECHNOLOGY)

BACKGROUND

In a recent report, the Brookings Institution compared the relative research and commercialization intensity of biotechnology clusters in 51 metropolitan areas in the US[21]. The results indicated that the majority of the activity was to be found in 9 metro areas and that both the biotechnology research and commercialization indices for these 9 metro areas were far higher than for the other 42 metro areas, as shown in the table below taken form the Brookings report.

SUMMARY MEASURES OF BIOTECHNOLOGY ACTIVITY IN METROPOLITAN AREAS

Measures of Biotechnology	Average Values for		
	All 51 Metro Areas	Top 9 Metro Areas	Other 42 Metro Areas
Biomedical research capacity and activity			
NIH research funding, 2000 (US$M)	$229	$812	$104
Biotechnology-related patents (1990-1999)	683	2,641	263
Index of biomedical research	1.0	3.7	0.4
Biotechnology commercialization			
VC investments in biopharmaceuticals (1995 - 2001, US$M)	$191	$957	$27
Value of biotech research alliances (1996-2001, US$M)	$201	$1,089	$11
New biotech firms established (1991-1999)	8	35	3
Biotechnology firms with >100 employees (2001)	6	24	2
Index of biotechnology commercialization	1.0	4.8	0.2

The 9 metro areas, which are listed in the following table taken from the Brookings report, account for more than three-fifths of all NIH spending on research and for slightly less than two-thirds of all biotechnology-related patents. Biotechnology commercialization is even more concentrated within these areas: more than three-fourths of all biotech firms with 100 or more employees and those firms founded in the past decade are in one of these nine areas; the same areas account for eight of every nine dollars in venture capital for biopharmaceuticals and for 95 percent of the dollars in research alliances.

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[21] Joseph Cortright and Heike Mayer, *Signs of Life: The Growth of Biotechnology Centers in the US*, The Brookings Institution Center on Urban and Metropolitan Policy, 2002.

METROPOLITAN AREA CLASSIFICATIONS

Top 9 Metro Areas		
Biotechnology Centres		
Boston-Worcester-Lawrence	San Francisco-Oakland-San Jose	San Diego
Raleigh-Durham-Chapel Hill	Seattle-Tacoma-Bremerton	New York-Northern New Jersey-Long Island
Philadelphia-Wilmington-Atlantic City	Los Angeles-Riverside-Orange County	Washington-Baltimore
Other 42 Metro Areas		
Research Centres		
Chicago-Gary-Kenosha	Detroit-Ann Arbor-Flint	Houston-Galveston-Brazoria
St. Louis		
Median Metropolitan Areas		
Atlanta	Austin-San Marcos	Buffalo-Niagara Falls
Cincinnati-Hamilton	Cleveland-Akron	Columbus
Dallas-Fort Worth	Denver-Boulder-Greeley	Greensboro-Winston Salem-High Point
Hartford	Indianapolis	Kansas City
Memphis	Miami-Fort Lauderdale	Milwaukee-Racine
Minneapolis-St. Paul	Nashville	New Orleans
Oklahoma City	Pittsburgh	Portland-Salem
Providence-Fall River-Warwick	Richmond-Petersburg	Rochester
Sacramento-Yolo	Salt Lake City-Ogden	San Antonio
Tampa-St. Petersburg-Clearwater		
No Significant Biotech Research or Commercialization		
Charlotte-Gastonia-Rock Hill	Grand Rapids-Muskegon-Holland	Jacksonville
Las Vegas	Louisville	Norfolk-Virginia Beach-Newport News
Orlando	Phoenix-Mesa	San Juan-Caguas-Arecibo
West Palm Beach-Boca Raton		

CANADIAN RESEARCH AND COMMERCIALIZATION INDICATORS

The following describes an attempt to situate the four clusters in the present study, Vancouver, Toronto, Montreal and Ottawa, within the context of the 51 US metropolitan areas using the biotechnology research and commercialization indices developed in the Brookings study.

Firstly, data for both research and commercialization parameters for the four Canadian clusters were developed. These data are presented in the table below in US$. The Research Index is based on two parameters, biomedical research funding and university/firm patents. The Commercialization Index is made up of four parameters, biopharma venture capital, biopharma research alliances, new biotech firms established and biotech firms with more than 100 employees.

The main differences with the Brookings data are the following;

- The Canadian data is the most recently available (up to 2004), while the US data is up to 2001;
- In the US, NIH is the principal source of biomedical research funding, while in Canada there are three major sources, CIHR, health-related CFI and NIH grants;
- The time frame for US venture capital is 7 years (1995-2001), while for Canada the time frame is 5 years (1999-2003) This difference is not very sensitive; a 20% increase in Canadian venture capital, for example, results in less than a 6% increase in the Commercialization Index for the four Canadian clusters (i.e.- 1.9 instead of 1.8); and
- The time frame for US biopharma research alliances is 6 years while that for Canada is 5 years, eight months.

Because of these differences, the results of the following analysis can only be regarded as **indicative** rather than rigorous.

BIOTECHNOLOGY RESEARCH AND COMMERCIALIZATION ACTIVITY BY CANADIAN CLUSTER

Biotechnology Activity	Biotechnology Cluster			
	Vancouver	Toronto	Montreal	Ottawa
Research Activity				
Biomedical Research Funding ($US)	49,882,878	108,865,243	102,760,897	24,532,939
CIHR Grants (2003-04)[a]	31,415,365	78,455,157	78,661,883	20,683,730
CFI Grants[b]	13,388,121	18,678,814	18,748,714	2,935,369
NIH Grants (2003)	5,079,392	11,731,272	5,350,300	913,840
Univ. & Firm Patents (1995-2004)[c]	179	427	457	50
Commercialization Activity				
Venture Capital ($M US) (1999-2003)[d]	316	296	523	65

Biotechnology Activity	Biotechnology Cluster			
	Vancouver	Toronto	Montreal	Ottawa
Value of Research Alliances (1999-Aug. 2004)[e] ($M US)	511 (12 disclosed; 2 undisclosed)	91 (3 disclosed; 4 undisclosed)	190 (8 disclosed; 2 undisclosed)	0
New Firms (1995-2004)[f]	38	50	68	18
Firms >100 Employees (2004)[f]	7	6	5	1

Notes:

a) CIHR grants were converted to $US at an average exchange rate of $1.40 Cdn/$US for 2003 (Bank of Canada)

b) CFI grants are yearly averages for the period 1998-2004 because of the year-to-year variability. The average exchange rate of $1.48 for the period 1998-2004 (Bank of Canada)

c) Source: Dr. Jorge Niosi, Appendix A (USPTO data).

d) Source: Dr. Jorge Niosi , Appendix B (based on data from Mary Macdonald and Associates). The average exchange rate of the period 1999-2003 was $1.50/$US (Bank of Canada)

e) Source: Peter Winter, Assessment of the Biopharmaceutical Product Pipeline in Canada, prepared for Industry Canada, August 2004. There were 31 research alliances in the four clusters, of which 23 were disclosed and 8 were undisclosed. Sensitivity analysis indicated that the undisclosed values of research alliances did not affect the Commercialization Index significantly (e.g., a doubling of value for Toronto altered the Commercialization Index by 5%)

f) Source: Peter Winter

Secondly, the Canadian data for the four clusters was incorporated into the US data so that a comparison could be made among 55 metropolitan areas. These revised measures are shown in the table below. As can be seen, the average indices do not change significantly due to the weight of the 9 key US centers.

REVISED RESEARCH ACTIVITY MEASURES TO INCLUDE THE FOUR CANADIAN CLUSTERS

	Average for 55 Metro Areas	Average for the Top 9 Metro Areas	Average for the 46 Other Metro Areas
Research Funding (Millions $US)	$218	$812	$101
Number of Patents	654	2,641	264
Research Index	1.0	3.9	0.43

Thirdly, the indices for both the research and commercialization activities for the four Canadian clusters were calculated. These are shown in the tables below.

INDEX OF BIOPHARMA RESEARCH ACTIVITY FOR CANADIAN CLUSTERS WITHIN 55 METRO AREAS

	Research Funding (million $US)	Number of Patents	Research Index
Average for 55 Metropolitan Areas	$218	654	1.0
Vancouver	$50	179	0.25
Toronto	$109	427	0.58
Montreal	$103	457	0.59
Ottawa	$25	50	0.10

Some observations regarding this comparison of the index for research activities: all Canadian clusters fall below the average index of 1.0 for all 55 metro areas; Montreal and Toronto are the leading Canadian research centres.

However, three Canadian clusters, Vancouver, Toronto and Montreal, fall above the average Research Index for the other 46 metro areas, with Toronto and Montreal being well above the average as shown below. Montreal is the Canadian cluster with the highest Research Index, slightly ahead of Toronto.

INDEX OF BIOPHARMA RESEARCH ACTIVITY FOR CANADIAN CLUSTERS WITHIN 46 METRO AREAS

	Research Funding (million $US)	Number of Patents	Research Index
Average for 46 Metro Areas	$101	264	0.43
Vancouver	$50	179	0.59
Toronto	$109	427	1.35
Montreal	$103	457	1.38
Ottawa	$25	50	0.22

Revised Commercialization Activity Measures to Include the Canadian Clusters

	Average for 55 Metro Areas	Average for the Top 9 Metro Areas	Average for the 46 Other Metro Areas
Venture Capital ($M US) (1999-2003)	$199	$957	$50
Value of Research Alliances ($M US) (1999-2004)	$201	$1,089	$27
New Firms (1995-2004)	11	35	7
Firms >100 Employees (2004)	6	24	2
Commercialization Index	1.0	4.4	0.34

As shown in the following table, the Commercialization Indices for Vancouver, Toronto and Montreal are above the average for the 55 metropolitan areas. Montreal is the leader followed by Vancouver and then Toronto. Given that the Research Index for the Canadian clusters fell below the average for the 55 metropolitan areas, the conclusion arrived at for these three clusters is the same as that reached in the Vancouver study using the Brookings approach[22], that is that 'we do more with less'. The exception is Ottawa whose Commercialization Index is below 1.0.

It is also interesting to note that both the Research and Commercialization Indices arrived at in the Vancouver study, 0.34 and 2.5 respectively, are not that different from those developed for Vancouver in the present study; that is 0.25 and 2.2 respectively. This is most interesting since the data used in the two studies are for two different time frames as indicated above.

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[22] Vancouver Economic Development Commission *et al., Vancouver: A North American Biotechnology Centre*, October 2002.

COMMERCIALIZATION ACTIVITY INDEX FOR CANADIAN CLUSTERS WITHIN 55 METRO AREAS

	Venture Capital ($M US) (1999-2003)	Value of Research Alliances ($M US) (1999-2004)	New Firms (1995-2004)	Firms >100 Employees (2004)	Commercialization Index
Average for 55 Metropolitan Areas	$199	$201	11	6	1.0
Vancouver	$316	$511	38	7	2.2
Toronto	$296	$91	50	6	1.9
Montreal	$523	$190	68	5	2.7
Ottawa	$65	$0	18	1	0.5

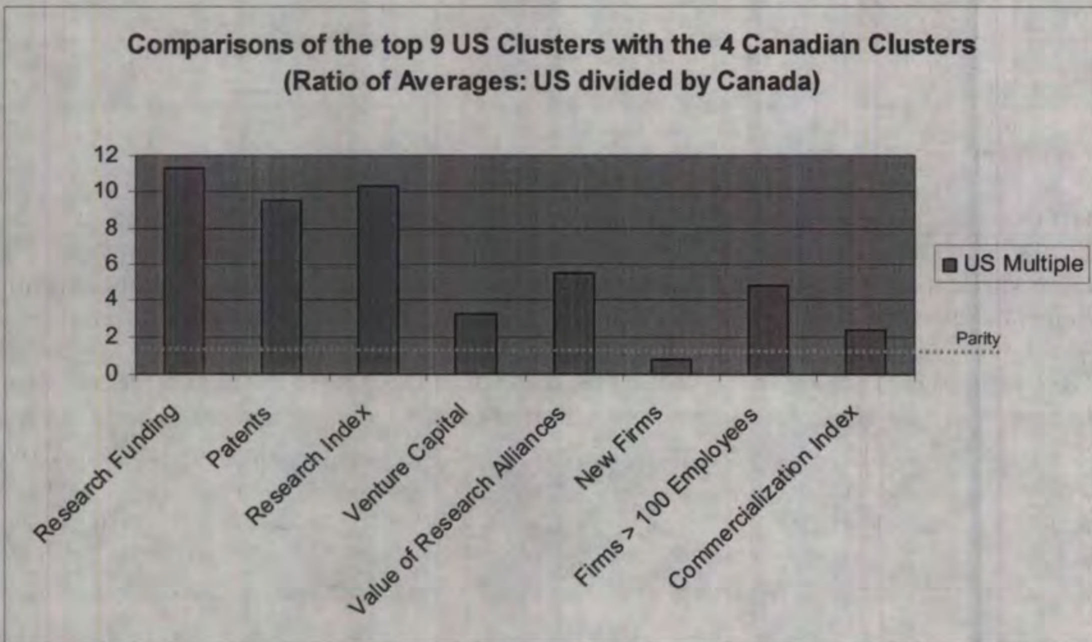
However, if the 9 leading metro centers are removed, the Commercialization Indices for the four Canadian clusters now fall well above the average for the 46 remaining clusters.

COMMERCIALIZATION ACTIVITY INDEX FOR CANADIAN CLUSTERS WITHIN 46 METRO AREAS

	Venture Capital ($M US) (1999-2003)	Value of Research Alliances ($M US) (1999-2004)	New Firms (1995-2004)	Firms >100 Employees (2004)	Commercialization Index
Average for 46 Metropolitan Areas	$50	$27	7	2	0.34
Vancouver	$316	$511	38	7	8.5
Toronto	$296	$91	50	6	4.9
Montreal	$523	$190	68	5	7.4
Ottawa	$65	$0	18	1	1.0

A major conclusion of this analysis is that three of the four Canadian clusters, Vancouver, Montreal and Toronto, do particularly well when compared to the 46 US clusters. However, as a whole, the four Canadian clusters do not compare well overall vis-à-vis the top 9 US clusters or metro areas; the US top 9 Research Index is 10.3 times higher than that for the four Canadian clusters Research Index while the Commercialization Index is 2.4 times higher, as shown in the table below.

One exception seems to be new firm formation. This 'apparent' Canadian advantage is due to the fact that new firm formation data was gathered in two different time frames for Canada (i.e. 1995-2004) and the US (i.e. 1991-1999) and that there was a rapid rate of new firm formation in Canada in the last few years. For the 1991-1999 period the average number of new firms in the four Canadian clusters was 33, which is in line with the average new firm formation in the top 9 US clusters. However, while we appear, on average, to create firms at the same rate as the US, we do not grow as many firms to the 100-employee level.



It is interesting to note that while NIH research funding and patenting activity have diminished somewhat in the 9 major US metro centers in the 1990s compared to the 1980s, commercialization activities (i.e., venture capital, research alliances, new company formation) have become much more concentrated in these 9 centers in the 1990s. This infers that the 9 metro areas are favoured clusters for the development of biotechnology companies and products. These well established clusters offer a critical mass of talent, resources and investment opportunities making it more difficult for other clusters to emerge and grow. There could be spillovers of this effect on Canadian biotechnology clusters because of the attractiveness of these 9 metro areas.

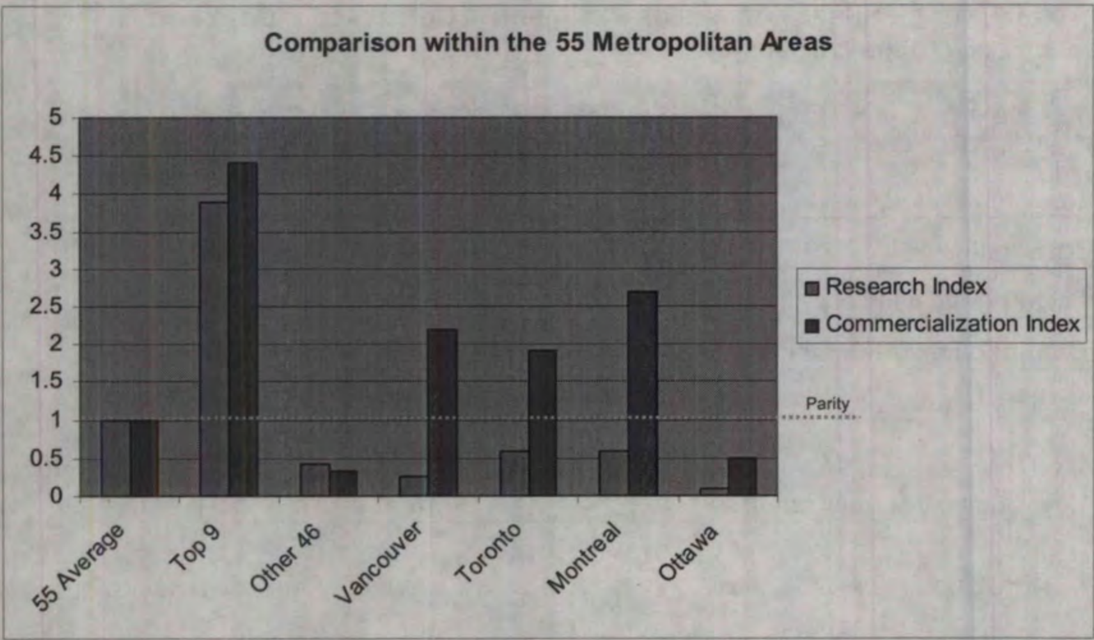
Top 9 Biotech Hubs: % share of Research & Commercialization Factors (1980s & 1990s)

Research & Commercialization Factors	1980s (%)	1990s (%)
Research Factors		
NIH Funding	63	59
Patents (total number)	71	68
Commercialization factors		
Venture Capital	81	86
R&DA (total number)	89	96
New Companies (total number)	61	77

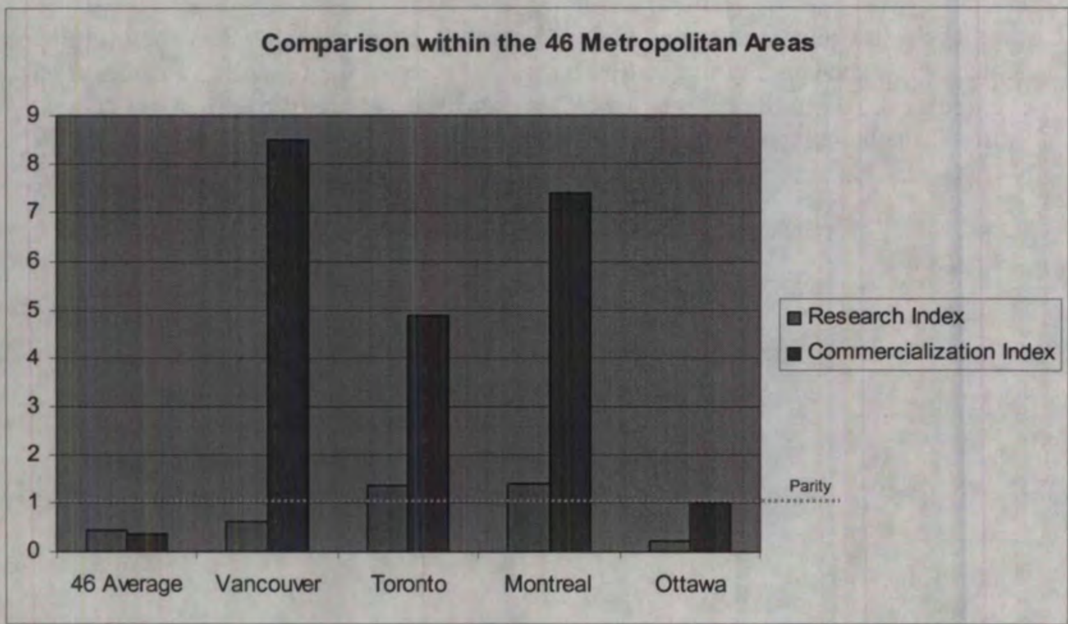
Source: Decision Resources Inc. (Data taken from *Signs of Life: The Growth of Biotechnology Centers in the US* Presentation made at the Brookings Institution Center on Urban and Metropolitan Policy, June 11, 2002).

These 9 US biotechnology clusters are our major competitors and they outdistance us in both the research and commercialization indices. This means that we have to focus attention on those biotechnology clusters that offer the most immediate potential to be able to compete internationally (e.g., Montreal and Toronto) because they have the research capabilities, diversity and staying power, while nurturing emerging clusters over the longer term.

In sum: The four Canadian clusters have Research Indices that fall below the average for the 55 clusters while the Commercialization Indices of three of the Canadian clusters are above the average as shown in the chart below. This indicates that relative to the US clusters that at least three Canadian clusters appear to do more with less.



The 9 key US clusters do better than the four Canadian clusters as shown above. However, if these 9 clusters are removed, the four Canadian clusters do well against the remaining 46 clusters as shown in the chart below.



But commercialization activity is becoming increasingly concentrated in the 9 major US clusters. These clusters are our main competitors.

KEY FINDINGS AND RECOMMENDATIONS

OVERALL

Following is a summary of the overall findings of this study with respect to cluster development in general. They represent important themes that emerged from the study and are applicable to cluster development in a range of high technology industries, as well as high technology sector development as a whole:

- **The importance of cluster diversity[23].** All four metropolitan areas have attained a considerable level of diversity in both the number and in the depth of development of clusters within their jurisdictions. This has helped to make the clusters more resilient during the technology downturn.
  - ⇒ The transferability of technical skills has helped mitigate the impact of the downturn in one technology area by providing new opportunities in other areas;
  - ⇒ The breadth of knowledge and skills is enabling the development of emerging markets and converging technology opportunities.

  Governments have recognized the trap of trying to pick technology winners in a fast moving environment where technological obsolescence occurs at a dizzying pace. Consequently, programs are typically structured to have fairly broad applicability in order to avoid this trap. It is clear that the same pitfalls can also occur at the cluster level, where whole sectors can emerge, and fall out of favour, with similar rapidity. The telecommunications cluster in Ottawa is a case in point. While enthusiasm for particular technology clusters should be encouraged, it is important that policy makers view such support within the context of longer-term cluster sustainability increasingly associated with greater cluster diversity. This can lead to the formation of integrated super-clusters that capture the existing clusters.

> ***Key Recommendation:***
>
> 1. ***Support the development of integrated cluster strategies that cover the full range of technology industries. An emphasis should be placed on supporting clusters that are deemed strategically important in terms of contributing to exports and thus to Canada's prosperity.***

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[23] Research in Europe and the US has shown that only larger cities with diversified activities are the cradle of innovation. Audretsch, David and M. Feldman (1999); *Innovation in cities: science-based diversity, specialisation and localised competition*, European Economic Review, 43: 409-429.

- **The need for coordinated and sustained leadership and support.** Leadership and support vary considerably across the clusters. However, it is apparent that this leadership and support are for the most part fragmented and not sustained. Association leadership, while sustained, is typically fragmented by industry and/or geographically within the cluster. Municipal leadership is present in some cases but is not backed up by meaningful support. Provincial leadership and support tends to swing back and forth depending on the government of the day and does not necessarily cover all technology sectors. Federal support is broader based and tends to be longer term in nature but is typically not focused on developing existing capabilities in key clusters. In some cases industry leadership plays a role in cluster development.

  Canadian clusters are competing against other large well-developed clusters in a global economy where national barriers to trade are being eliminated. This means that clusters are becoming the focal point of economic activity. In order to succeed, it is necessary to mobilize and coordinate resources around common goals and objectives. In the first instance, leadership must come from within the cluster and this leadership must be supported at the provincial level. Coordinated actions by stakeholders with divergent priorities and agendas can often be mobilized around significant projects and sustained by long-term funding commitments – an area in which the federal government can typically contribute.

> ***Key Recommendation:***
>
> 2. ***Identify and support one, or more, substantial projects aimed at accelerating cluster development in each key Canadian technology cluster. A particular emphasis should be placed on projects aimed at emerging market and/or converging technology opportunities.***

- **The need to grow larger companies – the commercialization dimension.** A key challenge facing Canadian technology clusters is not in spinning off more companies; rather it is growing the companies (SMEs) that already exist. The general view is that this requires an appropriate mix of skills; the availability of financing on a substantive and sustained basis; and the development of early market credibility.
  - ⇒ **Developing the right skills mix.** At this time, it appears that technical skills are for the most part in reasonably plentiful supply. What is required to grow companies is an increase in management, marketing and commercialization skills. These skills are currently in short supply.
  - ⇒ **Ensuring availability of substantive and sustained financing.** Securing adequate financing to build an internationally competitive company is clearly a major challenge facing virtually all technology companies across the entire commercialization spectrum. While the process will likely never be easy, there is clearly much the government can do to facilitate access to adequate financing through the policy levers at its disposal.

⇒ **The importance of market development.** Establishing early market credibility is clearly an important aspect of developing a technology company, particularly for those companies addressing emerging market opportunities where revenue potential is typically less well defined. It is important to recognize that finding early customers often occurs relatively early in the innovation cycle (e.g. alpha/beta product stage) and that such customers play a critical role in driving product requirements for the eventual commercial product. It is usually a pre-requisite to securing substantive financing. Government can help with this process through the policy and especially the procurement levers at its disposal.

Key Recommendations:

3. ***Work through the appropriate skills councils and universities to develop and fund programs to increase the pool of executive management talent, marketing professionals and commercialization experts capable of growing technology companies.***

4. ***Develop a broad approach to increasing the availability of substantive and sustained financing support for technology companies. As a minimum, this approach should consider:***

   4.1. ***Providing incentives to entrepreneurs, particularly serial entrepreneurs, to grow successful companies over time rather than selling out at the earliest opportunity.***

   4.2. ***Providing incentives to VCs to make long-term commitments to investing in companies from start-up through subsequent growth stages.***

   4.3. ***Increasing mobility of capital, particularly labour sponsored funds, across Canada.***

   4.4. ***Increasing the size of available capital pools for investing in technology companies (e.g. through changes in pension fund rules).***

5. ***Develop approaches to supporting early market development by technology companies. As a minimum, this approach should consider:***

   5.1. ***Extending the existing SR&ED tax credits to include activities related to confirmation of commercial product viability.***

   5.2. ***Encouraging the procurement of locally developed products and helping promote such products in international markets.***

WITH RESPECT TO ICT

Following is a summary of the findings of this study particular to the four ICT clusters. They represent important themes that emerged from the study and are applicable to ICT cluster development in general.

- **Dealing with ICT as a mature sector.** It is clear that the global ICT sector is dominated by a small number of large companies surrounded by an array of smaller niche players and component suppliers. These are clear signs of a mature sector and the consolidation is continuing apace. In Canada the large companies are increasingly foreign multinational enterprises and they are dominant players in all of the clusters studied except Vancouver.

  While there is some concern that Canada is becoming an R&D branch plant location for foreign multinational enterprises, and that the loss of decision-making will have a long-term detrimental impact on the health of the high-technology clusters, their presence cannot be ignored. There is clearly a need to nurture and grow the multinational enterprises, particularly in the R&D and commercialization/production areas, to ensure that they develop stronger local roots and remain in the cluster. The multinational enterprises are also in a position to assist local companies by developing supplier relationships, something that is generally not evident at present.

  Clearly government can play an important role in encouraging multinationals to increase their long-term commitment to Canada through the use of the policy and procurement levers at its disposal. The same approaches can also be used to retain such large indigenous ICT companies that continue to operate as independent entities.

Key Recommendation:

6. Recognize the growing importance of ICT multinational enterprises and encourage them to increase their long-term commitment to Canada. Policy initiatives should also be applicable to large indigenous ICT companies. Specific actions should include:

6.1. Encouraging local R&D through use of procurement levers.

6.2. Encouraging R&D linkages with local academia.

6.3. Encouraging local partnerships, particularly supplier development partnerships, through use of incentives and procurement levers.

6.4. Encouraging more commercialization and production in Canada. Product mandates for Canada should be encouraged.

- **Exploiting ICT's role as an enabler.** It is clear that the importance of ICT as an enabler of broad economic development has surpassed that of ICT as an economic sector in its own right. Much of the ICT R&D taking place in the clusters studied is in the area of emerging market opportunities, particularly those related to provision of infrastructure, content and applications targeting enabled sectors. Many of the ICT spin-offs and start-ups, as well as some of the medium-sized companies, are targeting ICT-enabled, emerging market opportunities.

This shift in emphasis to ICT as an enabling technology poses a challenge to policy makers in that it is becoming increasingly difficult to view ICT as a coherent sector and future success will require much stronger linkages between the ICT sector and other sectors of the economy. In this regard, it is important to facilitate ICT technology development and leverage ICT skills capacity at the interface between the ICT sector and other sectors of the economy.

Government is well positioned to take a leadership role in facilitating coordination and collaboration between the ICT sector and other sectors in a concerted manner and on a sustained basis.

Key Recommendation:

7. ***Shift the ICT policy emphasis from a sector orientation to one that is more focused on ICT as a broad enabler of economic development. Specific actions should include:***

    7.1. ***Increased coordination and collaboration between sector analysts and policy makers (the current study is a good example of this in the case of the ICT and Life Sciences sectors).***

    7.2. ***Encouraging increased coordination and collaboration between ICT industry associations and associations representing other sectors of the economy. A good starting point is to develop value chains that map the linkages between ICT and the enabled sectors as well as mapping cluster companies onto such value chains.***

    7.3. ***Supporting cross-sector initiatives aimed at developing partnerships between ICT companies and companies in other sectors The emphasis should be on product and market development partnerships involving substantial joint R&D activities that are intended to strengthen both the enabled company and the ICT participant(s), particularly with a view to growing larger ICT companies.***

    7.4. ***Supporting continuing development of the ICT skills base to better position the sector to launch next generation technologies into the enabled sectors.***

WITH RESPECT TO LIFE SCIENCES

Following is a summary of the findings of this study particular to the four Life Sciences clusters. They represent important themes that emerged from the study and are applicable to Life Sciences cluster development in general.

- **Integrating the three components.** For this study, Life Sciences clusters are made up of three components, pharmaceuticals, medical devices and biotechnology. There are very few linkages among these three components; they operate largely in silos. Linkages would strengthen the clusters.

> ***Key Recommendation:***
>
> ***8. Strengthen linkages between the pharmaceuticals, medical devices and biotechnology components of the Life Sciences sector. Specific actions should include:***
>
> ***8.1. Encouraging the merging of Industry associations into a single entity to support the development of clusters at the level of life sciences per se, not at the component level. This would facilitate interactions among firms in the three components.***
>
> ***8.2. Mobilizing local, provincial and federal governments support for the formation of consortia and projects that integrate the three components.***
>
> ***8.3. Setting in place demonstration projects within the hospitals to encourage linkages and demand pull.***

- **Focusing on Top Tier Clusters.** According to this analysis, Montreal and Toronto's biotechnology clusters currently have the critical mass to compete and/or collaborate most effectively with the nine leading US biotechnology clusters. The depth of their research capabilities and their related industrial diversity give Montreal and Toronto more staying power. Vancouver is a robust challenger with considerable commercialization capacity; Ottawa has a strong research base but needs to build its commercialization capacity.

> ***Key Recommendation:***
>
> ***9. Make the top tier Life Sciences clusters more competitive by mobilizing local, provincial and federal governments to ensure that the necessary capabilities and incentives are in place so that these clusters increase their potential to compete and cooperate internationally, to attract investment, skilled people and firms.***

- **Stimulating Alliances between Pharmaceutical Firms and Biotechnology Firms.** Canadian biotechnology firms are small and in need of financing to grow and steer their products through the lengthy regulatory process. Because financing can be difficult to obtain they often sell their intellectual property rather than exploiting it themselves. Long-term alliances with pharmaceutical firms are a way for biotechnology firms to develop and to strengthen the cluster if the alliances are local.

> *Key Recommendation:*
>
> ***10. Develop a support program to stimulate the formation of R&D alliances between biotechnology firms and Canadian-based pharmaceutical firms. One approach could be a program where government supports biotechnology firms by providing funds that match those provided by pharmaceutical firms***

- **Consolidating Biotechnology Firms.** Canada has many small biotechnology firms, some say too many. The difficulty is growing these firms. One approach is to consolidate like firms into entities that have a better chance of attracting the financing and the scarce management talent to be able to grow. Government programs, such as the Technology Partnerships Canada (TPC), could be targeted to encourage consolidation.

> *Key Recommendation:*
>
> ***11. Develop federal and provincial programs to encourage the consolidation of small biotechnology firm. A first step would be to identify firms that work in the same areas using similar molecular platforms to determine if there is sufficient synergy for consolidation.***

- **Developing a Local Supplier Base in Vancouver and Ottawa.** As a cluster grows there is an opportunity to create a strong local supplier base so that fewer goods and services have to come from the outside. Initially, aggregating demand for local supplies and services is important. This will likely not occur by itself since each firm will act independently. This aggregation of demand can be facilitated if the components of the life sciences clusters work closely together and if governments use their procurement lever to create a viable market locally.

Key Recommendation:

12. ***That industry associations as well as local, provincial and federal governments explore ways of aggregating local demand in order to help develop a local supplier base. A first step would be to identify the needs of Vancouver and Ottawa biotechnology firms to ascertain which areas provide market opportunities for local suppliers.***

WITH RESPECT TO CONVERGING TECHNOLOGIES

Following is a summary of the overall findings of this study with respect to the convergence of the ICT and Life Sciences sectors, particularly with respect to key converging technologies between the sectors. The findings are presented within the context of the four clusters studied:

- **The need to focus resources.** There are 9 major biotechnology centres in the US and 42 other identified areas with some degree of biotechnology capability. The Canadian clusters studied are not in the same league as the 9 leading clusters in the US except with respect to new company formation. They are reasonably comparable to the other 42 areas, particularly regarding commercialization (again, largely due to the extent of new company formation).

  It is clear that the 9 leading clusters have achieved a level of critical mass that is attracting big pharma interest and this, in turn, is fueling the continuing development of these clusters. Only Montreal and Toronto, and perhaps Vancouver, currently have the necessary capacity required to effectively challenge the leaders in this highly competitive environment. Ottawa has a strong research base but currently lacks the commercialization capacity to be considered a viable contender.

  Even in the more established clusters there is a lack of awareness and coordinated activity between the ICT and Life Sciences sectors. This is partly a maturity issue (i.e. biotechnology is much lower on the maturity curve) and partly a silo issue (i.e. ICT and Life Sciences generally operate in different universes at all types and levels of support). Only Vancouver appears to be addressing these issues in a systematic way.

  Government is faced with difficult choices – focus on the top tier clusters or spread support more broadly for emerging clusters. It appears that focusing resources on developing the strengths of Canada's top tier clusters in the short term is likely to yield greater long-term results than a more egalitarian approach.

Key Recommendations:

13. Leverage Montreal and Toronto's existing ICT and Life Sciences strengths. Specific actions should include:

13.1. Mobilizing resources to identify one, or more, key converging technology projects that would help accelerate cluster development. Participants in this process should include key executives from leading ICT and Life Sciences companies in the cluster.

13.2. Arranging sustained funding and support for the key project(s) identified.

14. Assess the potential of Vancouver and Ottawa to become globally competitive by leveraging their emerging strengths in bioinformatics and biophotonics, respectively. Specific actions should include:

14.1. Determine the business case for establishing a world-class bioinformatics centre in Vancouver that leverages existing strengths in the BC Cancer Agency.

14.2. Determine the business case for establishing a world-class biophotonics centre in Ottawa that leverages existing photonics strengths in the ICT sector.

- **The need to consider converging technologies more broadly.** The study considered nanotechnology as an ICT and Life Sciences converging technology. Nanotechnology is more appropriately a Materials Science technology that intersects with ICT and Life Sciences. The study found that converging technology activities are also taking place in the area of biomaterials (at the technology intersection of Materials Science and Life Sciences), particularly in Montreal. This suggests that Materials Science is playing an increasingly important role in the converging technology area and that this is not limited to nanotechnology.

Key Recommendation:

15. Future discussions on policy development regarding converging technologies should also include representation from Advanced Materials and Nanotechnology.

- **The need for policy coordination.** At the moment governments are not well equipped to deal with converging technologies. Industry support is typically organized along sector lines (e.g., ICT, Life Sciences, etc.). Therefore converging technology issues tend to be dealt with from a sector perspective. With convergence rapidly becoming a reality in a variety of technology areas, it is important to begin the transition towards addressing issues related to converging technologies per se. At the federal level, this could start with a secretariat within Industry Canada and later broaden out to include other departments and levels of government.

Key Recommendation:

16. Federal and provincial governments create a focus within their structures for converging technologies; possibly a secretariat to facilitate consensus development in the immediate future. Over time this secretariat could evolve into a more robust entity.

APPENDIX A: LIFE SCIENCES PATENTS COMPARISON

Four Canadian biotechnology clusters: A comparative analysis based on patents[24] (Dr. Jorge Niosi - June 17, 2004)

Montreal hosts Canada's largest biotechnology cluster, followed by those located in Toronto and Vancouver. It is also one of the most active by any standard measure.

Firstly, the Montreal cluster is mostly specialized in human health, with just a few firms active in agricultural or environmental biotechnology. Thus, in 2001, some 75% of all dedicated biotechnology firms (DBFs) active in the Montreal cluster were in this particular application, followed by nutrition, agricultural and environmental biotechnology (Niosi *et al.*, 2002). It is important to recall that almost all the fast growing Canadian DBFs are conducting research in the human health niche (Niosi, 2003). Incidentally, both Toronto and Vancouver are also specialized in human health applications, while agricultural biotechnology is the backbone of Saskatoon's regional innovation system, and looms large in both Calgary and Edmonton.

Secondly, Montreal's biotechnology cluster is part of a larger life sciences agglomeration of firms that includes large multinational pharmaceutical corporations, contract research organizations, venture capital firms, specialized law firms, four research universities (English-speaking McGill and Concordia universities as well as French-speaking Université de Montréal and the Université du Québec à Montréal) and Canada's largest public Biotechnology Research Institute (BRI) which is part of the National Research Council. In Canada, only Toronto hosts such a large and diversified life sciences agglomeration (Niosi and Bas, 2003). All the other Canadian biotechnology clusters, even the third largest one located in Vancouver, do not host these other types of human health and support firms, a fact that understandably has an effect on the potential positive externalities that DBFs can obtain from other complementary organizations located in the same cluster. In other words, it is easier and less costly to Montreal's DBFs (as well as those situated in Toronto) to obtain venture capital, intellectual property advice, or clinical research services than it is to biotechnology firms located in such census metropolitan areas as Calgary, Edmonton, Ottawa or Vancouver.

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24 The analysis is based on USPTO data and follows USPTO guidelines. Thus, only patents with the biotech keywords (i.e., hybridomas, genetic engineering, DNA, genes, bacteria, virus, molecular biology, genetically modified, genome) are considered biotech and most human heath patents are excluded. Definition for life sciences are based on: company activity (i.e., human health core biotechnology firms, pharmaceutical companies, contract research organisations, medical devices); university faculties of science (i.e. biology, biochemistry), pharmacology, and medicine; and government laboratories (i.e. three of the five NRC biotechnology research laboratories: BRI – Montreal, IBS – Ottawa, and IBD - Winnipeg).

However, there is a critical difference between Montreal and Toronto in terms of the R&D activities of pharmaceutical corporations. Montreal hosts three large multinational pharmaceutical companies with important research activities in the area. They are Merck Frosst, the Canadian subsidiary of the US based Merck corporation (#3 pharmaceutical company in the world on the basis of revenues according to Gassmann *et al.*, 2004), Boehringer Ingelheim, a second-tier German pharmaceutical firm and the British AstraZeneca (#4 in the world). All other multinational corporations operating in Montreal are active in clinical development, and/or in manufacturing, but not in research. In Toronto, only Aventis has a similar research activity, after the acquisition of Connaught Labs, in the late 1980s. In other words, Montreal is the largest Canadian center of corporate pharmaceutical research.

Thirdly, Montreal is only rivaled by Toronto in the number of publicly-quoted (e.g., traded on the TSE or NASDAQ) biotechnology firms. As the end of 2003, there were 89 publicly-quoted DBFs in Canada. Twenty-one of them had their head office in Montreal, against thirty in Toronto, and sixteen in Vancouver. The remaining twenty firms were located in Calgary (three), Edmonton (seven), Ottawa (three), Quebec City (two) and elsewhere. This is also an important indication of the vitality of the cluster. Since year 2000, when venture capital for biotechnology started to decline, almost all the new financings for Canadian biotechnology were made by large financial institutions and business angels, and almost all of them went to publicly-quoted biotechnology firms (Canadian Biotech News, various issues). In the last three years, the larger and most successful Canadian biotechnology firms, almost all of them public companies, received close to C$2 billion per year; less than ten percent of that amount went to privately held companies. In the same vein, since 2001, there were only two initial public offerings (IPOs) in Canadian biotechnology. Barriers to continuous financing thus affect new firms, but less so the larger and more established public firms in the major clusters. In the last three years, thus, some public Montreal companies such as Conjuchem, Neurochem, Procyon, Prometic and Theratechnologies have enjoyed uninterrupted access to new funds through private and public placements. Few privately held Canadian DBFs, either in Montreal or in other clusters, have benefited from such sustained financial support in the last three years.

Fourthly, Montreal competes with Toronto for the leading position in Canadian corporate life science research. As of June 16, 2004, some twenty-six companies in Montreal had biotechnology patents[25]. Three of them were the subsidiaries of the three above-mentioned multinational corporations. The other companies were DBFs, one of them and the largest, the subsidiary of a British firm (Biochem Pharma, became a subsidiary of Shire in 2000, but

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[25] This research uses exclusively US patents. The simultaneous use of American, British Canadian, European or other patent databases runs the risk of double counting, as several companies are granted the patents for the same invention in several countries or jurisdictions. Besides, the US patent database (unlike the Canadian database) allows us to precisely determine where the invention takes place, as the home of the inventors is published.

Shire recently sold the facilities to Neurochem while keeping the intellectual property). Some twenty-two were Canadian owned and controlled DBFs. Table 1 summarizes the situation.

TABLE 1: MONTREAL PRIVATE COMPANY PATENTS IN BIOTECHNOLOGY AND PHARMACEUTICALS

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded (in Canada)
Merck Frosst	US Merck	250	140	1899
Biochem Pharma	UK Shire	73	62	1986
Boehringer Ingelheim Canada	Germany Boehringer Ingelheim	54	48	1984
Adherex	Public[26]	19	19	1996
Supratek Pharma	Private	18	18	1994
Theratechnologies	Public	13	13	2001
Conjuchem	Public	10	10	1997
AstraZeneca Canada	UK AstraZeneca	9	9	1997
Methylgene	Private	8	8	1997
Ibex	Public	7	6	1986
Nymox	Public	7	7	1989
Labopharm	Public	6	6	1995
Haemacure	Public	5	4	1991
Angiogene	Private	3	3	1993
Neurochem	Public	3	3	1993
Nexia	Public	3	3	1993
Procrea	Private	3	3	1990
Synermed	Private	3	3	NA
Bioniche	Public[27]	2	2	1992
Gemin X	Private	2	2	1997
Genomics One	Public	2	2	1995
Procyon	Public	2	2	1986
Biophage	Public	1	1	1995

[26] Adherex has located its head office in Ottawa but conducts its R&D in Montreal.

[27] Bioniche has its head office in Ontario, but since 2001, it conducts part of its research in Montreal.

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded (in Canada)
Innu-Science	Private	1	1	1992
Mirador DNA	Private	1	1	1996
Phage Tech	Private	1	1	1997
Sanexen	Private	1	0	1985
Totals		**507**	**377**	

Source: USPTO

Note: These are the patents whose inventors live in Montreal and work for the above-mentioned companies. Some of these companies have patents protecting inventions made somewhere else. These are not included in the table. All these companies, except Sanexen, are active in human therapeutics.

The three top patent holders are now the subsidiaries of foreign multinational enterprises (MNEs). In the three cases, the Montreal R&D laboratories existed before the arrival of the MNE. When the patents of the recently-created (1997) laboratory of the local subsidiary of AstraZeneca are added, then these four subsidiaries of foreign MNEs represent 76% of all the biopharmaceutical patents held by companies in Montreal. If only the independent DBFs are taken into consideration, then again just five companies hold 53% of all the 130 patents of this group of firms.

Also, the patenting trend has enormously accelerated since 1995. About 74% of all the biopharmaceutical patents obtained since 1976 were granted in the 1995-2004 period. And 97% of the patents of the independent DBFs were granted in the last ten years.

University research in biotechnology is also thriving in Montreal. McGill University is the driving force of that movement, followed by the Université de Montréal (Table 2). Concordia (with no Faculty of Sciences or Medicine) is basically absent, and UQAM (with a Faculty of Science, but no medicine) is barely present. Patenting by universities, as in the corporate sector, has increased enormously in the last ten years.

TABLE 2: UNIVERSITY PATENTS IN BIOTECHNOLOGY, MAIN AGGLOMERATIONS

TABLE 2A: MONTREAL. UNIVERSITY PATENTS IN LIFE SCIENCE AND BIOTECHNOLOGY

University	Life science 1976-2004	Life science 1976-1994	Life science 1995-2004	Biotechnology Before 1995	Biotechnology 1995-2004
McGill	139	11	128	5	67
Montreal	38	6	32	0	12
UQAM	1	0	1	0	1
Concordia	0	0	0	0	0
Total	**178**	**17**	**161**	**5**	**80**

TABLE 2B: TORONTO. UNIVERSITY PATENTS IN LIFE SCIENCE AND BIOTECHNOLOGY

University	Life science 1976-2004	Life science 1976-1994	Life science 1995-2004	Biotechnology Before 1995	Biotechnology 1995-2004
Toronto	53	29	22	2	16
York	2	0	2	0	2
Total	**55**	**29**	**24**	**2**	**18**

TABLE 2C: VANCOUVER. UNIVERSITY PATENTS IN LIFE SCIENCE AND BIOTECHNOLOGY

University	Life science 1976-2004	Life science 1976-1994	Life science 1995-2004	Biotechnology Before 1995	Biotechnology 1995-2004
UBC	165	27	138	5	51
SFU	3	0	3	0	1
Total	**168**	**27**	**141**	**5**	**52**

TABLE 2D: OTTAWA. UNIVERSITY PATENTS IN LIFE SCIENCE AND BIOTECHNOLOGY

University	Life science 1976-2004	Life science 1976-1994	Life science 1995-2004	Biotechnology Before 1995	Biotechnology 1995-2004
Ottawa	16	4	12	3	7
Carleton	2	2	0	2	0
Total	**18**	**6**	**12**	**5**	**7**

When we compare Montreal's figures with those of Toronto, Vancouver and Ottawa, the differences are striking. In Toronto, one MNE (Aventis) dominates the inventive activity in biopharmaceuticals. In 1989, Institut Mérieux (France, later absorbed by Aventis) acquired the oldest and most prestigious Canadian biopharmaceutical laboratory, Connaught Labs. One domestically owned and controlled generic pharmaceutical company (Apotex) can also be found among the top inventors. All the other DBFs hold a minor position in the life sciences cluster (Table 3).

TABLE 3: TORONTO'S PRIVATE COMPANY PATENTS IN BIOTECHNOLOGY AND PHARMACEUTICALS

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded
Aventis Pasteur	France/ Aventis	184	162	1914
NPS Allelix	US/ NPS	111	84	1986

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded
Visible Genetics	Germany (Bayer)	61	57	1994
Apotex	Public	23	16	1951
Generex	Public	15	15	1995
Syn X Pharma[28]	Public	14	12	
Cangene	Public	12	10	1984
Vasogen	Public	12	9	1980
AMGEN Canada	US/AMGEN	9	9	1991
Hemosol	Public	9	9	1985
DUSA Pharma	US/DUSA	4	4	
Genzyme Canada	US Genzyme	3	3	1995
Trillium Therapeutics	Private	3	3	1996
Arius Research	Public	2	2	1999
Bonetec	Private	2	2	1998
MDS Proteomics	Private	2	2	
Toxin Alert	Public	2	2	1998
Viventia Biotech	Public	2	2	1995
Draxis Health	Public	1	1	1988
GlycoDesign	Public	1	1	1993
Hybrisens	Private	1	1	1986
Lorus	Public	1	1	1986
Pheromone Science	Private	1	1	1992
Prescient	Public	1	1	1999
Totals		**476**	**409**	

By June 2004, all 78% of all the biopharmaceutical patents based on inventions made in Toronto were under the control of foreign-owned corporations. If and when the absorption of Syn X Pharma by US-based Nanogen is completed, then 82% of all present days patents will be in foreign hands.

[28] In April 2004, Syn X Pharma was to be acquired by US Nanogen.

In Toronto, like in Montreal, most of the biopharmaceutical patents were granted in 1995 and afterwards. The exact proportion for Toronto is 86%, a lower percentage compared to Montreal, which reflects the fact that Toronto biotechnology companies (specially those acquired by foreign firms) are older and larger than in Montreal. When only the Canadian independent DBFs are considered, then seventeen firms hold only 81 US patents. This compares with twenty-three firms and 130 patents in Montreal.

As to university patents, in the 1995-2004 period, Toronto CMA became a distant third after Montreal and Vancouver. In 1990 the University of Toronto, representing 10% of Canadian university professors, decided to deregulate the intellectual property produced in its campuses. Professors could therefore assign patents to themselves, and/or to companies with which they collaborate. The number of patents assigned to U of T increased modestly after that period. U of T ceased holding first place in Canada's life science intellectual property, while smaller universities such as Montreal's McGill and Vancouver's UBC became first and second respectively (Table 2).

Vancouver is a different kind of agglomeration. There are no subsidiaries of MNEs, and foreign corporations have not (yet) absorbed local DBFs. Just 123 patents can be counted based on inventions by seventeen firms located in the agglomeration, all domestically owned and controlled, and the largest five companies (QLT, StemCell, Inex, Angiotech and AnorMed) hold well over 50% of these patents. (See Table 4)

TABLE 4: VANCOUVER PRIVATE COMPANY PATENTS IN BIOTECHNOLOGY AND PHARMACEUTICALS

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded
QLT	Public	26	26	1981
Inex	Public	20	20	1992
StemCell	Private	10	10	1993
Angiotech	Public	9	9	1992
Anormed	Public	9	9	1996
Inflazyme	Public	7	7	1992
Kinetek	Public	7	7	1992
ID Biomedical	Public	6	6	1991
NeuroMed	Private	6	6	1995
Forbes	Public	4	4	1993
Cardiome	Public	3	3	1992
Micrologix	Public	3	3	1993
Twinstrand	Private	3	3	1995
Phytogen	Private	2	2	1990
Welichem	Private	2	2	1995
Protiva	Private	1	1	2000
Response	Public	1	1	1990
Totals		**127**	**127**	

Also, all the Vancouver patents were granted in 1995 or after, a reflection of the young character of the local agglomeration. No foreign company has yet absorbed a major West Coast DBF.

In Vancouver, the University of British Columbia is now Canada's largest patent holder in life sciences in general; in biotechnology, McGill University still holds first place (Table 2).

Finally, Ottawa is a small and emerging cluster. There are MNEs in the National Capital Region. The five DBFs with patents have in all some 43 patents. Over 50% of these patents were granted to i-STAT, a US subsidiary (Table 5). Also, one of the Canadian owned and controlled biotechnology firms, Aegera Therapeutics, has located its head office in Montreal and its R&D in Ottawa, under the direction of the main star scientist of this city, Dr. Robert Korneluk, a professor of Biochemistry, Microbiology and Immunology at the University of Ottawa. In the long run, growth of the National Capital Region biotechnology cluster is handicapped by the fact that the only university with Faculties of Science and Medicine is the University of Ottawa; thus, the potential recruitment of high-profile scientists is limited, as is the hiring of hundreds of less prestigious but necessary mid-level graduates in biology, chemistry and pharmacology. Also, the University of Ottawa holds just ten biotechnology patents, out of only sixteen in life sciences (Table 2). Finally, government laboratories have only a limited potential for creating spin-off companies.

Ottawa small cluster is not specialized. Iogen works on biofuels (ethanol), IatroQuest on bioalloys, Aegera and Zinc Therapeutics are conducting R&D in human health products, while i-STAT produces bio-diagnostics devices.

TABLE 5: OTTAWA PRIVATE COMPANY PATENTS IN BIOTECHNOLOGY AND PHARMACEUTICALS

Name of firm	Ownership	Patents 1976-2004	Patents 1995-2004	Founded
i-STAT	US i-STAT, a subsidiary of Abbott	23	23	1988
Iogen	Private	10	10	1979
Aegera Therapeutics	Private	6	6	1995 (as Apoptogen)
Zinc Therapeutics	Private	3	3	2000
Iatro-Quest	Private	1	1	1998
Totals		**43**	**43**	

Finally, the University of Ottawa is the owner of some thirty-eight patents in all disciplines. Sixteen of them are in life sciences, and eight of them are biotechnology patents.

Conclusion

Montreal hosts the largest research-intensive life science cluster in Canada. With over 100 dedicated biotechnology firms, it holds promise, but at the same its future looks compromised on several accounts. On one hand, it hosts more independent companies than other Canadian clusters, and most of them are in the human health sector. Also, the cluster is populated with large laboratories of foreign multinational pharmaceutical corporations, contract research organizations and other support firms. On the other, venture capital being increasingly scarce in Montreal as everywhere else in Canada since 2001, the chances of seeing most DBF grow and become publicly-quoted firms are lower than in the 1990s. In Montreal, biopharmaceutical invention is concentrated in the large laboratories of foreign MNEs as well as in those of medium-sized independent DBFs such as Conjuchem, Neurochem, Procrea ou Procyon.

Ottawa's small cluster seems to have a limited potential for growth, as only one university in the cluster hosts faculties of both Medicine and Science. Also, the cluster is not specialized in biotechnology's most promising application, namely human health research and development.

In the two largest cities there has been a marked process of acquisition of the companies with the largest patent portfolios. In Toronto, such was the case of Connaught Laboratories (acquired by Aventis), followed by Allelix (US-based NPS) and Visible Genetics (by German-based Bayer Diagnostics in 2002). In Montreal, the same process occurred with Bio-Mega (by Boehringer Ingelheim) and BioChem Pharma (by Shire in 2000). The process has not yet reached Vancouver, and has not yet touched several promising medium-sized firms in Montreal and Toronto that remain independent. If the acquisition route continued, the biotechnology sector would follow the path that other industries, such as the automobile, pharmaceuticals and aerospace, have already pursued in Canadian economic history. They have started dispersed and mostly in local hands, and then concentrated under foreign control as soon as they matured and valuable companies emerged.

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APPENDIX B: LIFE SCIENCES VENTURE CAPITAL COMPARISON

Venture Capital in four major biotechnology clusters in Canada (Dr. Jorge Niosi - 25 August, 2004)

Since 2000-2001, venture capital available for the support of new technology firms has declined in Canada, as in all other developed countries. However, in comparative terms, biotechnology was somewhat less affected by the downturn, and has become the main investment sector since 2003. Table 1 shows that the number of companies financed and the number of investments in Canadian biotechnology has declined continuously since 2000, a year of maximum investment effort, while the total amounts invested had ups and downs, with a general declining trend.

TABLE 1: VENTURE CAPITAL AVAILABLE FOR BIOTECHNOLOGY IN CANADA, 1999-2003

Year	Number of biotechnology companies financed	Number of biotechnology investments	Total amounts invested in biotechnology (C$M)	Total amounts invested in all sectors (C$M)	Biotechnology as a percentage of all sectors
1999	96	226	316	2,168	12
2000	182	365	666	6,629	10
2001	109	358	842	4,874	17
2002	101	252	283	2,529	11
2003	87	248	317	1,486	21
Totals			**2,424**	**15,518**	**14**

Source: Canadian Venture Capital Association

During the 1999 to 2004 period, venture capitalists invested C$2.4 billion in Canadian biotechnology. Over two thirds of that amount was invested in four clusters: Montreal, Toronto, Vancouver and Ottawa. Quebec City, however, was the fourth largest recipient of venture capital investments in biotechnology during the same period, with C$178.6 million, leaving Ottawa in fifth place. Calgary and Edmonton followed Ottawa.

Montreal's census metropolitan area (CMA) dominated the venture capital leagues by the total amounts disbursed, the number of companies financed, and the total number of financings. In all, 79 companies were financed (thus a majority of all those firms operating in the cluster) through 196 investments, with an average financing per firm of close to C$10 million, and an average investment of almost C$4.5 million (Tables 1A and 1B). These statistics however conceal major differences in the amounts received by Montreal biotechnology firms. A few companies such as Axcan, Caprion, Celmed, Galileo Genomics, Gemin X, Methylgene and Xanthus obtained amounts over C$30 million in venture capital during the period, while other firms received less substantial amounts.

TABLE 1A: MONTREAL VENTURE CAPITAL 1999-2003

	Amount
Total venture capital disbursed (C$M)	784.76
Number of companies financed	79
Average financing per company (C$M)	9.9
Number of investments	196
Number of disclosed investments	182
Average financing per investment (C$M)	4.3

TABLE 1B: MONTREAL VENTURE CAPITAL PER STAGE, 2000-2003[29]

	Seed (1)	Start Up	Expansion (2)
Total venture capital disbursed (C$M)	276.9	170.1	261.2
Number of investments	62	41	60
Number of disclosed investments	54	37	58
Average financing per investment (C$M)	4.9	4.6	4.7
Number of companies financed	40	25	32
Average financing per company (C$M)	6.6	6.8	8.5

Note: Some companies have been financed through different stages; some investments disclosed in US dollars have been converted into C$.

(1) Includes other early stages
(2) Includes turnaround/acquisition

Source: Mary Macdonald and Associates

Montreal companies show a bimodal distribution. Seed and early stage capital investments dominated the type of financings. They were followed by expansion and other late

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[29] In this report the following definitions are used. **Seed:** Money used for the initial investment in a project or start-up company, for proof-of-concept, market research, or initial product development. also called seed financing or seed money. **Start up:** A new business venture in its earliest stage of development. **Expansion**: Growth of assets due to internal financing or appreciation, as opposed to external financing or acquisition.

investments. In the middle, the number of start-up investments, the amount disbursed and the companies financed in this specific stage were less substantial. These figures tend to validate the image of a younger biotechnology cluster in Montreal, with substantial renewal and addition of new firms, together with a small group of rapidly maturing firms.

Toronto's census metropolitan area (CMA) followed Montreal in terms of the number of companies and investments. However, it moved to third place, after Montreal and Vancouver, in terms of the total amounts of venture capital received. In Toronto, disclosed start-up investments represented close to 50% of all venture capital received in the last four years, while seed capital and early-stage investments represented only one quarter of the total. Venture capital supported 42% of all the biotechnology companies in the cluster: some 52 of them received this type of funds between 1999 and 2003. These figures tend to validate the image of a more mature biotechnology cluster in greater Toronto, with lesser support for new firms through venture capital. Like in Montreal, the distribution of funds was highly skewed, with one company, MDS Proteomics, absorbing one quarter of all venture capital funds disbursed in the cluster.

TABLE 2A: TORONTO VENTURE CAPITAL 1999-2003

	Amount
Total venture capital disbursed (C$M)	444.6
Number of companies financed	52
Average financing per company (C$M)	8.5
Number of investments	84
Number of disclosed investments	74
Average financing per investment (C$M)	5.3

TABLE 2B: TORONTO VENTURE CAPITAL PER STAGE, 2000-2003

	Seed (1)	Start Up (2)	Expansion (3)
Total venture capital disbursed (C$M)	85.1	145.2	96.4
Number of investments	28	22	17
Number of disclosed investments	24	18	15
Average financing per investment (C$M)	3.5	8.1	6.4
Number of companies financed	17	15	13
Average financing per company (C$M)	5.0	9.6	7.4

Note: Some companies have been financed through different stages
(1) Includes other early stages
(2) Includes a C$82.5 million financing for MDS Proteomics
(3) Includes turnaround/acquisition

Source: Mary Macdonald and Associates

The Vancouver CMA shows a younger and more vibrant cluster in terms of venture capital. Over 50% of all the disclosed amounts invested in the period in Vancouver were seed and early-stage investments; also, over two thirds of all companies operating in the area were financed in these early phases. A few companies, however, have attained a more mature stage and receive capital for expansion and/or acquisition or turnaround operations. These represented 39% of the funds and one third of the companies financed were in the expansion stage. Due to the bias in favour of seed and early stages, the concentration of funds was not as skewed as in Toronto, as seed and early stage investments are usually widely distributed. However, two firms, Xenon and Celfor, absorbed nearly 25% of all venture capital investments in the cluster.

TABLE 3A: VANCOUVER VENTURE CAPITAL 1999-2003

	Amount
Total venture capital disbursed (C$M)	474.46
Number of companies financed	41
Average financing per company (C$M)	11.7
Number of investments	77
Number of disclosed investments	73
Average financing per investment (C$M)	6.2

TABLE 3B: VANCOUVER VENTURE CAPITAL PER STAGE, 2000-2003

	Seed (1)	Start Up	Expansion (2)
Total venture capital disbursed (C$M)	219.9	29.6	156.6
Number of investments	37	9	17
Number of disclosed investments	35	9	15
Average financing per investment (C$M)	6.3	3.3	10.4
Number of companies financed	24	6	12
Average financing per company (C$M)	9.2	4.9	13.1

Note: Some companies have been financed through different stages. Some investments disclosed in US dollars have been converted to C$.

(1) Includes other early stages; includes several financings for a total of $60,000 in Xenon Pharmaceuticals.
(2) Includes turnaround/acquisition

Source: Mary Macdonald and Associates

Ottawa, while less important than Quebec City in terms of venture capital, is still in fifth place among Canadian metropolitan areas. Nine companies received nearly C$100 million and were financed through fifteen investments. The distribution was the most skewed of all the clusters examined: only three companies, Adherex Technologies (since 2002 a US company with operations in the Triangle Research Park and in Ottawa), Aegera Therapeutics, and Bioniche Life Sciences represented two thirds of the venture capital received for biotechnology within the cluster between 1999 and 2003. Also, two of the three above-mentioned companies have their head offices outside the National Capital Region, and only one is a genuine product of local research.

Table 4A: Ottawa venture capital 1999-2003

	Amount
Total venture capital disbursed (C$M)	97.7
Number of companies financed	9
Average financing per company (C$M)	10.8
Number of investments	16
Average financing per investment (C$M)	6.5

Table 4B: Ottawa venture capital per stage, 2000-2003

	Seed	Start Up	Expansion
Total venture capital disbursed (C$M)	5	26	66.4
Number of financings	5	5	5
Average financing per investment (C$M)	1	5.2	13.3
Number of companies financed	4	3	3
Average financing per company (C$M)	1.3	8.7	22.1

Note: One company has been financed through two different stages. All investments were disclosed.

Source: Mary Macdonald and Associates

It is, however, important to underline that these three companies are in an expansion phase, thus boosting the percentages of "expansion" venture capital funds and the average amount received per investment within the cluster. In the meantime, the average disclosed seed capital received per company amounts to only C$1.3 million, the lowest in Canada.

Conclusion

Canada's venture capital funds continued their support of domestic biotechnology firms in the major clusters, but the total amount disbursed declined across the board.

Montreal received one third of the total venture capital disbursed for Canadian biotechnology. Vancouver and Toronto, Quebec and Ottawa followed it in that order. In Montreal, venture capital supported mostly both ends in the investment continuum, seed and early stages dominated followed by the support of expansion activities in a few firms.

Vancouver was mostly skewed towards seed and early stages financings. At the very opposite, in Ottawa venture capital financed mostly the expansion of the three largest firms, leaving almost nothing for seed and early stages. If venture capital is taken as a measure of the stage of the cluster, Vancouver looks to be a young and emerging cluster; Toronto an adult one; Montreal has both young and mature companies; and Ottawa seems to be a rapidly maturing cluster with little renewal.

Graytek
Management Inc.

APPENDIX C: INDUSTRIAL CLUSTER ANALYSIS FRAMEWORK

INTRODUCTION

This Cluster Analysis Framework has evolved over a number of years as an integral part of a broader Sector Development Framework[30]. It represents a supply-side view and places particular emphasis on the importance of industrial clusters. The framework incorporates the following key elements:

- A Qualitative Assessment Tool, which identifies key success criteria for cluster development in order to facilitate qualitative assessment of the operational characteristics of a particular cluster;
- A Sector View characterizing the sector itself, together with the supporting infrastructure and sustaining policy environment that enables sector growth. As well it characterizes the markets that the sector addresses;
- A Cluster View characterizing geographically bounded concentrations of sector activity (clusters) operating within the sector as a whole. Structured along the same lines as the overall sector view, it provides a supply-chain orientation of the cluster;
- A Cluster Profile Template which integrates the Sector View and the Cluster View in order to provide a template for collecting and synthesizing data about the capacity of particular clusters in a City/region, as well as the converging technologies between them; and
- A Converging Technology View that identifies companies by cluster and key technology area, with a particular emphasis on converging technologies.

The Cluster Analysis Framework is based on accepted definitions of target sectors and their constituent industries (e.g., NAICS, in the case of North America). At this time, the framework includes definitions for the ICT and Life Sciences Sectors. It is intended for use in analyzing both ICT and Life Sciences clusters, as well as their converging next-generation technologies (e.g., bioinformatics, biophotonics, biosensors, nanotechnology, biochips, medical robotics, medical wireless devices).

INDUSTRIAL CLUSTERING - KEY CONCEPTS

Industrial clusters are regional or urban concentrations of firms including manufacturers, suppliers, and service providers in one, or more, industrial sectors. These firms are supported by an infrastructure that includes educational institutions (e.g., universities and colleges),

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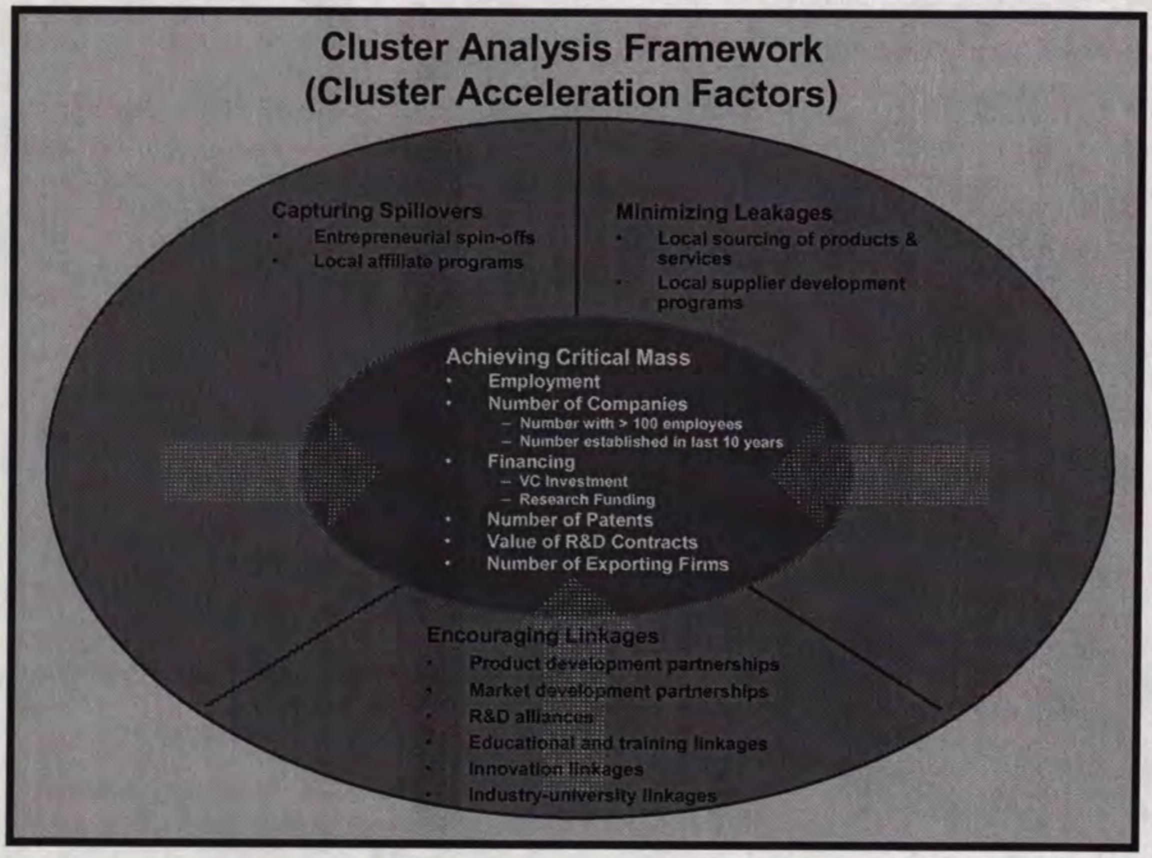
[30] Key participants involved in developing the methodology and framework include Graham Sibthorpe, Dr. Roger Voyer, Dr. Thomas Grandy and Rick Clayton.

research institutions, financing organizations, business incubators, business service providers and advanced physical infrastructure (e.g., telecommunications and transportation). The linkages among these players are key to driving cluster development.

The clusters are sustained by a supporting policy regime that provides a favourable environment for long-term cluster growth.

Cluster development can be accelerated in a number of ways that need to work together at the level of the cluster. Following is an overview of the key cluster acceleration factors.



Achieving Critical Mass. This is essentially the point at which a cluster reaches internal self-sustaining capability. It is a difficult concept to measure and there are several views on when critical mass is achieved, including: the point at which leakages are less than the value-added captured within the cluster; or the point at which fear of losing a job is replaced by the feeling of comfort that other suitable jobs/business opportunities are available within the cluster.

Performance Indicators:

- Employment

- Number of Companies
  ⇒ Number with > 100 employees
  ⇒ Number established in last 10 years
- Financing
  ⇒ VC Investment
  ⇒ Research Funding
- Number of Patents
- Value of R&D Contracts
- Number of Exporting Firms

Capturing Spillovers. Spillovers occur when a firm cannot capture all of the economic benefits from its innovation process (i.e. bringing its products to market). A typical example is when experienced people leave firms to set up their own firms or work for other firms in their field of expertise. Capturing these spillovers leads to the establishment of new capabilities and more growth in the area.

Performance Indicators:

- Entrepreneurial spin-offs
- Local affiliate programs

Minimizing Leakages. Leakages occur when a firm cannot satisfy the key requirements needed to bring its own products or services to market rapidly within the region and must source them elsewhere. Typical examples include the sourcing of product components and the availability of business support services. Minimizing leakage increases the overall business benefit to the cluster and also provides an incentive for new firms to locate in the cluster.

Performance Indicators:

- Local sourcing of products, and services
- Local supplier development programs

Encouraging Linkages. Strong formal and informal linkages among firms and the supporting infrastructure (physical and business) in a region tend to stimulate the innovation process, enhance the effectiveness of the innovation process, and stimulate the growth of the region.

Performance Indicators:

- Product development partnerships
- Market development partnerships
- R&D alliances

- Educational and training linkages
- Innovation linkages
- Industry-university linkages

QUALITATIVE ASSESSMENT TOOL

Extensive work examining Canadian and international examples of technology clusters has identified four distinct cluster models and eight characteristics for success in cluster development[31]. The cluster models are:

- Laisser - Faire (e.g., Montreal, Canada)
- Planned (e.g., Hsinchu, Taiwan)
- Design Centres of Multi-National Enterprises (e.g., Bangalore, India)
- Production Functions of Multi-National Enterprises (e.g., Ireland)

The eight characteristics of success are:

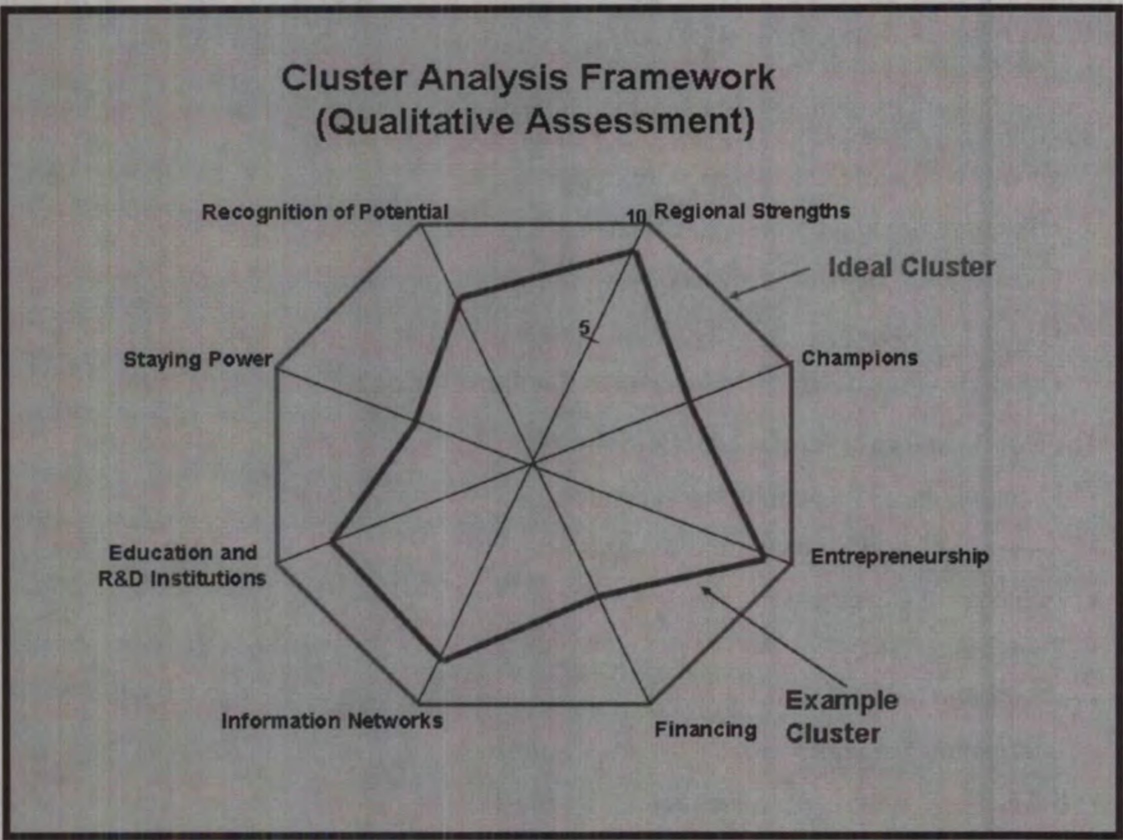
- Recognition of Potential by Local Leaders
- Support of Local Strengths and Assets
- Influence of Champions
- Entrepreneurial Drive
- Various Sources of Financing
- Information Networks
- Educational & Research Institutions
- Staying Power

Research has found that laisser-faire clusters take a long time to reach "critical mass". However, cluster development can be accelerated through planning and sustained support. It is important to take a commercial, rather than a scientific orientation, to stimulate cluster development. Furthermore, it is important to capture the design functions of Multi-National Enterprises where possible and to move to higher value-added functions in clusters where assembly / production functions dominate.

The eight characteristics of success need to work together at the level of the cluster. Following is a cluster analysis framework that can be used to show the relative performance

[31] Source: Dr. Roger Voyer.

of the cluster to an ideal, show how the performance of the cluster changes over time, and compare the performance of one cluster to another.



Recognition of Potential. Recognition of the opportunity usually comes out of meeting a need. For example; Frêche, the mayor of Montpellier, wanted to diversify the Montpellier economy from tourism; and Japan's Technopolis program was aimed at regional development and alleviating pressure on Tokyo.

Performance Indicators:

- Continued importance of clusters as part of the City/Region's economic plan
- Recognition by federal and provincial public sector as important "innovation cluster" location
- Continued, and growing, recognition as a priority cluster
- Funding of cluster-related infrastructure

Regional Strengths. Support of local strengths and assets typically include transportation infrastructure (e.g., road, rail and air links), telecommunications infrastructure and availability of conference space. The technological strengths lie in universities, government laboratories and major firms. There can be local market strengths in some well represented areas such as government procurement and banking. Social, cultural and entertainment infrastructure can be an important asset because skilled people are 'Foot-Loose' and migrate to areas with good quality of life.

Performance Indicators:

- R&D capabilities
- Procurement activities
- New investment in cluster-specific capital infrastructure
- Understand, leverage and enhance regional strengths
- New cultural and social amenities
- Housing costs
- Crime rates
- Pollution index

Champions. Champions are Important. They can include *individuals* (e.g., Terry Matthews, Michael Cowpland, Rod Bryden, Wilburt Keon, Gerry Turcotte in Ottawa, Professor Terman at Stanford University), or *institutions* (e.g., National Centres of Excellence, Chambers of Commerce, Economic Development Groups).

Performance Indicators

- Increase in number and profile of champions

Entrepreneurship. Entrepreneurial drive is central to firm and cluster development. It is found in individuals whether they are growing firms (e.g., Terry Matthews of Newbridge/March Systems) or are part of the supporting organizations (e.g., Gerry Turcotte in the early days of OCRI). Where it is weak clusters stagnate (e.g., Tsukuba, Japan).

Performance Indicators:

- Membership in entrepreneurial networks
- New companies created
- Percentage of employment in start-ups

Financing. Various sources of financing are required and the full spectrum of instruments is needed. Angel, venture capital, public equity and government funds are needed at the start-up phase. Debt/equity instruments are needed for the growth phase where about $1 of working capital is typically needed to support $1 of sales in ICT areas.

Performance Indicators:

- Increase in range and extent of financing available for cluster
- Trends in venture capital financing
- Number and value of Industrial Research Assistance Program (IRAP) grants

Information Networks. They can be *informal* where the focus is on the transfer of tacit knowledge (e.g., Il Fornaio Restaurant in Palo Alto) or *formal* (e.g., Industry Associations, Chamber of Commerce). Where such structures are weak clustering suffers (e.g., Route 128 in the Boston area)

Performance Indicators:

- Membership and participation in information networks, both within and external to the City/region
- Networking events

Education & R&D Institutions. They are necessary to provide skilled people and technological expertise. But, they are not sufficient for success unless there are strong linkages to industry (e.g., Silicon Valley). Where linkages are weak clustering stagnates (e.g., Taedok, South Korea; Baltimore USA, Tsukuba, Japan).

Performance Indicators:

- Availability of cluster relevant education programs
- Number of PhDs graduated
- Measures of R&D "Intensity"
  ⇒ Number of Principal Investigators
  ⇒ Research funding
  ⇒ Patents filed (measure of productivity of research investments – Ability to "Create Value")
- Employment and retention of local graduates in cluster
- Availability of cluster relevant research chairs
- Awareness and use of available innovation support (e.g., IRAP and SR&ED tax credits)
- Local sourcing of product ideas, technology ideas (e.g., headquarters of National Centre of Excellence)

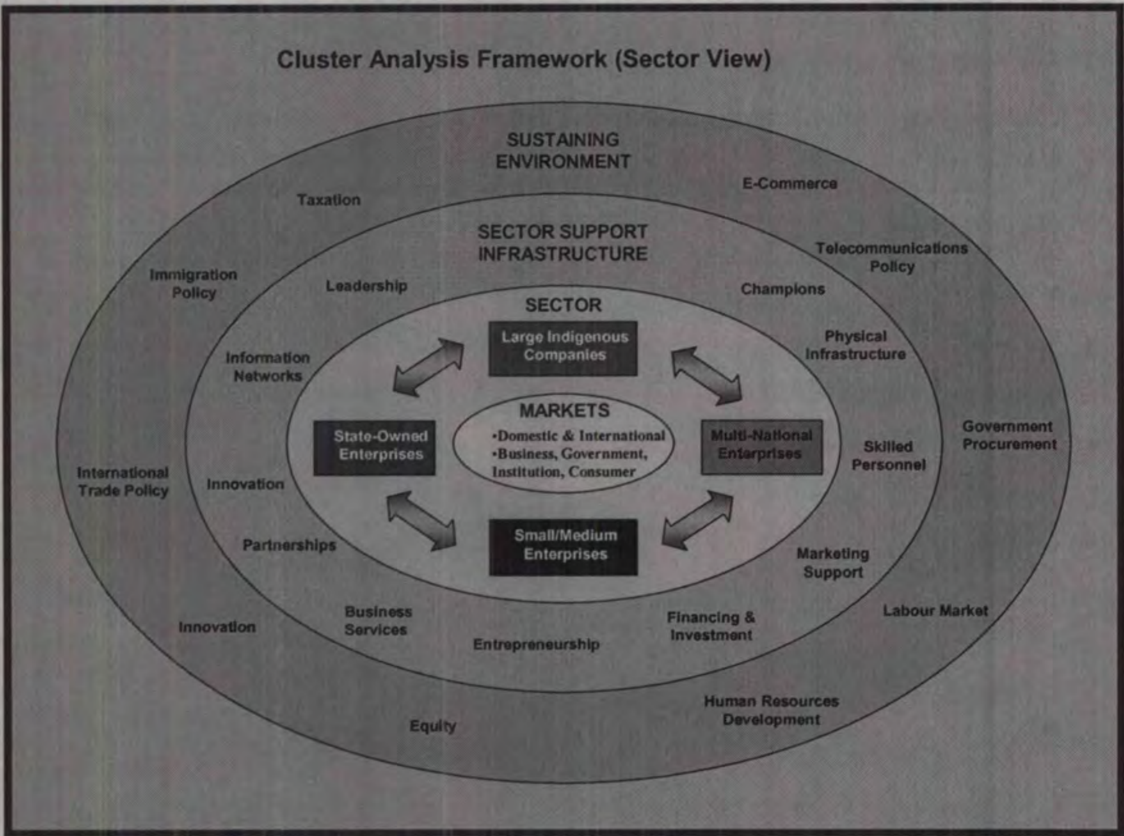
Staying Power. It can take 30 (+) years for a cluster to reach maturity (e.g., Ottawa high-technology). Growth can be accelerated through judicious government support (e.g., Hsinchu, Taiwan). Growth can also be accelerated by attracting multinational firms rather than by growing indigenous firms (e.g., Bangalore, India; Ireland).

Performance Indicators:

- Growth and diversity of cluster
- Net inflow of graduates to cluster from outside region
- Net inflow of multi-national transfers to cluster
- Unemployment rate within cluster
- Net immigration of cluster employment (e.g., do the employees stay here, even in bad times?)
- Use of employment/recruitment programs (e.g., youth Internship and foreign worker recruitment)
- Linkages to other clusters
- Nature and range of markets
- Long term R&D and financing programs
- Number of key firms/anchor tenants

SECTOR VIEW (DOMESTIC SUPPLY)

Overall Framework



Sustaining Environment

- Electronic commerce (e.g., the policies and legal framework for secure electronic commerce);
- Telecommunications policy (e.g., an open and competitive telecommunications sector);
- Labour market (e.g., accurate and timely labour market information, interpreting the impacts on manpower planning scenarios, and ensuring adherence to employment law);
- Human Resources Development (e.g., focusing education and training institutions on future competency requirements and speed of implementation of new curriculum, addressing the need for skilled workers, and ensuring broad access to education and training opportunities for continuous learning);
- Innovation (e.g., measures to stimulate an innovative economy, particularly providing protection for intellectual property rights, and ensuring that international agreements are adhered to);

- International trade (e.g., addressing the implementation of international agreements such as the World Trade Organization agreement on trade in basic telecommunications, foreign investment rules, etc.);
- Taxation (e.g., taxation measures to stimulate investment and growth in the sector);
- Immigration policy (e.g., offsetting the "brain drain" and the lack of skilled personnel in key occupational categories);
- Equity (e.g., addressing issues of universal access and affordability); and
- Government procurement (e.g., using government procurement as a lever to meet sector goals and objectives).

Sector Support Infrastructure

- Leadership (e.g., leaders who demonstrate recognition of the potential of knowledge-based industries and the importance of the particular sector);
- Champions (e.g., champions providing a catalytic influence on sector growth);
- Physical Infrastructure (e.g., telecommunications and transportation infrastructure upon which the sector is dependent);
- Information Networks (e.g., informal and formal information networks that provide cohesion to the sector);
- Innovation (e.g., research institutions supporting the sector);
- Skilled Personnel (e.g., educational and training institutions supporting the sector);
- Entrepreneurship (e.g., organizations supporting entrepreneurial drive and sound business practices);
- Business Services (e.g., legal, accounting, M&A, office location/relocation, human resource consulting, marketing consulting, information technology services);
- Financing & Investment (e.g., organizations providing various sources of investment capital);
- Marketing Support (e.g., organizations providing marketing support to the sector); and
- Partnerships (e.g., public and private sector partnerships within the sector, as well as between the sector and other sectors of the economy).

Sector

Any given industry within the sector comprises a number of large indigenous companies, multi-national enterprises, small/medium enterprises (<500 employees), and state-owned enterprises.

Sector Structure (ICT)

- Manufacturing (including, computer and peripheral equipment manufacturing, and communications equipment manufacturing);
- Intangible Services (including, software publishers, telecommunications, computer systems design and related services); and
- Goods related Services (including computer and communications equipment and supplies wholesaler-distributor).

Sector Structure (Life Sciences)

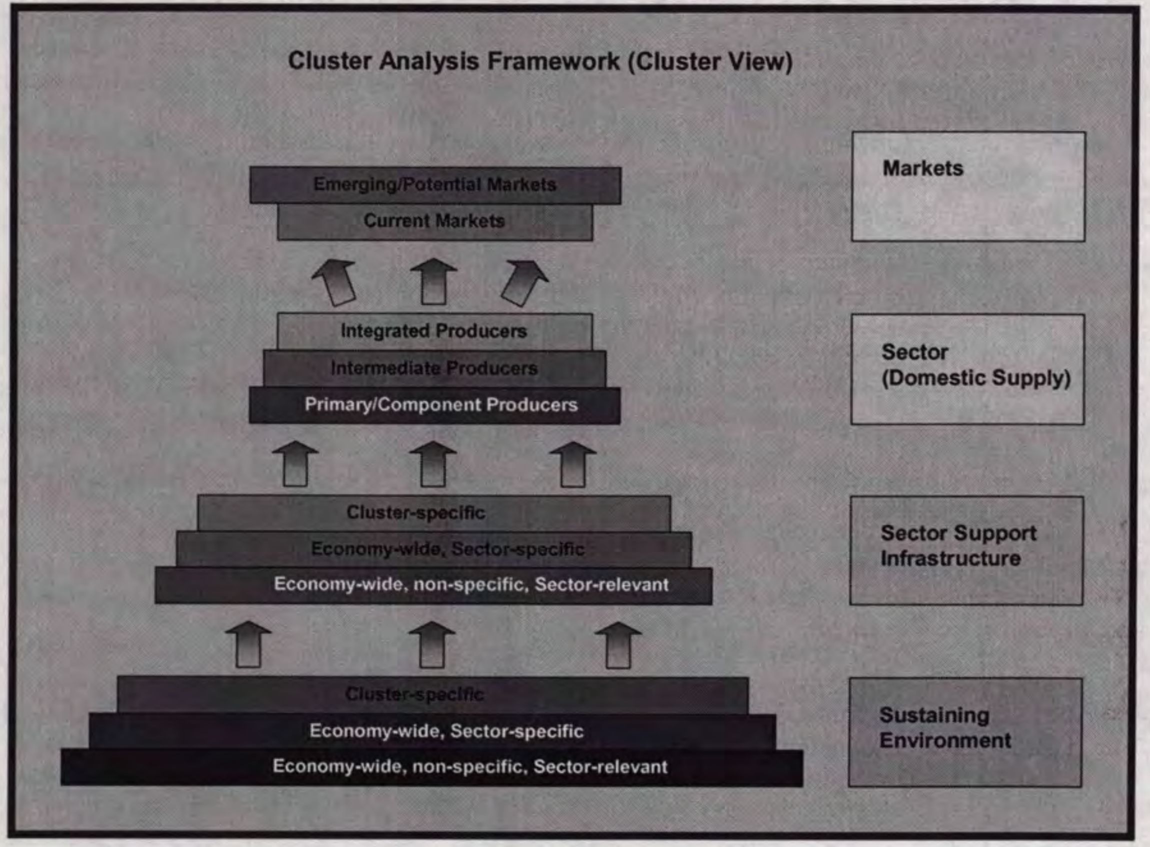
- Research and Development in the Life Sciences (including biotechnology research and development laboratories);
- Pharmaceutical and Medicine Manufacturing (specifically: Medicinals/Botanicals; Pharmaceuticals; Diagnostic Substances; and Biological Products, except Diagnostic);
- Medical Devices Manufacturing;
- Intangible Services (such as regulatory, consulting and engineering services);
- Goods Related Services (such as packaging, repairs, and device registration); and
- Other (non-health biotech including Agriculture biotech, Aquaculture biotech, Environment biotech, Energy biotech, and Forestry biotech).

Markets

- Domestic & International (e.g., current and potential demand for goods and services in both the domestic and international markets); and
- Business, Government, Institution, Consumer (e.g., current and potential demand for goods and services in across different sectors/constituencies of the economy).

CLUSTER VIEW

Overall Framework



Markets

- Current Markets (i.e. the demand industries both within the cluster and outside); and
- Emerging/Potential Markets (e.g., new opportunities beyond current markets that represent technology and market areas that relate to the cluster's supply capability, and potentially build on existing markets).

Sector (Domestic Supply)

ICT - Manufacturing

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, or as close to end-user form as the cluster can provide);

- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services to the mid- tier level).

ICT - Intangible Services

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide both application products and services for the domestic and export markets in end-user form, or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public and private sectors, that provide development tools and software to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide systems software, products and technical services to the mid-tier level).

ICT - Goods Related Services

- Integrated Producers (e.g., wholesalers and distributors of manufactured goods and software products).

Life Sciences - Research and Development

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems and services (e.g., clinical trials) to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services (e.g., contract R&D) to the mid-tier level).

Life Sciences – Pharmaceutical and Medicine Manufacturing

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, (e.g., pharmaceuticals, medicines) or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level; and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services to the mid- tier level).

Life Sciences – Medical Devices Manufacturing

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, (e.g., medical devices) or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services to the mid- tier level).

Life Sciences – Intangible Services[32]

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services to the mid- tier level).

Life Sciences – Goods Related Services[33]

- Integrated Producers (e.g., specific private-sector (i.e. wealth-generating) firms that provide products for the domestic and export markets in end-user form, or as close to end-user form as the cluster can provide);
- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level); and
- Primary/Component Producers (e.g., specialized organizations, in both the public and private sectors, that provide product components and technical services to the mid- tier level).

[32] This category covers miscellaneous service providers within the Life Sciences sector.

[33] This category covers Life Sciences distributors who do not provide value-added services.

Life Sciences – Other[34]

- Intermediate Producers (e.g., specialized organizations, in both the public, and private sectors, that provide intermediate products/sub-systems to the top-tier level).

Sector Support Infrastructure

- Cluster-Specific (i.e. organizations that provide business support services specifically to firms in the cluster);
- Economy-Wide, Sector-Specific (i.e. organizations that provide business support services to Sector firms across the economy but which are applicable to the Sector firms in the cluster); and
- Economy-Wide, Non-Specific, Sector-Relevant (i.e. organizations that provide business support services to firms across the economy and which are relevant to Sector firms in the cluster).

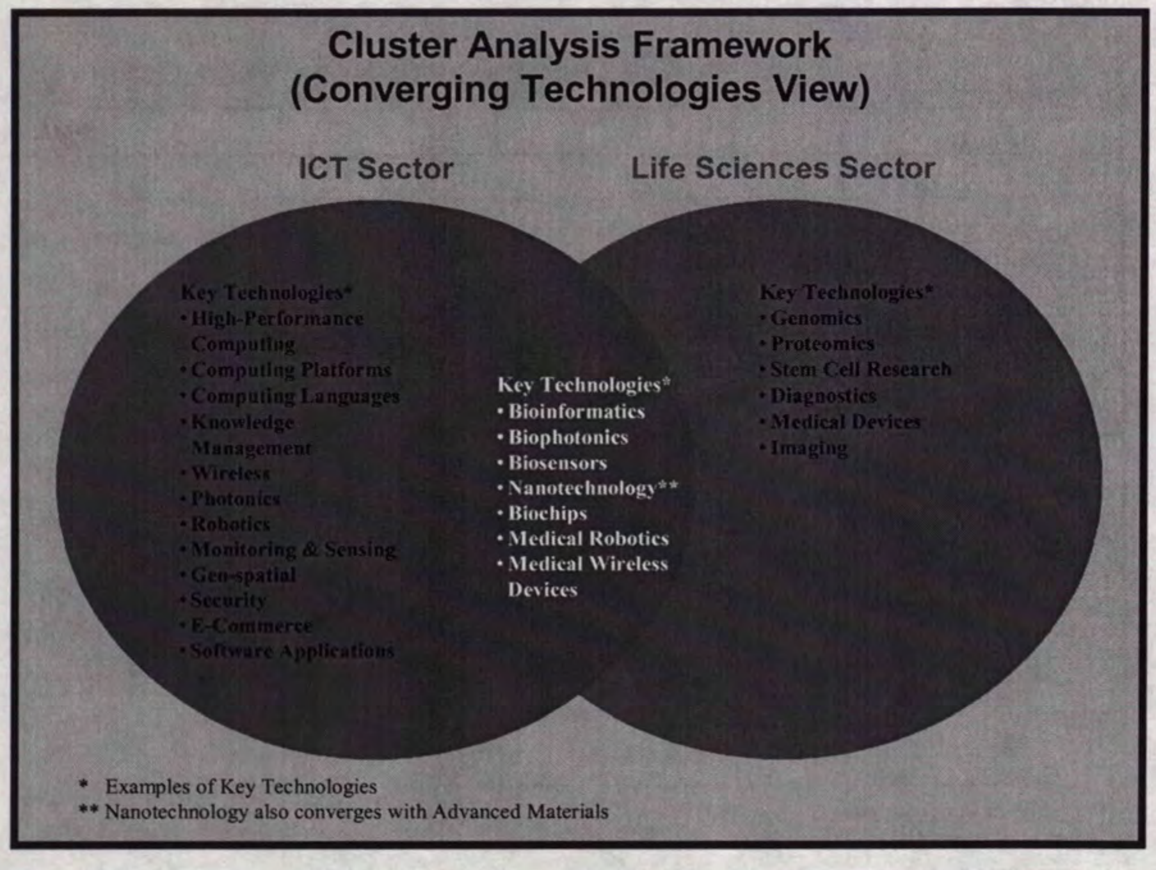
Sustaining Environment

- Cluster-Specific (i.e. policies and programs that are intended to specifically benefit firms in the cluster);
- Economy-Wide, Sector-Specific (i.e. policies and programs that are intended to benefit Sector firms across the economy but which are applicable to firms in the cluster); and
- Economy-Wide, Non-Specific, Sector-Relevant (i.e., policies and programs that are intended to benefit firms across the economy and which are relevant to firms in the cluster).

CONVERGING TECHNOLOGIES VIEW

The converging technologies view provides an analysis of companies in overlapping clusters in a City/Region based on their key technologies. The following diagram illustrates some key technologies of the ICT and Life Sciences sectors and the converging technologies between them.

[34] This category covers non-health bio-technology companies.



CLUSTER PROFILE TEMPLATE

Markets	Current Markets	Emerging/Potential Markets
Geographic		
Domestic		
International		
Sector/Constituent		
Business		
Government		
Institutions		
Consumer		

Sector (Domestic Supply)	Large Indigenous Companies	Multi-National Enterprises	Small/Medium Enterprises	State-Owned Enterprises
ICT - Manufacturing				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
ICT - Intangible Services				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
ICT - Goods Related Services				
Integrated Producers				
Life Sciences – Research & Development				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
Life Sciences – Pharmaceutical and Medicine Manufacturing				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
Life Sciences – Medical Devices Manufacturing				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				

Sector (Domestic Supply)	Large Indigenous Companies	Multi-National Enterprises	Small/Medium Enterprises	State-Owned Enterprises
Life Sciences – Intangible Services				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
Life Sciences – Goods Related Services				
Integrated Producers				
Intermediate Producers				
Primary/Component Producers				
Life Sciences – Other				
Intermediate Producers				

Converging Technology	Research Facility	ICT Company	Life Sciences Company
Bioinformatics			
Biophotonics			
Biosensors			
Nanotechnology			
Biochips			
Medical Robotics			
Medical Wireless Devices			
Other			

Sector Support Infrastructure	Cluster-Specific	Economy-Wide, Sector-Specific	Economy-Wide, Non-Specific, Sector-Relevant
Leadership			
Champions			

Sector Support Infrastructure	Cluster-Specific	Economy-Wide, Sector-Specific	Economy-Wide, Non-Specific, Sector-Relevant
Physical Infrastructure			
Information Networks			
Innovation			
Skilled Personnel			
Entrepreneurship			
Business Services			
Financing & Investment			
Marketing Support			
Partnerships			

Sustaining Environment	Cluster-Specific	Economy-Wide, Sector-Specific	Economy-Wide, Non-Specific, Sector-Relevant
Electronic commerce			
Telecommunications policy			
Labour market			
Education and training			
Legal framework			
International trade			
Taxation			
Immigration policy			
Equity			
Government procurement			

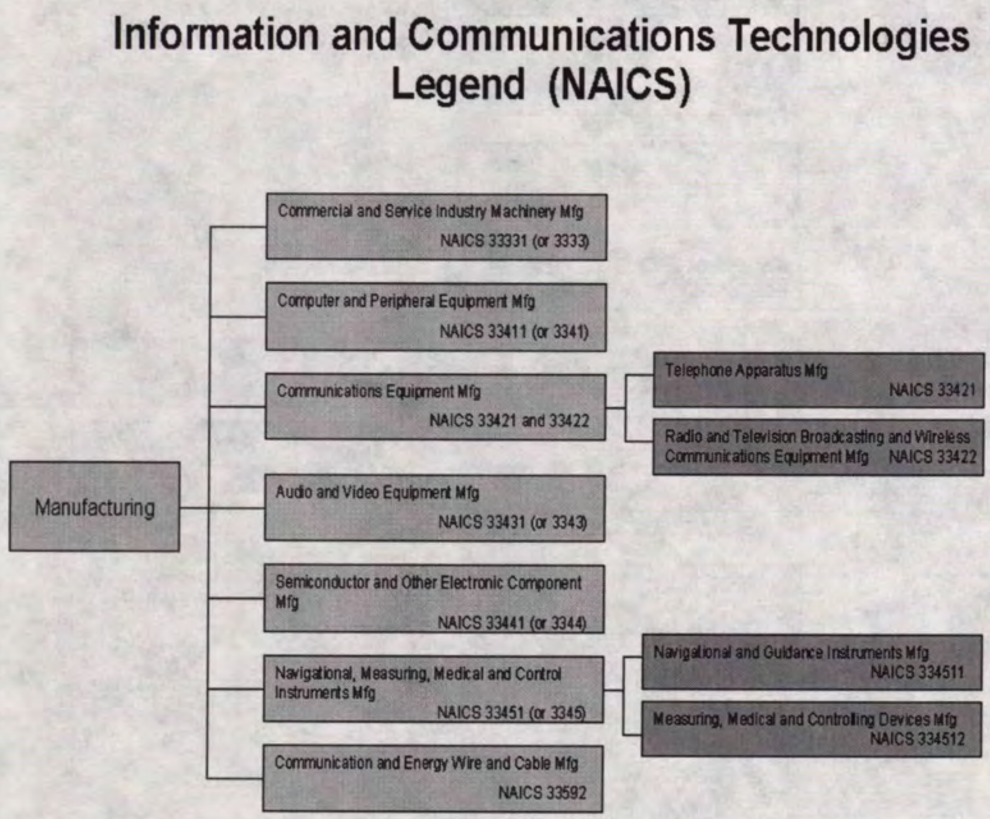
Notes:

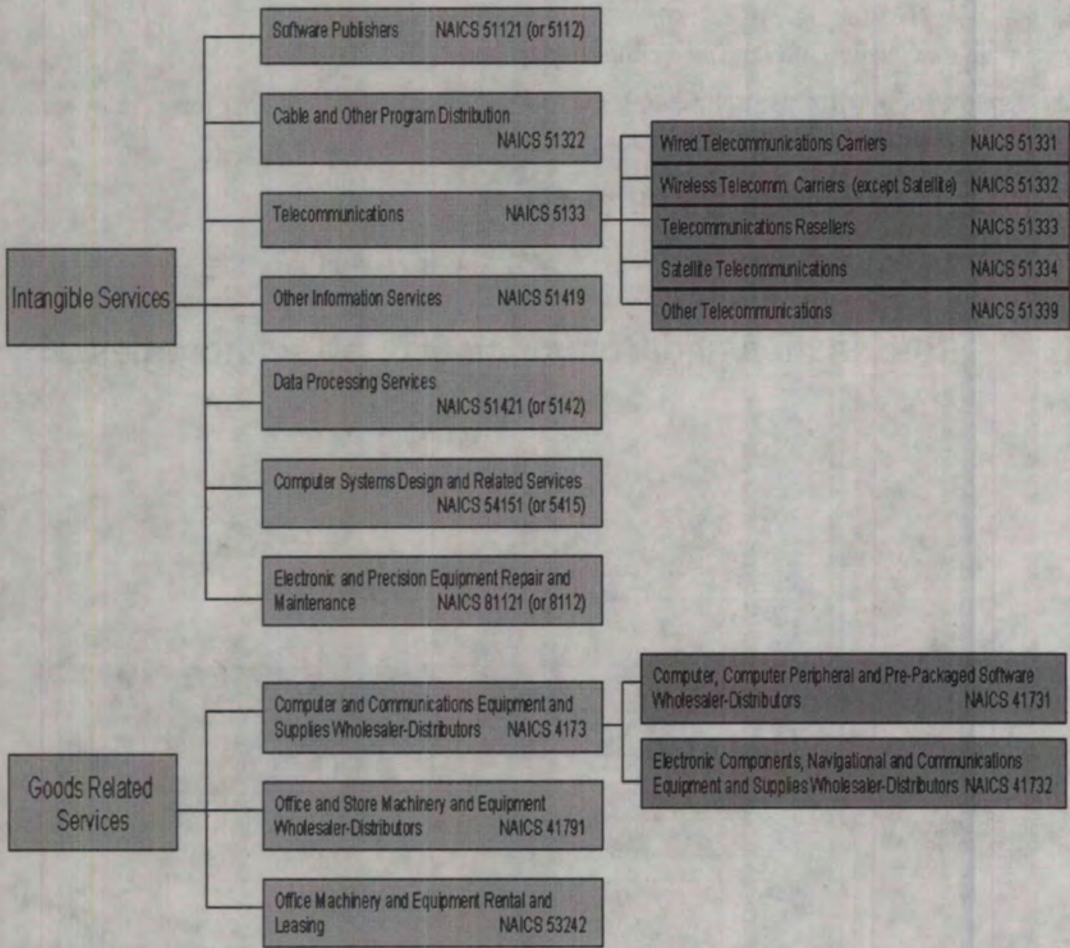
1. Basic company data is first collected in a spreadsheet and then mapped onto the Cluster Profile Template. The information collected in this spreadsheet includes:
   - ⇒ Company Name
   - ⇒ Company Type (SME, MNE, etc.)
   - ⇒ Revenues (if published)
   - ⇒ Local Employment (if published)
   - ⇒ Markets
   - ⇒ Product Categories

- ⇒ Key Technologies
- ⇒ Key Cluster Converging Technologies

2. Sector Support Infrastructure and Sustaining Environment information is relevant to all clusters unless otherwise indicated.

ICT SECTOR DEFINITION (NAICS, 1997)




Intangible Services
Software Publishers NAICS 51121 (or 5112)
Cable and Other Program Distribution NAICS 51322
Telecommunications NAICS 5133
Other Information Services NAICS 51419
Data Processing Services NAICS 51421 (or 5142)
Computer Systems Design and Related Services NAICS 54151 (or 5415)
Electronic and Precision Equipment Repair and Maintenance NAICS 81121 (or 8112)
Wired Telecommunications Carriers NAICS 51331
Wireless Telecomm. Carriers (except Satellite) NAICS 51332
Telecommunications Resellers NAICS 51333
Satellite Telecommunications NAICS 51334
Other Telecommunications NAICS 51339
Goods Related Services
Computer and Communications Equipment and Supplies Wholesaler-Distributors NAICS 4173
Office and Store Machinery and Equipment Wholesaler-Distributors NAICS 41791
Office Machinery and Equipment Rental and Leasing NAICS 53242
Computer, Computer Peripheral and Pre-Packaged Software Wholesaler-Distributors NAICS 41731
Electronic Components, Navigational and Communications Equipment and Supplies Wholesaler-Distributors NAICS 41732

Graytek Management Inc.

LIFE SCIENCES SECTOR DEFINITION (NAICS, 1997)

Research and Development in the Life Sciences (NAICS 5417102)

Pharmaceutical and Medicine Manufacturing:

- Medicinals/Botanicals (NAICS 325411)
- Pharmaceuticals (NAICS 325412)
- Diagnostic Substances (NAICS 325413)
- Biological Products (NAICS 325414)

Medical Devices (various NAICS codes, particularly 3391)

Intangible Services – No specific NAICS codes.

Goods Related Services – No specific NAICS codes.

Other – No specific NAICS codes.