Review of Knowledge Intensive Industrial Clusters in Canada

Scoping Study

Final Report

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For

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This report represents the views of the authors, and not necessarily those of Industry Canada

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EXECUTIVE SUMMARY

The objective of this work is to conduct a review of knowledge intensive industrial clusters. This report traces the evolution of the cluster concept from its origins in economic geography, to Michael E. Porter's **Competitive Advantage of Nations**, published in 1991 as well as more recent documents prepared by Porter, his followers and critics, the OECD and various other researchers.

The work by Porter, the CD Howe Institute and the OECD on clusters has addressed a number of issues on the role of government in facilitating the development of strong clusters. Several researchers argue that governments should provide a supportive environment, capital and human infrastructure and let the marketplace work effectively. Others are more proactive in their views on the role of government. Many studies conclude that protective trade policies, industry incentives (subsidies), weak competition policy and weak entrepreneurial spirit, attributable to an overly protective government, generally inhibit the development of strong clusters.

Porter does not support the picking of winners or champions by government. The experiences of Industry Canada and its predecessor departments in helping to develop industry champions and any lessons learned from either the successes or the failures of this approach provided useful insights for preparing this study.

Similarly, lessons learned from cluster-related experiences of OECD countries were highly relevant to this review. Cluster policies in most OECD countries have moved away from traditional industrial policies based on subsidizing national industries facing restructuring. The focus has shifted towards supporting knowledge-based strategic and technology-oriented sectors.

In addition to Porter, a number of studies concluded that governments should not pick winners. The development of innovation clusters must be market driven. Governments however are able to facilitate the development process through favourable framework policies including competition policy, corporate and personal taxes, the fiscal framework, deregulation and other reductions in market imperfections such as information barriers, organizational failures and by recognizing externalities.

Local participation and collaboration among regional firms is a prerequisite for cluster driven policies. The government can support cluster development by helping to facilitate venture capital and business services, building the technological base and by providing soft

infrastructure through human resource, education policies and other forms of intellectual capital that help build up the required skills.

A number of government agencies, universities, research institutes and municipalities have recently started to use cluster-based approaches in their economic development activities. These policies are more proactive than the free market concepts followed by Porter and his supporters. Currently, the federal government is involved in the clusters concept through the Atlantic Initiative of the National Research Council (NRC), regional development agencies, e.g., ACOA, WED and DEC and the recent announcement by the Social Sciences and Humanities Research Council (SSHRC) of the start of a major study program to comprehensively assess 22 clusters in 5 regions of Canada.

A significant amount of the cluster-based programming initiatives on the federal side stem from ACOA and NRC's efforts in Atlantic Canada, which are tied to the recently announced Atlantic Investment Partnership initiative ($700 million over five years).

Stemming from its community-based cluster model, the NRC is making significant new investments in Atlantic Canada over the next five years to expand various research facilities. Their clusters strategy focuses on linking existing local strengths and global opportunities in emerging sectors to NRC's core R&D capacities.

The NRC's cluster-based innovation approach is based on the following seven elements:

- Research and development;
- S&T knowledge technology transfer;
- Policy regulations;
- Incubation;
- Mentoring
- Finance/ risk capital; and
- Human resource and management skills.

The NRC plays a brokering role as an agent of innovation. It helps a community identify its strengths and encourages local residents and businesses to put together an action plan and working model. The City of Ottawa with its high tech telecommunications cluster is seen as a best practices model on how expertise and research capacity can feed growth.

The NRC has biotechnology cluster-related initiatives in Halifax, Montreal, Ottawa, Winnipeg, Saskatoon and Vancouver. It has announced intensions to proceed with the construction of a nanotechology facility in Edmonton, information technologies in Cape Breton and a facility on Prince Edward Island. It also has 290 Industrial Technical Advisors

serving small and medium sized enterprises (SMEs) throughout the country under the Industrial Research Assistance Program (IRAP). They advise firms about relevant technological advancements around the world and modern non-technical management practices. They encourage both R&D and innovation.

Canada's intellectual property growth has also been generated by research and development in other government departments, centres of excellence, provincial research establishments and by private sector investments. Canadian communications information equipment suppliers have been active. Biotechnology and biopharmaceutical firms are also expanding their R&D presence across the country, but particularly in Montréal and Toronto. Software firms are also R&D intensive with a need to stay on the leading edge midst changing operating platforms and burgeoning international competition. Some of these activities complement and lead the movement of transportation equipment to more sophisticated monitoring equipment and guidance systems. Other innovations in transportation equipment, oriented to fuel systems and efficiencies are more properly tied to transportation equipment suppliers.

The consultants interviewed key players that were located mostly within Industry Canada in Ottawa and the regional offices, but also reaching out to cover other government departments and agencies, incubation centres, universities and private sector associations.

Over fifty interviews have taken place. The organizations that have been interviewed included:

- Industry Canada:
  - Industry Sector branches;
  - Strategic Policy Branch;
  - The Innovation Policy Branch;
  - Micro Economic Policy and Analysis Branch;
  - Investment Partnerships Canada;
  - Technology Partnerships Canada;
  - Small Business Policy Branch;
  - Canadian Tourism Commission
  - Various regional offices;
- Department of Finance;
- Statistics Canada;
- Western Economic Diversification,
- Canada Economic Development;
- Atlantic Canada Opportunities Agency (ACOA);
- National Research Council Canada;
- Innovation Systems Research Network;
- Greater Hamilton Technology Enterprise Centre on incubation;
- Air Transport Association of Canada;

- Conference Board of Canada;
- Canadian Manufacturers and Export Alliance;
- Dalhousie University;
- University of Toronto; and
- Ministry of Industry and Commerce, Quebec,

Interviewees Had a Wide Range of Views

Some officers of Industry Canada and other agencies are sceptical about the role of knowledge clusters in industrial development. These people argue that Industry Canada's mandate is to foster industrial development. Clusters are the result and not the cause of successful commercialization activities, it is argued. Other officers' make the opposite case that development of knowledge clusters provides a powerful economic and regional development tool.

Champions or multinational enterprises often lead successful clusters. The role of Nortel in the Ottawa telecommunications equipment cluster has been used as an example regarding the impact of a champion on smaller and related firms within the cluster. A key role of the government is to help remove bottlenecks that are constraining the growth of the cluster. The availability of skilled workers, strong universities providing high tech graduates, community infrastructure support, favourable regulatory and taxation environments and international standards are considered to be critical success factors for the growth of a sustainable cluster. Governments at all levels should help facilitate the required soft and hard infrastructure.

The ability of universities to grow graduates is being seriously constrained by resource limitations, ageing teaching staffs that are not being adequately replaced upon retirement and stiff international competition for competent young faculty. Government support to universities should be a high priority in order to help alleviate these serious constraints facing the academic community and subsequently the availability of skilled workers to help clusters develop and prosper.

Regarding using cluster-based approaches as a regional development tool, the regional development agencies and the NRC believe that innovation mentoring, community-based research, and incubation practices are a more effective tool than the traditional approaches of supporting declining industries facing global pressures.

The goal is to help a community to acquire the needed knowledge, practices and social capital that will result in innovation driven growth and prosperity. If a given community acquires knowledge and best practices, it is argued the investment money from the private sector will follow as the predominant source of funds. ACOA and the NRC are

pursuing this approach in Atlantic Canada through the Atlantic Canada Investments Partnerships Initiative.

The NRC argues that their community-based projects are not based solely on redistribution goals. In their model, innovation is best developed through the collaboration and input from local representatives. The NRC projects are generally tied to the strengths and resource endowments of the participating community willing to invest in social capital. For example, the biotechnology research that occurs in Saskatoon is consistent with its agriculture economic base. Similarly, in St. John's, Newfoundland the Institute of Marine Dynamics and the Ocean Technology Cluster stem from the region's emerging marine and ocean industries economic base.

Several people argue that Canada has very few sustainable clusters at present, although a number of emerging clusters are evident. Interviewees generally agree with a stage growth analysis of cluster development. Acceptance of such a construct, gives room to recognize smaller clusters in more remote areas or those at the outset of their development. Several potential clusters have been identified. For example, new media is considered to be an emerging cluster in Vancouver, Toronto and Montreal. Photonics or wireless is considered to be an emerging cluster in Vancouver, Calgary, Ottawa and Québec City. The enabling technologies (biotechnology and information technology) are considered to be emerging clusters in all of Canada's five regions. Food and beverages, wood products and energy are considered to be clusters at various stages of development in Western Canada and Québec. An earlier, study funded by WED and provincial governments on clusters in Western Canada concluded that the agriculture biotechnolgy cluster in Saskatoon is the only cluster in the region that meets the minimum requirements to be a sustainable cluster[1]. This ranking was based on the potential for commercial success, which has yet to materialize.

Ontario's clusters include financial services, automotive, steel, aerospace, information technology, biotechnology, medical and new media. Quebec, especially Montreal has clusters in aerospace, biotechnology, medical and transportation equipment (other than aerospace).

The Atlantic Canada provinces have emerging clusters in e-business, geomatics, aquaculture, ocean technology, medical devices and food processing. In addition, a full analysis should include biopharmaceuticals, seafood, value added wood products, neutraceuticals and agri-horticulture, and traditional agriculture around the Agriculture College in Truro.

[1] Building Technology Bridges: Cluster-based Economic Development for Western Canada, 1996 by KPMG, DRI/McGraw-Hill and IMPAX Policy Services International.

While a number of interviewees believe that the cluster approach encompasses a strong set of economic tools, greater synergy and collaboration is required between two interdependent camps. One camp represents excellence and support for clusters with substantial critical mass and the other favours inclusion and support for clusters at the community level as a regional development tool.

The long list of potential clusters identified by the interviewees needs to be carefully assessed. The emerging clusters with strong growth potential need to be identified based on further research.

This research should be done collaboratively by the Industry Sector, other areas of Industry Canada and the Industry Portfolio Partners.

Bottom Line

Canada has very few large industrial clusters of the Michael Porter variety. However, it has many potential and emerging innovation clusters in each of the five regions of the country. Key success factors for growing clusters include:

- Community involvement in the innovation process;
- Social networking and exchange of best practices between MNE's government labs and SME's; and
- Development of an entrepreneurial spirit where the rewards of success take precedent over the fear of failure.

All of the organizations that were interviewed are involved in cluster development in some form or other. Different philosophies, cultures and approaches, however, are being used to foster the growth of clusters. The chances of success for these players collectively are much greater if they work together cohesively rather than being at odds with each other. In addition to the obvious need to put more effort in mapping and researching clusters, a forum needs to be established for the players to exchange views and to understand each participant's roles and responsibilities better.

Successful clusters are all about social cohesion and networking. The same principles should apply to the organizations trying to foster clusters.

I. PURPOSE

Knowledge intensive industrial clusters are generally considered to be regional or urban concentrations of firms including manufacturers, suppliers and service providers, in one or more industrial sectors linked by trade and/or intellectual resources and skilled personnel. These firms are supported by an infrastructure made up of universities and colleges, research institutes, financing institutions, incubators, business services and advanced communications and transportation systems.[2]

More specifically, the OECD defines clusters *as networks of production of strongly interdependent firms (including specialized suppliers) linked to each other in a value-adding production chain. In some cases, clusters also encompass strategic alliances with universities, research institutes, knowledge-intensive business services, bridging institutions (brokers, consultants) and customers.*[3] Further, knowledge-based clusters can encompass, firms unrelated to trading patterns, which, by virtue of their membership, gain access and contribute to tacit and explicit knowledge transfers that accelerate the diffusion of technologies.

The objective of this work is to conduct a review of knowledge intensive industrial clusters in order to help the Industry Sector, Industry Canada develop an appropriate engagement strategy and work program regarding this important area of research.

II. EVOLUTION OF CANADIAN CLUSTER CONCEPTS AND PRACTICES

Historically, analysts have identified industries with strong inter-industry trade and links to external markets as potential clusters or industry agglomerations. While industry trade flows can assist analysts in identifying clusters, the relative efficiencies of clusters is more heavily influenced by the degree of inter-firm cooperation (networks), agglomeration (external economies) generated through social capital (associative behaviour), and technology transfer and diffusion (knowledge spill-over). The last of these includes both explicit and tacit information and knowledge[4] flows among the firms and their interfacing with universities and private and public research centres. It may also extend the cluster's boundaries beyond those firms that trade among themselves. Each determinant contributes to each member firm's efficiencies and a cluster's "collective efficiency", that combination of external economies and

[2] An Industrial Cluster Strategy for Atlantic Canada, Final Report

[3] OECD Proceedings, **Boosting Innovation, the Cluster Approach**, *Cluster Analysis and Cluster-Based Policy Making in OECD Countries: An Introduction to the Theme* by Theo J.A. Roelandt and Pim den Hertog, 1999.

[4] "Knowledge" is used here in the sense of the ability to put information (data) in context.

joint actions, which explain higher returns accruing to specialized, clustered firms.[5]

> *Being part of a cluster allows companies to operate more productively in sourcing inputs* (both capital and labour)*; accessing information, technology and needed institutions; coordinating with related companies: and measuring and motivating improvement.*[6]

1. Historical Evolution

Elements of these influences on the development of urban states, regions and nations have been recognized for a long time. In Roman times, Pliney the Younger argued emphatically for attracting a school into his hometown as a means of realizing rents from students and building industry based on the expertise from its graduates.[7] In medieval times, masters in the trade guilds of Dedham, and elsewhere, recognized synergies among their trades while the larger emerging financial centres of Florence, Amsterdam and London established their roles, those of limited liability companies and money based on the sovereign's commitment to pay.[8] In 1890, Alfred Marshall pulled these elements together in recognizing the power of clusters—lower transaction costs, availability of specialized skills and services, and access to information and ideas.[9] Based on recent work by Piore and Sabel,[10] Rosenfeld attributes the rise of cluster strategies in the United States to the *prototypical economy of clusters—or of industrial districts, as they are known in Italy. The then region of Emilia-Romagna, in particular, was first noticed in the U.S. because of its unusually small, flexible, and specialized firm structure - at least by U.S. standards.*[11]

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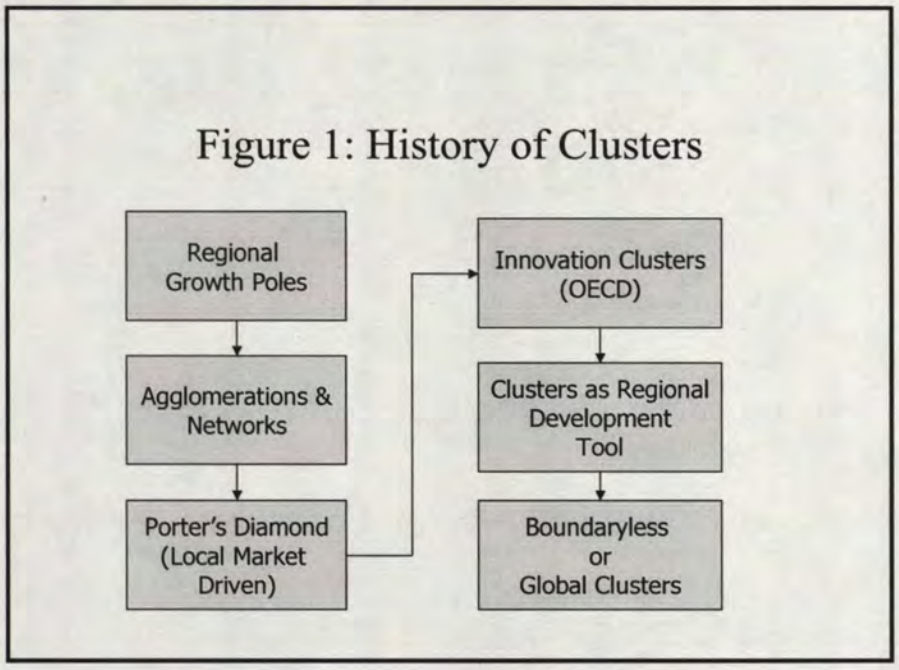
[5] This paragraph builds from, but is not entirely consistent with the opening paragraph in Stuart A. Rosenfeld, **Backing into Clusters: Retrofitting Public Policies**.
[6] Porter, Michael E. *Clusters and the New Economics of Competition*, **Harvard Business Review**, Nov.- Dec. 1998 p. 81.
[7] Gunther, Peter E. **Review of The Ancient Economy** by M. I. Finley in **Canadian Journal of Economics** Vol. VII no. 3, 1974, pp. 530-531.
[8] Hicks, John, **A Theory of Economic History**, Chapters V and VI. Pb. Oxford 1969.
[9] Marshall, Alfred, **Principles of Economics**, 1890, Reprinted Macmillan 1920 (eighth Edition).
[10] Piore, Michael and Charles F. Sabel. The *Second Industrial Divide.* New York: Basic Books, 1984..
[11] Op. cit. Rosenfeld p. 2.

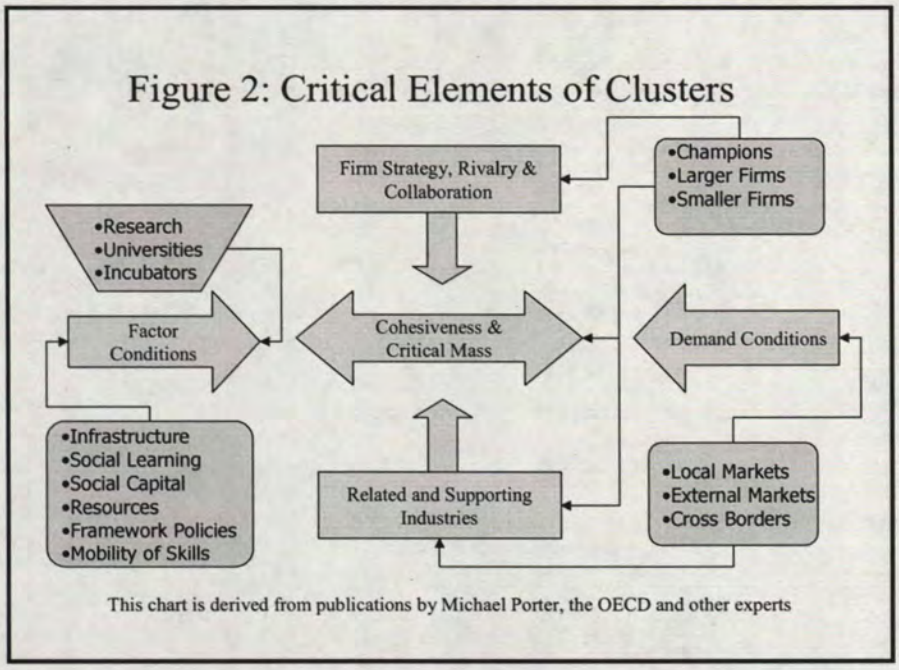


The post-war evolution of clusters has followed the pattern illustrated in Figure 1. Regional growth poles were historically viewed as a way of attracting firms to communities. In doing so they were virtually coincidental with an increased emphasis on economies of agglomeration, particularly in sharing highly skilled artisans and trade workers in industries such as publishing (New York and Toronto) and film making (Hollywood). These people were often linked through formal and informal networks. In 1991, Porter extended these concepts in his diamond approach on synergies developed among four base elements:

- Firm strategy, structure and rivalry;
- Factor conditions;
- Related and supporting industries; and
- Demand conditions[12].

As knowledge-based industries increased in importance during the 1990s his approach morphed into innovation clusters, touted by the OECD and others, with greater emphasis on ties to suppliers of knowledge. Although controversial, the analysis of clusters has become part of the lexicon of regional development, particularly among more proactive governments. The efficacy and effectiveness of such approaches depends heavily on the market driven boundaries of any particular cluster, some of which could be considered boundaryless in the sense of being international in their composition.

[12] Porter, Michael E. **The Competitive Advantage of Nations,** pb. Free Press, 1991, p. 133.



Critical considerations associated with each of Porter's base elements appear in Figure 2. Research, universities and incubators both impact on the need for factors of production and inform firms' strategies, inclusive of decisions concerning whether to remain rivals, merge, acquire, or to act in collaboration with each other. Infrastructure, including communications, social learning, social capital, resources, framework policies and mobility skills all impact on both factor conditions and related and the selection of related and supporting industries. Similarly, marketing strategies, whether they are local, outside the region or international, will directly affect demand conditions and the choice of related and supporting firms. The existence of a major champion may affect demand, rivalry conditions and preclude the choice of related and supporting firms in some instances, by maintaining links within a team created by the champion.

Figure 3: Cluster Elements and Innovation

Innovation Source	Cluster Element	Example
•Public Sector •Universities •Private Labs	•Factor Conditions	•NRC labs •University-industry links
•Customers	•Demand Conditions	•Government technology procurement
•Suppliers	•Related & Supporting Industries	•Embodied technology
•In-house	•Firm Strategy, Rivalry and Collaboration	•R&D intensity

In the cluster context, there are several stimuli to innovations that may act on the base elements. These are captured in Figure 3. The public sector, through laws, regulations, taxes and types of assistance can impact on factor conditions. Universities and colleges do so through the supply and quality of their graduates and via the R&D and intellectual property they generate. Similarly, private laboratories generate intellectual capital on behalf of the firm. Frequently they are also involved with the training of students during work terms and with the transfer of innovations through to the organization of production lines. Informed customers basically drive demand. Suppliers can be a source of innovation, since their innovations inevitably impact on the industry concerned. Under modern management practices, they also participate in design teams in order to minimize the amount of time a product is in design. Internal R&D will be related to the demands of the industry and vary from cluster to cluster and firm to firm in terms of the percentage of the R&D that is basic, as opposed to applied. R&D teams and their results will also be shaped by the degree of co-operation, rivalry among supporting industries and the spin-off policies of major investors in intellectual property.

2. Why Now

With its intellectual roots across the millennia, why has there been a sudden upsurge in the identification and use of clusters to promote local economic development? The explanation has to do with the types of innovations being adopted internationally, shifts in trade policies, the availability of knowledge workers and global expansion of communications technologies.

Settlement patterns tend to be associated with earning a living. Rural England was initially settled so that one could get to the fields in an hour or less. Grain elevators in the American and Canadian Prairies were sited within a days ride for a loaded wagon from the farm. The automobile changed those relationships forever because it facilitated far larger concentrations of people in fewer communities where commercial nodes were based on roads, rather than intersection of rivers, lakes and rails. The information age is, similarly, reshaping the maps by creating new market and intellectual nodes in cyberspace. Modern communications are sufficiently omnipresent to facilitate greater choice in locales and to reshape the economies of agglomeration in ways that analysts are only beginning to understand. Information and communication systems most certainly augment business ties beyond the realm of most communities and, frequently, the countries in which firms are located. For example, innovations in communications and transportation have also facilitated a broader distribution of highly skilled part-time personnel in printing and publishing out of New York and Toronto.[13]

The shift among national governments to embrace globalization and freer trade has added opportunities for businesses to reconsider their locales and markets. In addition, half the scientists in the history of the world are alive today.[14] A higher percentage of the world's population is better educated and immensely more connected than at any time in history. While intellectual capital and technological evolutions create marketing opportunities for communities, they also present challenges for communities to document their abilities, to attract, and to retain knowledge-based industries.[15]

> *Firms now operate in a universe where the level of 'inter-creation' between technology, organization and location has been heightened*

[13] Wannocott, Ronald and Paul Wonnacott, **Free Trade Between Canada and the United States**, Pb. Harvard 1965, Agglomeration Chapter.

[14] Cattaui, Maria Livanos *Opportunities in the Global Economy* **The Drucker Foundation the Community of the Future** ed. Frances Hesselbien *et al.* pb. Jossey-Bass 1998, p. 168.

[15] With the recent morphing of the North American Free Trade Agreement to encompass Mexico and Chile, and the related expansion of the automotive industry into Mexico, the cluster boundaries would need to be revisited based on interviews about current inter-industry ties. Similarly, the emergence of California as the world design centre for automobiles would rewrite the intellectual component of the cluster, relative to the Wonnacott's findings in the early 1960s.

> *considerably. ...Firms generate the maximum synergy through 'goodness of fit' among these different dimensions.*[16]

Competing and satisfying these conditions is the challenge faced by all communities seeking development and growth. Local dynamics, systems characteristics and interdependencies of individual clusters[17] will determine how well newcomers and current plants fit within each locale.

Figure 4 highlights the networks of excellence that link laboratories in all regions to both industry and government. The federal government places demands on its laboratories to meet society's needs, to establish regulations, to test products for public safety and health reasons, to expand understanding of basic science and to produce scientific platforms of interest to industry for multiple possible commercial applications. Spin-off companies and other commercial interests frequently establish their own laboratories that may or may not be networked with others. University laboratories are linked to private research establishments through networks of excellence, grants, research chairs and student work terms. Several regional laboratories, such as the Alberta Research Institute, have become integral sources of excellence for their communities. Personnel at all these laboratories are linked to markets for their innovation through national and local incubator sites, venture capitalists and ultimately users of the technologies. Users will include citizens and the rest of the world, often through multinational enterprises.

Canada's intellectual property growth has also been generated by private sector investments. Canadian communications information equipment suppliers have been active. Biotechnology and biopharmaceutical firms are also expanding their R&D presence across the country, but particularly in Montréal and Toronto. Software firms are also R&D intensive with a need to stay on the leading edge midst changing operating platforms and burgeoning international competition. Some of these activities complement and lead the movement of transportation equipment to more sophisticated monitoring equipment and guidance systems. Other innovations in transportation equipment, oriented to fuel systems and efficiencies are more properly tied to transportation equipment suppliers.

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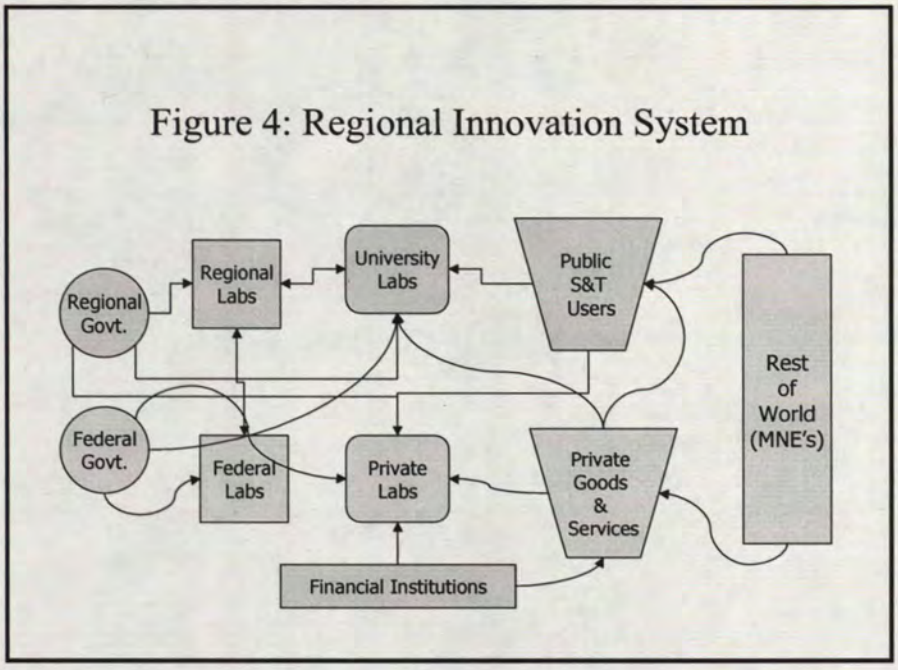
[16] John de la Mothe and Gilles Paquet, *Evolution and Inter-creation: the Government-Business-Society Nexus*, **Evolutionary Economics and the new International Political Economy**, ed. John de la Mothe and Gilles Paquet, pb. Cassell, 1996, p. 12.

[17] Guinet, Jean, *Introduction*, **OECD PROCEEDINGS Boosting Innovation: The Cluster Approach**, OECD 1999, p. 8.



3. Government Engagement

From an engagement point of view, behind what is measured as a cluster, there is a myriad of economic activities related to the generation of external trade, information, knowledge and knowledge transfer. These activities can be facilitated or frustrated by government interventions as they relate to trade, taxation, investment policies, R&D, education, innovation, competition, intellectual property, communications policies, privacy, and the general macroeconomic environment.

By definition, governments are at least partially[18] constrained to act within their own jurisdictions and geographical boundaries, except when international protocols to the contrary exist. These focussed interests lead governments at all levels, which fund research on cluster research, to usually restrain analysis to their own territory or their immediate surrounding areas.

4. Geographically Bounded Clusters

Where international trade occurs among members of a complete cluster, economic linkages will only be delineated fully when the scope of the research in the cluster is international. Peter F. Drucker bluntly discusses this issue:

[18] Extraterritorial issues do arise but are beyond the scope of this paper.

> *To compete successfully in an increasingly competitive international environment, a company has to know the costs of its entire economic chain and to work with other members of the chain to manage costs and maximize yields. ... The legal entity, the company, is a reality for its shareholders, for creditors, for employees and for tax collectors. But 'economically', it is fiction. ...What matters in the marketplace is the economic reality, the costs of the entire process, regardless of who owns what (or where production occurs).*[19]

By extension, the same point is true for industrial clusters. Prior to Mexico joining NAFTA, a North American automotive cluster could have been observed over a vast territory from Western Quebec, across Eastern and Southern Ontario, the southern Lake Erie Shore and Michigan winding its way South through Indiana, central Kentucky and Tennessee, and into northern Alabama. The missing link would have been the external design teams, in California and Milan.[20]

The relatively slow population growth in the U.S. North East and East Central regions, even prior to Mexico joining NAFTA, may be attributed to the efficiencies of modern air conditioning, ageing of the American population, rising heating costs and relatively low housing costs in more southern climates. Pierre Paul Proulx captures these same spatial shifts in regional competitiveness indices relating competitiveness to weighted regional changes in manufacturing value added, retail sales and revenues in selected services and in services to firms, 1972-97. He shows the relative decline in competitiveness of the U.S. North East and East Central regions, whether or not the positive effects of Canadian centres are included with their neighbouring U.S. areas.[21] **The implication is that Canada's major industrial clusters are integral parts of regions with declining relative competitiveness.** There is a corresponding need to bolster productivity and to ensure Canadian clusters market more deeply into the American south and internationally than they historically have been.

Industrial linkages in the production of a final consumer good or service can be traced backwards through several stages of production to the raw materials. Many industrial linkage studies have used variations on this theme. Identification of very large international clusters documents the size of the market and may attract additional competition. Industry

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[19] Drucker, Peter F. **Managing In Time of Great Change**, pb. Truman Tally Books, 1995, pp.126-27.
[20] Florida, Richard, *Calibrating the learning Region,* **Local and Regional Systems of Innovation**, ed. John de la Mothe and Gilles Paquet, Pb. Kluwer Academic Publishers, 1998, p. 19.
[21] Proulx, Pierre Paul, Villes, régions et intégration économique en Amérique du nord, La conference Les liens en Amérique du nord, Occasions et défis pour le Canada, Le 21 juin 2001.

Canada took this international approach in defining its advanced manufacturing processing cluster with the United States.[22]

For countries, regions or cities, with more narrowly defined boundaries, parallel studies may identify missing links where they may be able to attract firms, educational and/or research institutions to fill voids in their innovation systems.

After 25 years of operating under the Canada-United States Automotive Free Trade Agreement, should readers be surprised when Porter observed that Canadian ties in its internal automotive sector are weak? Of course not! In restricting his study to Canada, he is only observing a fraction of the cluster. The Auto Pact and the North American Free Trade Agreements were designed to create a cluster on the New York to Chicago axis and down "Auto Alley". The New York - Chicago axis just happens to run through St. Thomas, Ontario. While Canada has a strong end product or assembly industry, Porter believed that a high concentration of imported parts and almost no specialty machinery made in Canada provided serious impediments to Canada becoming a world-class and competitive nation.[23] When one observes only part of a cluster, it ought not to be surprising to find that the linkages in the part are weaker than for the whole. Similarly, expansion of international trade may weaken ties within regional clusters.

Municipalities and regions commission most work on clusters. Within such narrowly defined boundaries, linkages can be expected to be weak compared to those in nations and internationally. For example, in their work on clusters in the Atlantic Region of Canada the authors are so emphatic about the region's weaknesses as to raise questions the strength of any cluster they claim to have found. In this sparsely populated region of 2.5 million people distributed over a land and water mass the size of Ontario (with five times the Atlantic Canada population) the authors found:

- Weak management practices within firms (e.g. lack of sound management practices; lack of international marketing skills);
- Weak linkages among firms in the clusters;
- Weak linkages between R&D institutions and industry;
- Difficulty in accessing financing due to immature business practices; and
- A lack of skilled people, especially IT personnel.[24]

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[22] Industry Canada, Advanced *Manufacturing: Technology, Sector Competitiveness Framework*, Changing Conditions and Industry Response, Page 3, Strategis, 1999.

[23] Porter Michael E. **Canada at the Crossroads: The Reality of a New Competitive Environment**, pb. Business Council on National Issues, 1992,1990. p.150.

[24] Nordicity Group Ltd. Syntel Consulting Inc. and Horizon Consulting Ltd. **Prospects for Growing Knowledge-based Clusters in Atlantic Canada**, 1997.

Regional boundaries simply preclude identification of the entirety of most economic clusters. Nevertheless, the linkages identified can be significant within the specific region's context. Regional work tends to be based, initially, on commercial linkages that result in concentrations of growth and/or employment and certain skills relative to national or state rates and percentages[25], for which data are available or may be obtained through surveys.

Information relating to agglomeration and associative behaviour is less readily available. The simple presence of a university, community college or significant research facility is insufficient to tie either type of institution to a cluster. The tough questions regarding how knowledge based facilities are linked to each cluster need to be answered and documented. Indicators include:

- Joint appointments;
- Joint academically acceptable publications;
- Shared equipment;
- Spin-offs out of the institutions of higher learning and government laboratories;
- Students on work terms located in the laboratories or in related industries;
- Patents, held jointly and separately;
- Corporate influence on course curriculum; and
- The community's history of excellence.

The explicit and tacit flows of information among firms in a community can also be important, whether or not companies do business together. The measurement of information flows was virtually ignored in Porter's earlier work, albeit he has explored this issue recently.[26]

> *Investing in public goods is normally ... a function of government, yet cluster thinking clearly demonstrates how companies benefit from local assets and institutions. ... Trade associations can provide the forum for the exchange of ideas and a focal point for collective action in overcoming obstacles to productivity and growth. Associations can lead in ... establishing university-based testing facilities and training and research programs; collecting cluster-related information; offering forums on common management*

[25] Op. Cit Rosenfeld p.13. *The most common measures are, for each combination of sectors in the cluster, (1) numbers of employees and establishments, (2) location quotients for each that compare the local concentrations of the industry sectors included within the cluster to concentrations of the same group of sectors for the entire state or for the entire United States, (3) input-output tables that estimate supply chain linkages, and (4) growth rates.*

[26] Op. cit. Porter 1998 and Porter, Michael E, **The Competitive Advantage of Nations**, The Free Press, 1990.

problems; investing in solutions to environmental issues; organizing trade fairs and delegations and managing purchasing consortia.[27]

In his attempt to distinguish the network concept from those of clusters, Rosenfeld developed Figure 5. While some might quibble with the limits he places on networks, the Figure emphasizes the role of social capital in clusters.

Figure 5: Comparing Networks to Clusters

Networks allow firms access to specialized services at lower costs
Clusters attract needed specialized services to a region
Networks have restricted membership
Clusters have open "membership"
Networks are based on contractual agreements
Clusters are based on social values that foster trust and encourage reciprocity
Networks make it easier for firms to engage in complex production
Clusters generate demand for more firms with similar and related capabilities
Networks are based on cooperation
Clusters require both cooperation and competition
Networks have common business goals
Clusters have collective visions

Source: Stuart A. Rosenfeld, **Backing into Clusters: Retrofitting Public Policies**, p. 6.

Although the global reach of networks influences clusters and increases participants' market access, the community aspects of clusters remain germane. They may yield trust[28], reciprocity, cooperation midst competition, collective vision and openness to new arrivals.

The cluster approach is highly differentiated from a sector approach to development and growth. These differences are summarized in Figure 6. The analysis implies that forward and backward linkages are insufficient to delineate all potential participants in clusters since a diverse range of

[27] Op. Cit Porter (1998), p. 89.

[28] The role of trust depends on one's view of whether or not it is required before the development of a cluster or is part of the outcome of a cluster and the experience of working together. Jane Fountain treats trust as an inherent part of a cluster. Her constituent elements of social capital are trust, norms and reliable networks with reasonable permeable boundaries for new members.

Rather than viewing trust as an *a priori* condition for social contact, Woolcock views it as an outcome of social capital.
"... It is important that any definition of social capital focus on its source rather than consequences, i.e. on what social capital is rather than what it does. This approach eliminates trust from the definition of social capital. Trust ... is more accurately understood as an outcome (of repeated interactions, of credible legal institutions, of reputations.)" Woolcock, Michael, *The Place of Social Capital in Understanding Social and Economic Outcomes*, **ISUMA** Vol. 2, No. 1, 2001, p. 13.

What is more likely is that working as part of a cluster sharpens one's judgement as to the situations in which partners can and cannot be trusted.

firms can benefit from similar innovations among different industries. This result implies that the social capital operating within clusters needs to be widely spread via open membership. Thus clusters facilitate diffusion among industry sectors, not just up and down the supply lines at which the original R&D or innovation may be directed.

Figure 6: Traditional Sector Approach vs. Cluster-based Approach to Development

Sector-based Approach	Cluster-based Approach
Groups with similar network positions	Strategic groups with mostly complementary and dissimilar network positions
Focus on end-product industries	Include customers, suppliers, service providers, and specialized institutions
Focus on direct and indirect competitors	Incorporate an array of interrelated industries sharing common technology, skills, information, inputs, customers and clients
Hesitancy to co-operate with rivals	Most participants are not direct competitors but share common needs and constraints
Dialogue with government often gravitates towards subsidies, protection and limiting rivalry	Wide scope for improvements in areas of common concern that will improve productivity and increase competition A forum for more constructive and efficient business dialogue.
Search for diversity in existing trajectories	Search for synergies and new combinations.

Source: Roelandt, Theo J. A. and Pim den Hertog, *Cluster Analysis and Cluster-based Policy Making in OECD Countries: An Introduction to the Theme*, **OECD PROCEEDINGS Boosting Innovation: The Cluster Approach**, OECD 1999, p. 13.

Richard Florida argues that in a well functioning regional cluster, networking by individuals will build their own employment safety net, enhance their mobility within the cluster, and minimize both search and switching costs[29]. These benefits are part of the returns to the social capital of the region.[30] They include reduced search time and the avoidance of costs related to physically moving from one home to another.

> *The central idea of social capital ... is that networks and the associated norms of reciprocity have value. They have value for the people who are in them, and they have, at least in some instances,*

[29] Florida, Richard, *Calibrating the learning Region,* **Local and Regional Systems of Innovation**, ed. John de la Mothe and Gilles Paquet, Pb. Kluwer Academic Publishers, 1998.
[30] Saxenian, Annalee, *Regional Systems of Innovation and the Blurred Firm*, **Local and Regional Systems of Innovation**, ed. John de la Mothe and Gilles Paquet, Pb. Kluwer Academic Publishers, 1998 Ch. 3.

demonstrable externalities, so that there are both public and private benefits of social capital.[31]

Parallel dynamics underpinning the strategies for firms' development of social capital through participation in clusters command realignments to government interventions in:

- Providing the necessary communication technologies to make decentralised structures more workable (in shaping and reaching global markets);
- Facilitating partnerships and alliances for both the development and optimal utilization of new knowledge and for the best exploitation of increasing returns and external economies;
- Fostering the most suitable education and training infrastructure;
- Ensuring that labour laws and social contracts are likely to generate the largest flow of innovations and the most effective capacity to transform rapidly to new opportunities;[32] and
- Establishing the macro economic framework that is conducive to growth[33]

Fundamentally, the technology-trade nexus in the new knowledge-based world economy is focussed on the production of knowledge. The accumulation of knowledge and innovations depend on three interconnected dynamics:

- The shape and strength of the technological system;
- The 'goodness of fit' between the technology and the economic systems; and
- The capacity to 'fine-tune' adjustments between the techno-economic system and its broader social system.[34]

The well being of these dynamic forces to shape the new economy is founded on both local and national economies. A well-functioning local economy encourages learning among those on the production floor through to all segments of the cluster[35], sharing of practical and tacit knowledge to make rapid adjustments to the learning and production regimes and the polity within which the society is situated. It is rich in social capital.

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[31] Op. cit. Putman, p. 41.

[32] John de la Mothe and Gilles Paquet, *Evolution and Inter-creation: the Government-Business-Society Nexus*, **Evolutionary Economics and the new International Political Economy**, ed. John de la Mothe and Gilles Paquet, pb. Cassell, 1996, pp. 12-13. A counter example, where these conditions are not met, appears in, Carlsson, Bo *Innovation and Success in Sweden: Technology Systems,* In the same volume pp. 257-277.

[33] . Martin, Roger L. and Michael E. Porter, *Canadian Competitiveness: A Decade after the Crossroads*. C. D. Howe Research Institute Working Paper 2001 - 1.

[34] Op. cit. de la Mothe and Paquet, p. 13.

[35] Op. cit. Florida, Richard, (1998) Ch 2.

> *The contribution of social capital to economic development also has roots in Northern Italy. The many U.S. delegations that traveled to Italy to learn about networks invariably spent more time more on the support structure, the trade and industry associations and sector hubs that served as convenors and informal brokers for the manufacturing networks. An analytical framework for the social foundation of clusters was provided by Robert Putnam's research, which compared Northern and Southern Italy's economies in 1993, and by Annalee Saxenian's research, which compared Silicon Valley and Route 128 high tech economies in 1994. Their widely cited analyses confirmed the importance of social infrastructure to competitiveness. As a result, regions began to pay more attention to the roles of intermediaries and gatekeepers such as business associations, chambers of commerce, and community based organizations. This view of how clusters "work" melded the interests and techniques of sociologists with those of economists.*[36]

De la Mothe and Paquet point out that the dynamic process of innovation, rather than its structure, is of critical importance. They emphasize dynamic interactions among three important dimensions; cognitive space, the capabilities/absorptive capacity of firms, and the governance of the communities of practice in weaving partners together. By "cognitive space," they refer to transversal areas among domains of different layers in innovation processes (sciences, technologies marketing etc.) that are capable of informing and learning. The use that firms make of what they learn will depend on their absorptive capacity and each firm's balance between exploration and exploitation. The positioning of a firm within the governance of the community of practice will determine its access to engagement levers to intervene in the workplace in order to encourage both learning and innovation. There is no one-to-one relationship between learning and innovation, since a requisite degree of dissonance is necessary to stimulate innovation.[37] De la Mothe and Paquet argue that:

> *In an economy dynamized by information flows, knowledge, competence and capabilities, and the communities of practices, the new relevant units of analysis have to be those that serve as the basis to understand and nurture innovation.*[38]

A well-functioning national economy facilitates investment, international trade and income growth driven by the twin quests of better quality and greater choice through expanded variety and knowledge flows.[39] The latter not only generates more consumer choice, but also better informed

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[36] Op cit. Rosenfeld, p. 10.
[37] De la Mothe, John and Gilles Paquet, *Introduction,* **Local and Regional Systems of Innovation**, ed. John de la Mothe and Gilles Paquet, Pb. Kluwer Academic Publishers, 1998 pp. 2-5.
[38] Ibid p. 5.
[39] Op cit Martin and Porter.

decisions, including those relating to investment. Aside from supply chain management activities, this point is central to engagement in cluster development by federal and national governments in the creation of sustainable clusters.

> *'Sustainable advantage' means that organizations, regions and nations shift their focus from short-run economic performance to re-creating, maintaining and sustaining the conditions required to be world-class performers through continuous development of human resources, the use of clean production technology, the elimination of waste, and commitment to continuous improvement.*[40]

From this overview of studies relating to economic development, is it readily apparent that:

- Cluster approaches encompass their predecessor growth pole approaches, but place far greater emphasis knowledge creation in the form of explicit and tacit human and social capital;
- North American communities are using cluster-based analysis in attempts to persuade investors of their regional superiority versus others;
- Comparative claims among urban areas are generally exaggerated, more out of ignorance of others' strengths than attempts to mislead, which after all only destroy the credibility of the analysis;
- Few if any clusters are viewed internationally, except those of the European Economic Union, which tries to exert international influence as a multi-country trading bloc, rather than a single emerging federal state; and
- Little rigour is devoted to analyzing networking among narrow geographical clusters.

5. Stages of Cluster Development

This general discussion has led us to adopt a stage growth approach to clusters. The advantage of such an approach is to expand the analysis from observing a few relative large mature clusters, often centred in Québec and Ontario, to a much more general approach to development in all Canadian regions. The six stages are:

- Birth;
- Potential;
- Emerging;
- Sustainable;
- Mature; and
- Declining.

[40] Op. cit. Richard Florida (1998) p. 28.

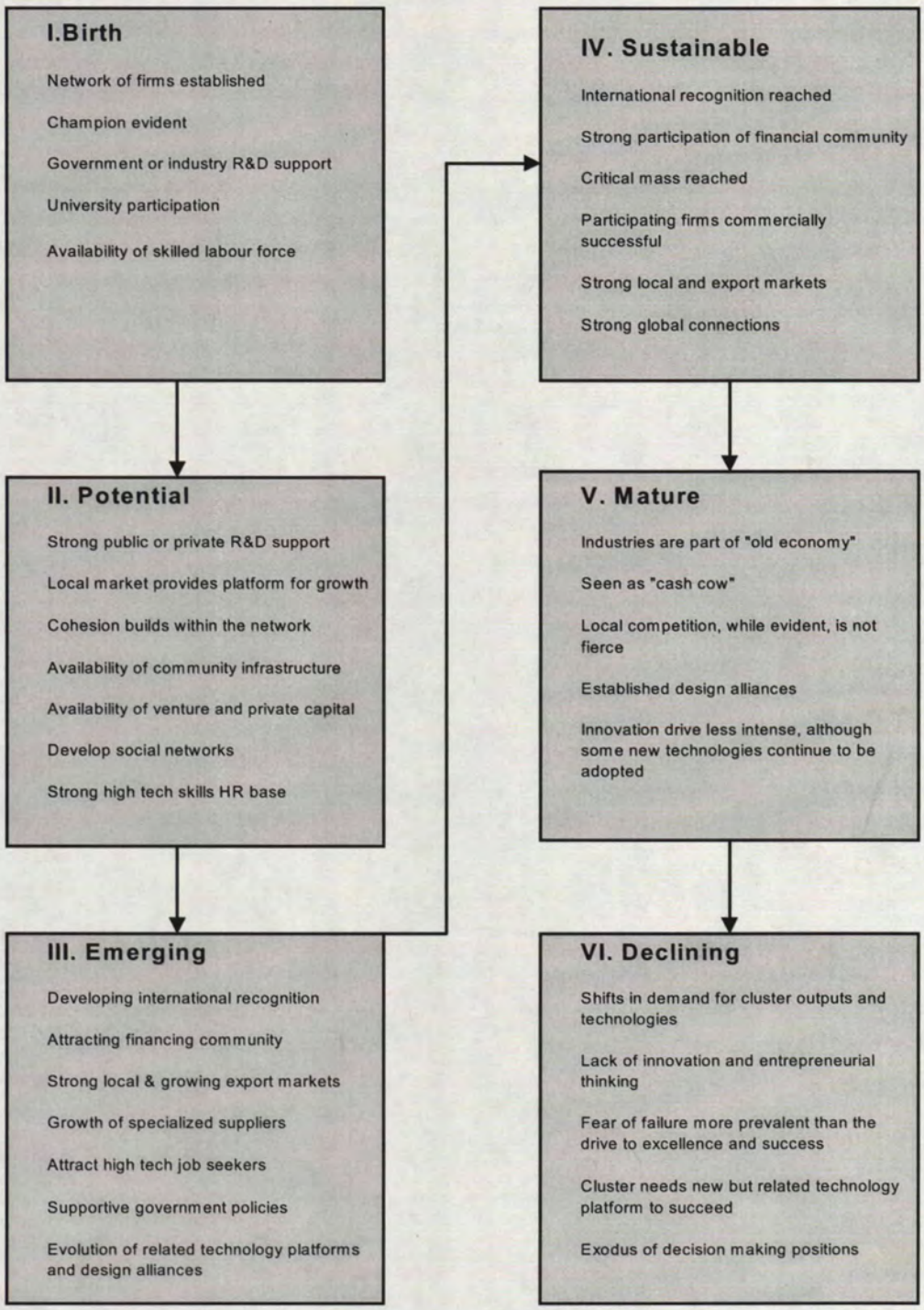
This is not to argue that there is any inevitability that all clusters will go through all stages. History suggests the contrary. Some potential clusters may be stillborn. Similarly, elements of various stages may be taking place simultaneously among different elements of a cluster so that the stages are not strictly linear and may overlap. The summary of these stages appears in Figure 7.

Briefly, *Birth* of a cluster involves mustering elements that have the potential to coalesce and to grow, namely established networks among industries, universities and government with a champion that is usually drawn from industry, but may be within the leadership of the university. The planned growth path of the cluster needs to be consistent with the present and future labour skills of the community. *Births* are financed mainly out of current operating budgets and by angel investors, or alternatively they involve established businesses, with little previous contacts beginning to coalesce to meet new market demands.

Birth emerges into *Potential* based on additional research, the development of markets, expanding collaborations, networks, improved dedicated infrastructure and increased community support, especially in the supply of skilled personnel and fora for the exchange of ideas and information. During the potential stage, private venture capitalists, usually from outside the region, supplement activities of early angel investors for the larger leading firms.

Emerging clusters are more advanced than *Potential* ones in that firms participate in rapidly growing markets, attract international financiers and launches on stock markets. They also begin to establish dedicated suppliers and to draw skilled workers from outside the region. With their increased economic presence, they initiate demands and sometimes obtain government direct or indirect support to perpetuate growth. Conceptually, they operate in the context of scientific and design platforms that facilitate product and market diversification as well as R&D into more advanced future platforms and product arrays.

Figure 7: Stages of Cluster Growth



Subject to ongoing good management, clusters are *Sustainable* when there is informed international recognition of them, often realized by the participation of an increasing number of international firms in the cluster's locale. The strength of the financial community's confidence in the cluster is realised through not only support of cluster leaders but also selected spin-offs and other suppliers. The market focus is increasingly international, based on global networks of several firms. The *Sustainable* cluster also reaches critical mass in that labour becomes quite mobile within the cluster, without firms or individuals having to incur the costs of physically moving new recruits. Through this mobility, individuals have the opportunity to capitalize on the community's social capital as part of their own mobilisation strategy.

In the *Mature* stage clusters are perceived as part of the old economy. Leaders are seen as "cash cows" and supply lines well established. While there is a degree of competition, it is not fierce among a limited number of suppliers and producers. Design alliances are often well established and well integrated. In the context of modern management practices, design teams frequently include established suppliers of key components, based on understandings of contractual considerations subject to time and quality criteria being met.

Decline comes with market shifts away from either the products of the cluster or alternative sites become more attractive by virtue of market opportunities, lower costs and their social capital. These factors cause an exodus of entrepreneurs and decision-makers that weakens the cluster. Clusters can also lose their innovative character through management practices that instil a fear of "failure" and commensurate risk avoidance behaviours that lead to stagnation. They result in an emigration of innovators and costly delays in the evolution of new scientific platforms from which to perpetuate growth. That loss undermines long-term international competitiveness and leads to decline. Such declines can terminate growth at any stage in the cluster development process.

6. Canadian Practices

Canadian development practices normally have been fairly broadly focussed. Historically and today, there have been attempts to implement growth pole practices by attracting a major manufacturer to an area on the premise that it would attract its suppliers. Given that assembly processes were often capital intensive and the supporting infrastructure for suppliers scarce, this policy was high profile and risky, with limited results. Nevertheless, governments were willing to make adjustments to training budgets and even labour legislation to accommodate key elements around those, which other companies might rally.

A less risky, but lower profile, approach was to use cluster-based analysis in various jurisdictions to identify missing links and to try to attract firms to fill those missing elements. Both the low and high-stakes versions of interventions designed to attract clusters could also be viewed as "beggar thy neighbour policies," that eroded national economies of scale. The old DREE was frequently criticized by Ontario on precisely these grounds. These approaches were also fundamentally mercantilist and antithetical to free trade and the consumer benefits attached thereto. Indeed, abandoned federal policies, used historically to attract firms, would be circumscribed now by terms of international trade agreements.

In 1992, Michael Porter argued that Canadian industry was in a state of *comfortable insularity.*

> *...there was little pressure for Canadian firms to innovate in order to compete. In fact, within the old economic order such investments may well have been sub-optimal. Government reinforced patterns of corporate behavior by seeking to insulate the Canadian economy and thereby to keep the nation together. The price was limited by a lack of international competitiveness outside of the resource sector, a lack of dynamism in the economy, and often higher than necessary prices in the domestic market.*[41]

Porter stated that Canada has an abundance of basic factors of production and market protection creating little pressure for upgrading. Porter argued that Canadian industry utilized *inward looking cost-based strategies, conservative goals and a lack of intense local rivalry blunted innovation and reduced the sophistication of buyer behavior.* Porter also argued that Canada is weak in related and supporting Industries. Canadian industry was *risk-averse and price-dominated buyer behavior often slowed technology adoption, reinforced factor dependence, and limited the development of supporting industries.*[42]

Porter argued that five narrow and shallow clusters were evident in Canada. These were in forest products, transportation equipment, petroleum and chemicals, metals and minerals and food and beverages. Porter stated these clusters were shallow due to an absence of specialized inputs made in Canada and the lack of a competitive machinery and equipment industry in order to supply highly specialized domestic inputs to the cluster.[43] Most of the transportation equipment exports are related to the Auto Pact. The industries in the cluster producing end products are automotive, bus and truck assembly, railway locomotives and rail and

[41] Op cit. Porter 1992, pp. 150-151.
[42] Ibid. p. 151.
[43] Ibid. p. 256.

freight car assembly, snow removal equipment, and aerospace manufacturing.

These approaches focussed on commercial linkages, rather than economies of agglomeration and related knowledge flows. The emergence of Silicon Valley, Silicon Valley North and other linked high-tech centres in Richmond and the Lower Mainland of the Fraser Valley, Calgary, Montreal, and Halifax are modern examples of emerging clusters utilizing economies of agglomerations and associative behaviour.

Table 1 outlines the top R&D performing companies in Canada. In addition to the government supported laboratories and universities, these companies are owners and gatekeepers of Canada's intellectual capital. Many of these companies are successful on the world stage, e.g., Nortel Networks (ranked number 1 in Canada), Pratt & Whitney Canada (ranked number 2, Magna International (ranked number 3, Ericsson Canada (ranked number 4) and ATI Technologies (ranked number 5). It is interesting to note that Nortel spends on average 13.2 percent of its revenues on R&D. Many of the top 25 R&D performing companies are involved in telecommunications, computer software, biotechnology and transportation components.

Municipal and regional studies have identified clusters that Porter and company would not and did not identify at the national level. The number of clusters in each community and the strengths of the inter-industry and intellectual linkages vary with the criteria used in the studies and the size of the community being studied.

Of particular interest are the biotechnology clusters associated with the NRC. The reach of these institutes varies with the reliance on the Internet for networking among its client base. In each community, where they are located, NRC's laboratories are also integrated with local academic institutions through joint appointments, research projects, publication and the training of students from high school onward. Ties with small and medium sized business are forged through not only the incubation sites but also through guest workers, direct consultations, patent transfers, spin-offs and Canada wide consultations through Industry Technology Advisors operating under its Industrial Research Assistance Program. Funding is also available to assist firms in undertaking R&D. Beyond biotechnology clusters, the NRC, through its own research activities, also participates in other clusters including optics and photonics. It is also an active member of an association of over 100 Canadian laboratories and Centres of Excellence.

Table 1: Top 25 R&D Companies in Canada for 2000

2000 Rank	Company	R&D 2000 $000	R&D as % of Revenues	Industry
1	Nortel Networks Corp.	5,948,200	13.2	Comm./Telecom Equip.
2	Pratt & Whitney Can.	331,000	15.9	Aerospace
3	Magna International	246,500	1.6	Automotive
4	Ericsson Canada	237,800	34.3	Comm./Telecom Equip.
5	ATI Technologies	224,300	11.0	Computer Equip.
6	PMC Sierra	203,000	32.0	Electronic Parts & Comp.
7	Atomic Energy of Canada	173,400	31.4	Energy
8	JDS Uniphase	168,400	7.9	Comm./Telecom Equip.
9	Mitel Corp.	152,900	10.9	Comm./Telecom Equip.
10	Bombardier Inc.	132,200	1.0	Aerospace
11	CAE Inc.	126,400	10.9	Aerospace
12	Geac Computer Corp.	120,400	12.2	Software/Computer Services
13	Alcan	120,300	0.9	Mining & Metals
14	Apotex	110,000	18.0	Pharma/Biotechnology
15	Hydro-Quebec	103,000	0.9	Electrical Power & Utilities
16	Creo Products	95,600	14.3	Software/Computer Services
17	Glaxo Wellcome	90,400	16.3	Pharma/Biotechnology
18	Ballard Power Systems	86,500	210.5	Energy
19	Cognos Inc.	80,600	14.1	Software/Computer Services
20	Biovail Corp.	78,200	17.0	Pharma/Biotechnology
21	Tembec Inc.	74,600	2.9	Forest/Paper Products
22	BioChem Pharma	71,800	22.1	Pharma/Biotechnology
23	AstraZeneca Canada	70,600	10.0	Pharma/Biotechnology
24	Motorola Canada	67,000	6.1	Comm./Telecom Equip.
25	Corel Corp.	65,200	27.9	Software/Computer Services

Source: The Impact Group, Research Money: *Canadian Corporate R&D Directory Database*, 2001.

In conjunction with the Department of Foreign Affairs and International Trade's Technology Inflow Program, NRC's IRAP is also intended to transfer information and knowledge from R&D undertaken around the world. Many researchers at the laboratories also participate formally in joint research projects. These international ties are supplemented by more informal relationships based on individual networking arising from diverse academic backgrounds and ongoing work in international fora.

The NRC's evolution to centre stage in Canada's knowledge-based clusters has not been accidental. It has done so by a gradual transition and a strategy of consistently improving its global and Canadian networking capabilities. Its early, 1992, interest in the knowledge economy[44] and subsequent strategic think tanks[45] all impacted on its vision.

[44] Gunther, Peter E. and Fred Belaire, **From Here To The Knowledge Economy**, pb. National Research Council and Environment Canada, 1992.

[45] Belaire, Fred W. and Peter E. Gunther, **NRC'S Symposium on Systematic Relationships between Science and Technology and Economic Growth**, 1997.

Elsewhere in Canada, clusters are also strongly linked to intellectual resources beyond those of NRC's current activities. Toronto's biotechnology cluster is tied to the University of Toronto's medical school, hospitals and industrial laboratories whose lineage can frequently be traced back to that source. Similarly, Denzil Doyle has traced Ottawa's microelectronic cluster back through laboratories at Nortel, its not-for-profit subsidiary Bell Northern Research, Newbridge, Mitel, Corel and even failures such as Nabu to the NRC.[46] Large industrial laboratories also continue to promote good relations with universities through:

- Participation in joint research projects;
- Joint sponsorship of chairs with the National Science and Engineering Research Council;
- Guest research positions;
- Carrying out technical work such as producing experimental chips in capital-intensive clean air laboratories;
- Employment of students during work-terms and after graduation; and
- Outright funding of university research.

As Porter suggests, resource industry clusters[47] continue to play a role. In this context laboratories, such as PAPRICAN, sponsored jointly by the pulp and paper industry, its machinery and equipment suppliers and government, continue to play a critical role in pre-competitive R&D and in linkages to institutions of higher learning.

These interrelationships are all relevant to understanding knowledge flows and the roles of clusters in the innovation process. Based on its highly educated population, the knowledge economy flourishes within Canada, despite stiff competition from the United States for scarce human resources.

From a sample of growing Canadian SMEs measured over the period from 1984-88, John Baldwin researched several different functional strategies on the importance of management, human resources, marketing, finance and innovative activities. While all were more heavily used among the more successful firms relative to less successful firms, the last of these was empirically most related. Innovative activities rose with the internal presence of an R&D unit, R&D expenditures relative to total investment

[46] Denzil Doyle, Chart on the History of Technology in Ottawa.
[47] Porter (1992) identifies the following resource based clusters:

- Canadian Forest Products;
- Materials and Metals;
- Petroleum and Chemicals; and
- Food and Beverages.

and its R&D to sales ratio. Yet, the importance of R&D was generally not well recognized by their own management who ranked it near the bottom regarding the relative importance of different functional strategies.[48] In addition to the output of their own research facilities, SMEs also benefit from the R&D done by larger firms since a larger share of SME innovations are the result of liaisons with customers.[49]

Baldwin also examined competitive qualities distinguishing more successful from less-successful firms. *The more successful group give themselves a 33 percent higher mean scores for R&D innovation spending, a 7 percent higher score on the range of products offered and an 8 percent higher score on the level of their production costs relative to their competitors.* Other positive factors included; product range, labour climate and product quality.[50] They viewed themselves as doing less well in customer services, price and employee skills. These negative indicators suggest that the more successful were also harder on themselves in these self-assessment approaches.

In a later study (1999), Baldwin and Johnson compare the characteristics of successful Canadian science-based firms with successful start-ups that are non-science based. Differing characteristics emphasize the roles of networking and clusters. Successful science-based firms:

- Rely more heavily on repeat business - over 50 percent;
- Have more rapid rates of new product introduction and customisation, but not with respect to price and quality in general;
- Attract managers who make greater use of information technologies;
- Invest more heavily in new technologies, R&D and use of intellectual property - 69 percent of investments compared to 42 percent elsewhere;
- Reduce production time and use computer controlled process;
- Innovate - 50 percent of products versus 21 percent;
- Target markets, especially foreign markets - 36 percent exporting compared to 11 percent for the others;
- Experience greater stress in recruiting skilled employees and upgrading through training - 63 percent versus 52 percent; and
- Place less emphasis on financial results and more on quality.[51]

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[48] Baldwin, John R. *Innovation: the Key to Success in Small Firms,* **Reprint Series**, CIAR Program in Economic Growth and Policy, Paper No. 29, May 1995.

[49] Baldwin, John R. *The Importance of Research and Development for Innovation in Small and Large Canadian Manufacturing Firms,* **Reprint Series**, CIAR Program in Economic Growth and Policy, Paper No. 66, 1996.

[50] Baldwin, John R. *Innovation and Success in Canada: Small and Medium Sized Enterprises,* **Evolutionary Economics and the New International Political Economy**, ed. John de la Monthe and Gilles Pacquet, Pinter, 1996, pp.246-247.

[51] Baldwin, John and Joanne Johnson, **The Defining Characteristics of Entrants in Science-based Industries**, pb. Statistics Canada, 1999, 88-517-XPB.

Engagement in cluster-based approaches may be aimed at removing imperfections in the innovation systems by facilitating the efficient functioning of those systems.

III. LESSONS LEARNED

The evolutionary heritage of clusters, discussed earlier, implies that some lessons learned concerning elements of clusters predate the concept. This chapter then draws upon rich lessons from structural approaches to economic development whenever and wherever they are relevant to knowledge-based clusters. As with much of the rest of the economy, some advocate a laissez-faire approach while others favour somewhat more proactive engagement by governments. In reality, Canadian government policies balance both views.

1. Laissez-faire

Porter views competition as an important characteristic of well-functioning clusters. *Although extensive vertical integration may have once been the norm, a fast-changing environment can render vertical integration inefficient, ineffective and inflexible.*[52] Drucker concurs but attributes competitiveness to suppliers' ability to deliver quality, rather than necessarily the lowest price. *To get productivity you have to outsource activities* (to firms)*...that have their 'own' senior management. ...The trend to outsourcing has very little to do with economizing and a great deal to do with quality.*[53] Elsewhere in his same volume, as documented earlier, Drucker stresses costs. According to both authors, the presence of competition stimulates productivity and real economic growth, whether competition lowers costs of inputs or improves quality.

During the late 1980s and early 1990s in Porter's views, Canada's macroeconomic indicators reflected a considerable drain on the Canadian economy:

- The government's budget deficit of 6.6 percent of GDP, twice that of any other G-7 nation other than Italy, was putting upward pressures on interest rates and an unfavourable investment climate;
- High personal and corporate income tax rates discouraged investment and effort and encouraged emigration;
- The highly developed social safety net discouraged personal skills upgrading and disincentives to work; and

[52] Porter, Michael E, *Clusters and the New Economics of Competition*, **Harvard Business Review**, Nov.-Dec., 1998 p. 80.
[53] Op cit. Drucker 1995, p. 3.

- Declining long-term real prices of natural resources, on which four of Porter's five Canadian clusters were still founded.[54]

Similarly, microeconomic indicators revealed additional problems:

- Intense rivalries among locales and provinces combined with complacent customers created weak demand pressures for firm productivity upgrading;
- Supporting industries were either already weak or slowing their pace of innovation;
- Factor conditions, especially with respect to human and capital and R&D infrastructure constrained more sophisticated ways of competing;
- Many firms had no global orientation and those that had were in international markets focussed on the less demanding U.S. clients; and
- Canadian firms tended to leave the upgrading of the business environment to government, rather than to support specialized education or cluster developments.[55]

This is not to say that Porter and his colleagues envisage no role for governments. They would, however, limit governments to:

- Set the macroeconomic environment with competition stimulated by trade, and reductions in inter-provincial trade barriers to the flows of goods, services and capital;
- Abandon attempts to produce national champions;
- Redress the deficit and reduce personal and corporate income taxes;
- Develop an educational system that produces the skills mix required in today's and future labour markets, from researchers to production line technicians;
- Adopt more stringent and forward looking environmental standards;
- Accelerate the pace of deregulation in infrastructure sectors such as communications and transportation; and
- Invest more heavily in education and specialized skills development.[56]

The Canadian Manufacturers and Export Alliance (CME) have recently produced *The Business Case for Innovation*, which suggests a role for government similar to what Porter and his colleagues are envisaging. According to the CME, governments have a role to play in:

[54] Op. cit. Martin and Porter, p. 3.
[55] Ibid. p. 3.
[56] Ibid. p. 4.

- Reducing the costs of taxation and regulatory compliance;
- Streamlining product approval processes;
- Removing regulatory obstacles to trade and other regulatory impediments to investment or business flexibility;
- Assisting cooperative efforts among businesses, facilitating knowledge transfers between companies and research organizations, and removing regulatory impediments to the formation of business networks;
- Providing adequate funding for academic and government research;
- Facilitating centres of excellence in order to pool resources across academic and government research establishments based on industry needs;
- Supporting education programs geared to industry needs, changing immigration requirements to reflect business requirements, and encouraging skills training; and
- Strengthening financial incentives for business investments in new product development and new technologies.[57]

2. A More Proactive Approach

Recognition of the pivotal role of institutions of higher learning and major private and public laboratories in knowledge-based clusters implies that governments either directly or indirectly are engaged in building and sustaining knowledge-based clusters. In Canada, it is governments who license universities and are the main funding source for them. Governments also locate, build, and, in large part, fund government laboratories.

> *Just as the right institutional arrangement for the firm is not one that relies exclusively on the price system, neither is that the right institutional arrangement for the nation as a whole. We have to think about institutional arrangements that will encourage the production, the distribution of ideas as well. Nations are repositories of knowledge and ideas, just as firms are. This is where the truly big challenge lies for policy makers - how to structure the economic system ... in a way that it will encourage knowledge production and distribution.*[58]

These institutions have a heritage of rigorous documentation of their scientific activities. In so doing, they build and make explicit intellectual capital. They have a rich history of excellence in technology since operating at the frontiers of science frequently requires the development of finely tuned prototypical equipment. They are also sources for the

[57] Canadian Manufacturers and Exporters, *The Business Case for Innovation*, August 2001.
[58] Romer, Paul, *Progress and Puzzles in Understanding the Determinants of Economic Growth*, **Modern Perspectives on Economic Growth**, pb. The Canadian Institute for Advanced Research, 1995, Ch. X, p. 10.

transfer of intellectual capital to their communities in that leading scientists bring their own international networks of expertise within their own and associated disciplines and specialties to both their employers and their communities. With the increased connectedness from recent innovations in digital communications, access, to these networks and individuals, has become almost instantaneous. For the extraordinary computing demands of the genomics network, broadband communications have also become part of the scientific tool kit. Major laboratories and universities are then reservoirs of intellectual capital, which are well-documented ideas, concepts and scientific platforms from which diverse innovations may flow.

The laboratories and universities are also sources of human capital since they educate and train skilled individuals from undergraduates through to postdoctoral students and experienced scientists.

Linkages of dubious quality to these intellectual resources have restrained the extent to which universities and laboratories could and did deliver technical information, knowledge and job-ready candidates to the business community. At the outset of their administration, large gaps between town and gown and U.S. emphasis on defence R&D, led Bill Clinton and Alan Gore to call for a refocusing of science policy by shifting funds from defence to more market targeted R&D and the building of social capital.

> *American technology must move in new directions.... We cannot rely on the serendipitous application of defense technology to the private sector. We must aim directly at these new challenges and focus our efforts on the new opportunities before us, recognizing that governments can play a key role helping private firms develop and profit from innovations.*[59]

Social capital develops the ways and means of facilitating the economically effective flow of information and knowledge among groups, inclusive of business, government, universities, laboratories, and individuals. There are several avenues in which social capital operates. Contractual commitments among these groups frequently call for the explicit transfer of information and knowledge. Transfers occur horizontally in industry associations, vertically in supply-chain relationships and multidirectional through more general fora like Chambers of Commerce, business training institutes and general think-tanks. Students embody some of the knowledge of their universities when they enter the work force. From their work term experiences they also take information and knowledge back to their universities. Similarly, anyone who moves from one employer to another embodies knowledge transfers.

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[59] Clinton, William J. and Alan Gore Jr. **Technology for America's Economic Growth, A New Direction to Build Economic Strength**, White House, February 22, 1993, p. 1.

More subtle fora, are those in which non-contractual contacts are made among key players that accelerate knowledge transfer and diffusion in the process of forging new working relationships.

> *The notion of social capital extends our understanding of 'cooperation' or 'collaboration' in two significant ways. First linking cooperation to the economic concept of 'capital' signals the investment of growth potential of a group's ability to work jointly. Second the concept identifies the structure created from collaborative effort as capital. Well-functioning partnerships, consortia and networks are in and of themselves a form of social capital.* [60]

The constituent elements of social capital involve trust, norms and reliable networks with reasonable permeable boundaries for new members.[61] In this regard, effective social capital is integral to development and maintenance of clusters. Given Canadian governments' established positions in higher education and their ownership of key laboratories, the scope for government engagement in knowledge-based clusters is broader than that envisaged by Porter and his associates.

While issues concerning the overall efficacy of the governments' roles in financing these institutions are beyond the scope of this paper, the present financial structure provides clear avenues for engagement. The need for effective social capital to make the necessary linkages to efficiently use intellectual resources means that siting a research facility or university is far different from locating a warehouse or box store. **Knowledge-based facilities require a community commitment at the local, provincial and national levels of governance to build credible social capital to shape research programs and to make use of intellectual capital as it evolves.** The shaping of research programs is essential. If researchers and scientists do not know what is broken, or inefficient, they are unlikely to address the issues, let alone find solutions.

Similarly, it is at least equally incumbent on those in government to understand the likely social benefits of emerging innovations so as not to create or to perpetuate, unnecessarily, regulations that delay and impede their market entry and adoption. There is an interlocutory role here waiting to be filled in promoting future Canadian clusters in the context of influencing government agencies to structure laws and rules and appropriate regulations so that Canadians will be able to reap social benefits and the related employment.

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[60] Fountain, Jane E. *Social Capital: A Key Enabler of Innovation,* **Investing in Innovation: Creating a Research and Innovation Policy that Works**, ed. Lewis M. Branscomb and James H. Keller, MIT Press, 1997, p. 87.

[61] Ibid. p. 89. As noted earlier, there is some controversy over the inclusion of "trust" in this list.

Engagement in cluster-based approaches may also be aimed at removing imperfections in the innovation systems by facilitating the efficient functioning of those systems. The rules of engagement for governments have been changing. For example the American Advanced Technology Program (ATP) supports private R&D to offset risks and to provide benefits to Americans that go beyond those likely to be recovered by the firm or other member of the consortia. This clause explicitly recognizes externalities. The program is now structured to favour applicants who are members of consortia.[62] Overwhelmingly, recipients view their participation in consortia as the main benefit of the ATP with secondary impacts relating to getting to markets sooner, than would have been the case without ATP assistance.[63] Federal funding for some American government laboratories now requires at least 25 percent private participation.

In addition from 1970 to 1993, industry financing of United States university research rose nearly 600 percent to $1.2 billion, only part of the near doubling in real R&D funds to $20.6 billion accruing to universities over the same time period.[64] These trends represent concrete evidence of increasing synergies between industry and the R&D community in the United States, that is the building and accumulating social capital leading to the creation of knowledge-based clusters.

Universities are closely associated with high-tech clusters. For example, among U.S. Metropolitan Statistical Areas identified as having high-technology clusters by Zolton Acs, essentially all have strong universities and on average twice the educated population as the national average.[65]

In Canada, there is strong evidence indicating that universities conducting R&D have achieved success based on the significant number of papers produced and the high level of number of patents registered compared with the number of people in universities.[66] Canadian universities obtain research funds from the federal and provincial governments (grants, government contracts, etc.) as well as *from industry both in kind and in cash that often includes proprietary knowledge held by*

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[62] Ibid. p. 102 and Hill, Christopher T. *The Advanced Technology Program: Opportunities for Enhancement,* **Investing in Innovation: Creating a Research and Innovation Policy that Works,** ed. Lewis M. Branscomb and James H. Keller, MIT Press, 1997, pp. 143-173.
[63] Op. Cit. Fountain, p. 103.
[64] Branscomb, Lewis M. and Richard Florida, *Challenges to Technology Policy in a Changing World Economy,* **Investing in Innovation: Creating a Research and Innovation Policy that Works,** ed. Lewis M. Branscomb and James H. Keller, MIT Press, 1997, p. 24.
[65] Acs, Zolton, *American High-Technology Clusters,* **Evolutionary Economics and the New International Political Economy,** ed. John de la Monthe and Gilles Pacquet, Pinter, 1996 pp. 193-198.
[66] *A Canadian Innovation Agenda for the Twenty-First Century,* Fifth Report of the Standing Committee on Industry, Science and Technology, June, 2001.

industry. [67] Governments and universities often exchange *knowledge often with complementary objectives and facilities.*[68]

European management and governance structures have also been adjusting. The number of strategic alliances among European firms increased five times from 1980 to 1995.[69]

Innovation is now seen as non-linear rather than as sequential and linear. The dynamics of innovation have become a focus of study and for policies relating to:

- Creating favourable conditions for the smooth functioning of markets;
- Externalities associated with R&D and, more broadly, knowledge creation;
- Governments' presence in the community; and
- Removal of imperfections in innovations system.[70]

The first two of these are well known. The third involves not the building of national champions, but, rather, **changing procurement practices to challenge firms and groups of firms to innovate by using functional rather than detailed technical specifications.**[71] The fourth is more aimed at avoiding impediments to building social capital than at eliminating the externalities, outlined in the second point.[72] The entrepreneurial view of the innovation process and the technical-scientific approach differed significantly forty years ago, but are now reaching a convergence toward an interaction model that emphasizes external factors - interaction, learning, exchange of knowledge, and social and institutional infrastructure[73].

Possible Canadian avenues for engagement in the building of social capital involve:

- Documenting knowledge-based clusters such as the SSHRC's Cluster's Initiative [74] and the evolution of technologies within communities;[75]

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[67] Ibid.
[68] Ibid.
[69] European Commission, **Second Report on S&T Indicators**, 1997.
[70] Roelandt, Theo J. A. and Pim den Hertog, *Cluster Analysis and Cluster-based Policy Making in OECD Countries: An Introduction to the Theme*, **OECD PROCEEDINGS Boosting Innovation: The Cluster Approach**, OECD 1999, p. 9.
[71] Ibid. p. 17.
[72] Ibid. p. 18.
[73] Landry, Réjean, Moftar Lamari et Richard Nimijean, *Stimuler l'innovation par le développement de milieux créateurs*, **Obeservatoire de Développement économique Canada**, 2001.
[74] http://www.utoronto.ca/isrn/clusters.htm. Milestones and the project framework can be found at: http://www.utoronto.ca/isrn/documents/milestones_doc.pdf. Speaking notes for Dr. Mark Renaud,

- Complementing IRAP's activities directed at ensuring that SMEs are alerted to innovative possibilities;
- Enhancing information flows in line with Industry Canada's activities on Strategis;
- Supporting those associations at the community level which are actively involved in building social capital and enhancing knowledge diffusion through them;
- Stimulating technopoles and supporting the effectiveness of incubators as nascent local clusters; and
- Propagating innovative management practices that encourage the adoption and adaptation of new technologies.

Internationally, development policy to stimulate innovation is shifting emphasis from direct assistance to the catalytic and brokerage roles of government strengthening interaction, learning, knowledge exchange and participation in social and institutional infrastructure. The intent is to offset deficiencies in dissemination, interface and infrastructure rather than to interfere in R&D markets. Policies are based less on either demand-pull or supply-push and more on horizontal co-operation requiring horizontal networks and clusters and partnerships within a transforming regional milieu to a new type of governance. This process requires that the government have in-depth knowledge of the industry and the region as well as linkages to other clusters and to global markets.

New types of governance for innovation tend to centre on four factors:

- Creating or increasing consensus among regional players by organizing activities that result in the development of the region (regional networks);
- Strengthening social values as trust and reciprocity to allow the emergence of networks, cluster and regional co-operation with regard to innovation;
- Bolstering the ability to adopt new technology and enhance learning; and
- Improving the infrastructure on which firms depend for R&D, advanced technology and innovation.[76]

These directions are supported by SMEs from Québec. Jacob in his analysis of that group concludes:

President, Social Sciences and Humanities Research Council of Canada of Canada (SSHRC) to launch this project can be found at: http://www.utoronto.ca/isrn/documents/renaudremarks.pdf

[75] See op. cit. Denzil Doyle and http://www.pwcglobal.com/ca/eng/ins-sol/spec-int/techmap-qc.html for Ottawa and Québec respectively. Other Price Waterhouse Coopers Techmap™s inspired by the Doyletech family tree for Ottawa home-grown technology companies, include the BCTechmap™ in 1997 and the Technology Triangle Techmap™ (Kitchener and Waterloo).

[76] Op cit Landry *et al.*

Entrepreneurs believe that the future role of government will be one of shedding light on economic tends and mobilizing all stakeholders than that of providing direct services. In decreasing order of importance their suggested mobilizing mechanisms involved:

1. *Shedding light on future directions by sharing the results from economic monitoring or watch;*
2. *Improving co-operation among different orders of government including specialized research and technology centres and education facilitating skilled recruitment and moving towards learning communities;*
3. *Creating networks rich in information, information brokers and promoting regional intercommunications;*
4. *Forging partnerships, chiefly between industries and institutions using flexible instruments through local or sector action groups; and*
5. *Demonstrations and technical assistance transfers.*[77]

3. Risks

As part of the legacy of clusters, there were low and high stakes versions of growth pole theories. The low-stakes version was straightforward:

- Identify goods and services flows that were in a local industry cluster;
- Compare these to those of one or more larger clusters in the same industry;
- Identify what industries were missing in the smaller cluster that could most beneficially be added to it; and
- Shape incentives, training and infrastructure and go out to attract those industries.

The high-stakes version was less mundane and far more likely to fail. It attracted a new large assembly plant as a nucleus of a future cluster. This type of endeavour resulted in several failures including a heavy water facility in Cape Breton, Bricklin in Fredericton as well as Beaufort and other Arctic petroleum ventures that did not realize concrete results as anticipated.

Internationally, the track record is fraught with failures. The Concorde was an aeronautic success that failed to "take-off" economically. Leaders of the American billion dollar SST supersonic civilian aircraft project from 1962-1970 learned enough from the Concorde project to realize that

[77] Jacob, Réal, et Patrice Ouellet et al., Glogalization, the National Economy and Competitiveness: A Synthesis of the Trends and Strategic Issues for Québec SMEs, SME Research Institute, Université du Québec à Trois-Rivières, 2001, Last Chapter.

commercial success was unlikely and folded. Britain's advanced gas-cooled reactor required investment funds in excess of £3,800 million that was clearly uneconomical compared to American technology by the time the initial 200 MW station was completed in 1975. Britain's Alvey Program designed to gain world leadership in software development in specific markets with 200 projects had only 10 successful ones, mostly in relatively closed military markets. Japanese Commercial Aircraft 1954-1965 failed due to its small domestic market and the lack of required skills that could not be transferred easily from other industries.[78]

Despite these failures, in Lipsey's and Carlaw's opinion, there have been some successes in areas related to key U.S. clusters:

- U.S. Department of Defense (DoD) competitions for the design of military aircraft with commercial spin-offs that contributed to Boeings 707 and 747;
- Japanese early success in licensing and adopting microelectronic technologies, followed by MITI's subsequent focus on basic R&D, competition among commercial users of the R&D, and networking among competitive companies, including international competitiveness scans;
- Department of Defense's support for semiconductor R&D that has been easily transferred to commercial uses;
- Kenya's research into more energy efficient stoves while creating new technologies that its existing industry could adopt easily; and
- Canada's broadly based IRAP in encouraging innovations among small and medium-sized enterprises.[79]

Both the low and high-stakes versions of interventions designed to attract clusters could also be viewed as a "beggar thy neighbour policies," that eroded national economies of scale and misallocated scarce investment funds contributing to long-term devaluations of the related currencies. The old DREE was frequently criticised by Ontario on precisely these grounds. These approaches are also fundamentally mercantilist and antithetical to free trade and the consumer benefits attached thereto. Indeed, some abandoned federal policies, used historically to attract firms, would likely be circumscribed now by terms of international trade agreements.

4. Risk Avoidance

Clustering usually involves the mitigation of risks. For prospective investors, information about immediate markets and the availability of

[78] Richard G. Lipsey and Ken Carlaw, *A Structuralist View of Innovation Policy*, The **Implications of Knowledge Based Growth for Micro-Economic Policies**, ed. Peter Howitt, pb. University of Calgary, 1996 pp. 225-333.
[79] Op. Cit. Lipsey and Cralaw.

nearby suppliers and human capital, that were integral to growth pole analysis, remain important location determinants for expansions and new ventures. Second, as reported above, there have been some successes. Thirdly, modern knowledge-based clusters extend beyond flows of goods and services to include synergies among:

- The adoption of integrative features in modern management and communications practices, such as Six Sigma and Lean;
- Links to related regional industrial laboratories, government funded research and universities;
- Ongoing human resource ties to institutions of higher learning, mitigating against obsolescence;
- Global financial markets; and
- Social capital, to which local and national and local associations all contribute within their specific regions.

Proximity enables tacit knowledge flows and the capacity for learning that is conducive to innovations and even spin-offs. Facilitators include frequent face-to-face meetings, a shared regional culture, pool of skilled labour resources, rapid redeployment of any laid-off resources, R&D institutions, innovation-supporting institutions and the financial community. When these facilitators are aligned to the mutual benefit of participating firms, social capital is created within a region.

With advances in modern communications, it may be advantageous to view clusters, not in isolation, but in how they influence other clusters in both their own industries and in related areas of activity. Possible transformations, rather like rapidly mutating and propagating spider plants with spurs going off in several directions may pose interesting possible points of engagement. Like everything else these can be viewed as evolutionary spider plants with an ability to intertwine in mid-air to mutual benefit and future growth.

Consider, Spadina Bus, a "new economy" cluster of high-tech firms in the King and Spadina area of Toronto. The largest number of companies, nearly one-fifth, specializes in media and content development, with web designers second at 16 per cent and access providers and e-commerce companies rounding out the top three. The vast majority of respondents are Canadian-owned (90%), with 59 per cent operating from offices within Canada only.[80]

Another example is the rapid expansion of the auto industry into Mexico-Texas to take advantage of Mexico's entry into the North American Free Trade Agreement and recent U.S. migratory patterns. Alternative examples are the evolution of microelectronic devices into medicine in

[80] http://www.spadinabus.com/Route%20Map%20-%20Spadina%20Bus%20Survey.pdf

combination with biotech advances leading to artificial hearts and the migration from microelectronics to photonics and optical networks in the Greater Ottawa cluster[81] and more recent extensions into Québec and Vancouver.

The NRC is beginning to test the viability of its institutes in creating satellite campuses, where recipient communities and firms demonstrate the commitment to working together to cultivate potential synergies. It is also exploring riskier ventures in areas, such as Cape Breton and Prince Edward Island,[82] without strong university and college support in the immediate vicinity. While there are colleges in both locales, they are not large by North American standards, nor highly ranked like Mount Allison and Acadia. While other colleges are nearby, they are not always easily accessible in winter.

5. Other Observations

Beyond Lipsey and Carlaw, others have made observations of interest to government engagement in clusters:

- Knowledge-based clusters are located usually in areas where a high proportion of the population have university degrees;
- Bernstien substantiates the need to be vigilant in continuing to transfer R&D from the United States to Canada firms since, according to his estimates spillovers from U.S. R&D contributed more than ten times to Canadian economic growth from 1986 to 1991, than did spillovers from Canadian R&D communications laboratories;[83]
- Acs, de la Mothe and Paquet point out that if the new world is being reshaped by the centrality of networks and selective co-operation and local character in systems of innovation, then government engagement needs to change toward:
    - New frameworks based on intelligence and innovation, away from old centralized systems of goals-cum-guidance and control; and
    - Identification of discursive communities with adequate fora developed for concepts to transform into action[84] - **local governments must be convinced and willing to act.**[85]

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[81] Martin, Roger L. and Michael E. Porter, **Canadian Competitiveness: A Decade after the Crossroads**, C.D. Howe Institute Working Paper 2001 - 1, pp. 24-25.
[82] Johnson, David, *Industrial Policy and the "'New' Economy"*.
[83] Bernstien, Jeffery I. *The Canadian Communications Equipment Industry as a Source of R&D Spillovers and Productivity Growth,* **The Implications of Knowledge Based Growth for Micro-Economic Policies**, ed. Peter Howitt, pb. University of Calgary, pp. 391-412.
[84] Acs, Zoltan, John de la Mothe and Gilles Paquet, *Local Systems of Innovation: In Search of Enabling Strategy,* **The Implications of Knowledge Based Growth for Micro-Economic Policies**, ed. Peter Howitt, pb. University of Calgary, pp. 339-359.

- Recognition of the need for cognitive learning infrastructures at the sub-national level and the need to harmonize different layers of governance characterizing the policy world;[86]
- Acs demonstrates the central role of strategic local resources in the collective capability for continuously innovating at the level required by international standards based on well-managed co-operation between the community's scientific resources and its productive capacity. While these processes require synergistic learning among participants, they also need external markets in order to develop their innovative potential and to enhance their techno-scientific skills[87]; and
- Acs' general thrust is confirmed in the Canadian context by Baldwin who found that strategy scores for more successful, rather than less successful, Canadian firms were higher with greater emphasis on: R&D, particularly with a R&D agenda; accessing particularly export markets; frequent new product introductions; obtaining new technologies; lowering costs by using new materials, lowering energy costs and using current materials more efficiently; and making use of government R&D programs;[88]

Voyer and Roy place somewhat greater emphasis on the availability of social cultural amenities, the catalytic effects of champions growing out of the European technopole experience and financial staying power, given the long term nature of cluster developments.[89]

All these factors contribute to the success or failure of clusters. Government engagements need to be supportive of a vast range of activities in order to encourage their success.

IV. KEY PLAYERS AND POTENTIAL CLUSTERS

A number of government agencies, universities, research institutes and municipalities have recently started to use cluster-based approaches in their economic development activities. Currently, the federal government is involved in the clusters concept through the cluster initiative of the National Research Centre (NRC), regional development agencies, e.g., ACOA, WED, etc. and the recent announcement by the Social Sciences

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[85] Voyer, Roger and Jeffery Roy, *European High-technology Clusters*, **The Implications of Knowledge Based Growth for Micro-Economic Policies**, ed. Peter Howitt, pb. University of Calgary, pp. 220-237.
[86] Op cit. Acs, Zolton, John de la Mothe and Gilles Paquet.
[87] Acs, Zolton, *American High-technology Clusters*, **Evolutionary Economics and the new International Political Economy**, ed. John de la Mothe and Gilles Paquet, pb. Cassell, 1996, pp. 183-219.
[88] Baldwin, John, *Innovation and Success ion Canada: Small and Medium-sized Enterprises*, **The Implications of Knowledge Based Growth for Micro-Economic Policies**, ed. Peter Howitt, pb. University of Calgary, pp. 238-256.
[89] Op. cit. Voyer, Roger and Roy, Jeffery.

and Humanities Research Council (SSHRC) of the start of a major study program to comprehensively assess 22 clusters in 5 regions of Canada.

The *Innovation Systems Research Network*, which is a collaborative network of several Canadian universities, is conducting the SSHRC study.

> *The goal of our research is to determine how the formation and growth of clusters contribute to economic development and long-run prosperity within a set of regions across Canada. We want to know how local networks of firms interact in these regions, along with supporting infrastructure of institutions and organizations interact to foster innovative dynamism leading to robust economic development. To what extent – and in what ways – do local, extra-firm relationships and interaction enable firms to make the transition to more innovative and knowledge-intensive forms of production.*[90]

Case studies will include the analysis of clusters for biotechnology/biomed, culture/multimedia, photonics/wireless, wood products, food and beverage and information technology, and automotive/steel/aerospace.

The ISRN cluster analysis is examining the:

- Size and composition of the cluster;
- Evolution and history of the cluster;
- Relationships between firms as well as with research infrastructure;
- Geographical structures;
- Role of finance capital (angels and venture capitalists);
- Role of social capital; and
- Other factors influencing the cluster.

In addition to its nanotechnologies initiative in Edmonton based on its community-based clusters model, the NRC is making significant new investments in Atlantic Canada over the next five years to expand its existing facilities. The Atlantic clusters strategy will focus on linking existing local strengths and opportunities in emerging sectors to NRC's core R&D capacities. The following initiatives are at play:

- A technology cluster is being developed in New Brunswick on e-commerce and the information technologies that underpin this sector.

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[90] Wolfe, David A. and Meric S. Gertler *Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada, SSHRC Major Collaborative Research Initiative, Milestones and Framework Document*, 2001.

- A life sciences cluster is being established in Halifax. Through an expansion of the Institute for Marine Biosciences, and the establishment of a campus of the Institute of Biodiagnostics, Nova Scotia has more than 100 life sciences companies and is well positioned to attract new biosciences firms.
- The information technology sector in Cape Breton is being strengthened.
- A cluster on ocean engineering in St. John's Newfoundland is being fostered. The Institute for Marine Dynamics is situated in St. John's and an expansion of this facility is to be the foundation for the development of the ocean engineering cluster.
- The NRC plans to expand its IRAP office in Charlottetown into an innovation center, which will provide the province with a portal to the NRC and other federal S&T expertise.

The NRC's cluster-based innovation approach is based on the following seven elements:

- Research and development;
- S&T knowledge technology transfer;
- Policy regulations;
- Incubation;
- Mentoring;
- Finance/ risk capital; and
- Human resource skills.

The NRC plays a brokering role as an agent of innovation. It helps a community identify its strengths and pull together an action plan and working model. Ottawa, with its high tech telecommunications cluster housing five of Canada's top 25 private laboratories, is seen as a best practices model of how expertise and research capacity can feed growth.

Figure 8: Biotechnology Clusters Associated with the NRC

Name & Locale	Specialties	Primary Geographic Coverage
Institute for Marine Bio-sciences: Halifax	1) Fish, Shellfish and Marine Aquaculture 2) Safe Seafood 3) Geonomics, and Proteomics 4) Operations of Canadian Bioinformatics Resource	All Coasts for the first two operations and all of Canada linked to the Worldwide Geonomic Network - 60 linked sites
Biotechnology Research Institute: Montreal	Pharma Biotech. Environment Bioprocesses	Greater Montreal and Kingston
Institute for Biological Studies: Ottawa	1) Cell & Molecular Study of Neurode-generative Diseases and peptide therapy for Osteoporosis 2) Immunochemistry	Ottawa and Toronto with small presence in Vancouver
Institute for Biodiagnostics: Winnipeg	Instrument based Biodiagnostics - Informatcs - Biosystems - Magnetic Resonance - Spectroscopy	Western Canada with sub-campus in Halifax for the Atlantic
Plant Biotechnology Institute: Saskatoon	- Carbohydrate Modification - Cell Tech. - Gene Expression - Growth Regulation - Legume Biology - Molecular Pathology - Promotor/Gene Discovery - Seed Adaption - Seed Oil Biotech	Canada, United States, China, Argentina & Taiwan

Source: NRC work in progress.

A list of recent cluster-related initiatives by various government agencies in Canada is attached as Annex A of this report.

1. Identification of Clusters in Canada

Key players were interviewed regarding their experiences and views on the cluster approach including potential areas of engagement by governments to facilitate economic development and the innovation process.

The organizations interviewed are covered in Figure 9. The literature search and the interview process have allowed the authors to identify clusters at various stages of development for each province or territory.

Figure 9: Organizations Interviewed

Consultations		
Industry Canada	Industry Canada Regional Offices	Dalhousie University
•Industry Sector	Western Economic Diversification	Air Transport Association of Canada
•Innovation Policy	Department of Finance	Canadian Manufacturers & Exporters
•Strategic Policy	National Research Council	Innovation Foundation, University of Toronto
•Information Technology Branch, SITT	Atlantic Canada Opportunities Agency	Ministry of Industry & Commerce (Quebec)
•Investment Partnerships Canada	Canada Economic Development	
•Technology Partnerships Canada	Statistics Canada	
•Canadian Tourism Commission	Greater Hamilton Technology Enterprise Centre	
•Small Business Policy Branch	Innovation Systems Research Network	

a. Western Canada

Figure 10 illustrates the clusters identified in Western Canada. While many might view the first three industries identified, forest products, energy and food processing, as traditional industries, they are both increasingly tied to high technologies. Forestry makes use of modern geomatic techniques to improve cutting plans, forest management and fighting forest fires, new environmentally friendlier processes in manufacturing and other innovations to ensure the optimum use of fibre. The food and beverage industry is developing new products to meet global consumer demands including some use of genetically modified foods. The discussions clearly showed that Western Canada's oil patch has been a leading innovator and adopter of new technologies that are leading to a doubling of recovery rates and better productivity. B.C. is included in the energy cluster due to its hydro and coal developments, gas fields in the

Peace River that it shares with Alberta, its offshore petroleum potential, and resident intellectual capital in areas such as designing offshore drilling rigs in shallow water. Of these, fuel cells are also highlighted in the table with an industry leader in Ballard and additional intellectual support from the NRC's laboratories in the Lower Mainland.

Winnipeg's aerospace cluster is small by international standards and, typical of the industry, highly integrated with global markets. Edmonton's medical cluster has been an integral part of Alberta's strategy to diversify away from an over-reliance on petroleum resources. The NRC's recent announcement to locate its nanotechnologies research in Edmonton is expected to complement and to build on related medical R&D strengths. Other medical leaders in the Prairie Provinces centre on specific NRC facilities such as the diagnostics laboratories in Winnipeg and the one in veterinary medicine in Saskatoon that complements training by the University of Saskatchewan in Saskatoon. According to WD's Vancouver office there is also a fledging BioHealth cluster starting-up in Vancouver. Calgary's thrust into wireless, with Nortel as the traditional lead, is being further bolstered by Panasonic's decision to locate its wireless activities in this location. It complements the emerging information technologies cluster in British Columbia's Lower Mainland.

Figure 10: Clusters Identified in Western Canada

Cluster	Location	Type
Forest Products	BC, AB, SK & MB	Mature
Food & Beverages	BC, AB, SK & MB	Mature
Energy	BC, AB, SK & MB	Sustainable
Aerospace	Winnipeg, MB	Sustainable
Health/Bio	Vancouver	Potential
Agriculture/Bio	Saskatoon, SK	Potential
New Media	Vancouver, BC	Emerging
Wireless	BC, AB	Potential
Information Technology	Vancouver, BC	Emerging
Fuel Cells	Vancouver, BC	Potential
Medical	BC, AB, SK & MB	Potential

b. Southern and Eastern Ontario

Southern Ontario remains Canada's industrial heartland with clusters shown in Figure 11. Its automobile cluster is highly integrated with nearby locations in the United States and in the mid-west. The intricacies of this relationship are becoming easier to measure with the

implementation of the North American Industrial Classification System (NAICS). Toronto's aerospace industry continues to compete in international markets with Montreal for Canadian leadership. Toronto's financial cluster is looking to diversify diversifying markets and locations abroad and in the United States. While Toronto and the Waterloo, Guelph and Cambridge triangle have emerging IT clusters, Silicon Valley North (Ottawa) is considered to be more similar to the ideal cluster based on the California Silicon Valley model by many experts.

Figure 11: Clusters Identified in Southern Ontario

Cluster	Location	Type
Automotive	Southern Ontario	Mature
Aerospace	Toronto	Sustainable
Financial Services	Toronto	Sustainable
Information Technology	Toronto & Waterloo	Emerging
Medical	Toronto	Potential
New Media	Toronto	Emerging
Agriculture-biotech	Guelph	Sustainable
Biotechnology/ Biopharmaceutical	Toronto	Potential
Steel	Hamilton	Mature
Logistics	Southern Ontario	Emerging

The University of Toronto, its teaching hospitals and successful spin-off companies are at the core of the medical cluster in Toronto. The University of Toronto is one of North America's largest medical schools with industrial spin-offs going back to the development of insulin. This intellectual node is the champion of Toronto's biotechnology and biopharmaceutical clusters. Ontario's MARS project, an incubator site for biotechnologies and biopharmaceutical start-ups in close proximity to the University of Toronto's main campus, needs to proceed in order to accelerate the transfer of emerging technologies, retain excellent university staff and perpetuate contributions of this intellectual capacity by providing scientific platforms. The new media cluster has been discussed earlier. Its incubation space is limited and bursting at the seams. The University of Guelph continues to lead in areas related to agriculture, especially in veterinary medicine and has the potential to link up with MacMaster along Highway 6 inclusive of the Greater Hamilton Technology Enterprise Centre in biotechnologies related to animal and human health. Hamilton's mature industry steel cluster is tied to

automobiles and other transportation equipment industries, as well as to information technologies through fasteners and other IT components.

Figure 12 identifies key Ontario clusters outside of the Oshawa-Windsor corridor. The universities and colleges in the Sudbury area have been instrumental in persuading INCO and Falconbridge to co-operate in building the social capital for a mining cluster in Sudbury, inclusive of research and training. As mentioned earlier Ottawa's information technologies cluster with its genesis at the NRC and its exemplary social capital is one of Canada's strongest clusters. Its labour force skills are readily transferable to photonics were JDS Uniphase has emerged as an international leader, and to certain aspects of medical research from artificial hearts to wheelchairs.

Figure 12: Clusters Identified Elsewhere in Ontario

Cluster	Location	Type
Mining	Sudbury	Developing
Photonics	Ottawa	Developing
Telecommunications and other IT	Ottawa	Sustainable
Medical	Ottawa-Kingston	Potential

c. Québec

Economic development policy in Québec embraced clusters as a means of increasing social cohesion and stimulating growth several years ago. The Quebec provincial government enriched R&D support beyond Canada's R&D Investment Tax Credits is intended to attract and to stimulate the growth of innovative firms. Quebec-based clusters appear in Figure 13.

Bombardier has emerged as a leader in aerospace. This firm has embraced the Six Sigma management practices approach and endeavours to drill these down through its supply chain as well as other operations of its own. The NRC has been the knowledge leader of Montreal's biotechnology and biomedicine clusters with joint appointments with local universities and a strong incubation program.

Nortel, Bell Canada Enterprises and Spar Aerospace lead Montréal's information, telecommunication and communications (ICT) thrust.

Textiles and clothing have recovered as profitable industrial clusters based largely on their access to U.S. markets and timely delivery of quality products. In addition to its resource base, Québec houses key associations in pulp and paper and pre-competitive research facilities for the industry. It is also a leading supplier of dairy and poultry products to Canadian markets. With SNC Lavalin as an industry leader in consulting engineering, it is playing a leading role in the development of knowledge-based management tools for subcontracting with Canadian suppliers, storage of drawings and the tracking of change orders.

Figure 13: Clusters Identified in Quebec

Cluster	Location	Type
Aerospace	Montreal	Sustainable
Biotechnology	Montreal	Emerging
Biomedicine	Montreal	Emerging
Telecommunications	Montreal	Sustainable
Textiles & Clothing	Montreal	Sustainable
Forest Products	Quebec-wide	Sustainable
Photonics	Quebec City	Birth
Food & Beverages	Quebec-wide	Sustainable
Mineral Products	Quebec-wide	Sustainable
Consulting Engineering	Montreal	Sustainable
New Media	Montreal	Emerging

d. Atlantic Canada

Atlantic clusters appear in Figure 14. Due to small population distributed over vast distances, the ties among some of these clusters are relatively weak compared to other regions in Canada.

Various aspects of e-business, including bilingual call centres and more sophisticated communications systems in Cape Breton and early completion of the fibre optic loops in New Brunswick, are contributing to the economy.

Atlantic Canada has shown leadership in geomatics based on an early shift to airborne mapping techniques and the Maritime advanced land registration systems. Issues related to offshore management and exploration are spurring growth. The geomatics industry deploys air services and advanced diagnostic software systems to map the ocean floor and various entities including the movement of icebergs. Such

information, along with weather patterns and ocean currents form the basis for predicting paths of these behemoths that threaten to disrupt offshore oil production.

Aquaculture is emerging as a cluster due to both structural changes in the wild fishery and a strong consumer demand for seafood products.

Ocean technologies are being rejuvenated by the efforts of the NRC's Institute of Marine Dynamics, growing offshore developments and growing demand for ship repair operations both at home and abroad that is related to offshore energy initiatives.

Halifax has several aerospace firms including The IMP Group, Pratt & Whitney and Atlantic Turbine. Dalhousie's medical school supports the growth of Halifax's biomedicine and medical devices and related services. In the future, the NRC's diagnostics satellite campus and NRC's resident leadership in genomics will further support the medical devices cluster.

Figure 14: Clusters Identified in Atlantic Canada

Cluster	Location	Type
E-Business	NS,NB, PEI & NF	Potential
Geomatics	NS,NB, PEI & NF	Potential
Aquaculture	NS,NB, PEI & NF	Emerging
Forest Products	NS,NB & NF	Sustainable
Food & Beverages	NS,NB, PEI & NF	Sustainable
Ocean Technology	NF, NS & NB	Potential
Biomedicine	Halifax, NS	Potential
Aerospace	Halifax, NS	Potential
Medical Devices & Services	Halifax, NS	Potential

2. Main Findings

A key objective of the consultations was to record the range of opinions on cluster-based economic development. The goal was not to create a consensus where none exists, but to fairly present both sides of any debates about the efficacy of certain approaches.

There are certain issues on which both people within Industry Canada and outside of it felt strongly. These issues are presented as issues and

not attributed to any specific organization See items "a" and "b" below. Other issues were highly reflective of the organizations and industries covered and are presented separately under those headings after the more general results.

a. Clusters and the Role of Government

Interviewees included individuals who are advocates of minimum interference with markets as well as those with more proactive approaches.

Those who favoured less rather than more market interference made the following arguments:

- Governments are bad at picking winners and losers good at choosing governments;
- SMEs oppose corporate give-aways which they see as accruing mostly to large companies;
- Governments' role is to set the macroeconomic context and let the market take care of the rest;
- Current government policies are perceived to disperse firms and to undermine cluster benefits that would otherwise occur from greater concentration;
- By assigning clusters to locales, government creates single industry reliance in smaller communities, increases business cycle risks, and may thwart attracting firms, desirous of non-designated locations;
- Each announcement creates more disappointment among multiple losers than satisfaction among a few winners;
- It is difficult to design effective incentives within international trading rules; and
- From the Atlantic and the West, development policies based on Porter's conceptualization of clusters have a strong Central Canada bias.

In their opinion, markets determine cluster boundaries, not those preordained by political fiat. While inter-industry trade flows can assist analysts in identifying clusters, the relative efficiencies of clusters within a geographic entity will be determined by the degree of:

- Inter-firm co-operation (networks);
- Agglomeration (external economies);
- Social capital (associative behaviour); and
- Technology transfer and diffusion (knowledge spill-over).

Their emphasis is very much on getting the macro-economic environment right, including trade policy, tax policy, regulatory policy, fiscal framework, inflation and education.

Those who favoured a more proactive role for government made the following points:

- Governments implicitly pick winners now, so why not do it in a co-ordinated manner focussed on clusters with increased odds of global success?
- Industrial policy needs to be well co-ordinated so that its components are complementary inclusive of:
  - Establishment of university chairs;
  - Construction of infrastructure;
  - Transportation;
  - R&D focus;
  - Improvements in innovation and technology transfer mechanisms;
  - Incubators targeted at synergistic clients;
  - Ensuring that regulatory policy facilitates socially beneficial innovations, rather than retarding and inhibiting them; and
  - Building of social capital among existing and fledging firms;
- Must redress significant failure rate of SMEs in the first ten years; and
- Development policies needed to capture cluster benefits.

b. Innovations Expand Cluster Boundaries

Interviews yielded several examples of the migration of whole industries among clusters, as innovations were made and new markets opened. Geomatic firms in Calgary expanded beyond traditional cadastral operations by adopting new, frequently airborne, technologies to service the oil patch. While still expanding with respect to natural resource markets, Alberta's 80 strong geomatics firms have formed their own association. Geomatics is also moving toward supplying logistics solutions to firms and private operators of automobiles to forewarn drivers of traffic jams and appropriate re-routing to minimize congestion. In doing so it is attaching itself to the auto industry cluster.

Similarly, advances in miniature remote monitoring are more fully integrating information technologies with aerospace, pulp and paper equipment and medicine. In many of these industries these pending changes will be revolutionary. In aerospace, early indications of deterioration in non-essential parts can be spotted electronically in the air and the replacement module ordered automatically to be available at the

next destination. As these mechanisms proliferate, prolonged downtimes for major overhauls are expected to fade into history, generating more effective use of aircraft.

Another application of miniaturization in electronics is contributing to medical diagnostics and treatment where nanotechnologies will facilitate, in part, artificial transplants. This is a clear migration of a technology from the information technology cluster involving mass communications systems to the medical cluster and personal communications.

Advances in chemistry and paints facilitate use of aluminium and plastics, with steel, in automobile exteriors. All need either to fade at the same rate or not at all, in all types of climates. Such technologies fundamentally alter cluster boundaries and the operations among those within the earlier boundaries.

Clusters are dynamic, not static, with amorphous sector boundaries, dependent on technologies, knowledge-flows and firms' innovative capacities. Being proactive in developing clusters and facilitating these transitions would place government and Canadian industry on the frontier of growth opportunities.

c. Industry Canada

Most sector branches of Industry Canada are well aware of the clusters in which their sectors participate, but few are organized along cluster lines. The Life Science Branch publishes biotech cluster maps on Strategis. In addition, the Information Technologies Branch has prepared a draft cluster study. Innovation Policy Branch and MEPA are starting to work on cluster-related issues. Investment Partnership Canada views clusters as an important tool for investment prospecting and branding. Technology Partnerships Canada is implicitly supporting the Ottawa information technology cluster, but generally does not favour formalizing cluster driven approaches.

Branches that had not developed cluster maps, frequently mentioned the Sector Competitiveness Profiles and Frameworks as containing some elements of a clusters approach. Several personnel indicated that consultations with sector firms in producing these documents had contributed to the social capital of the industry. Trade missions were also viewed in a similar manner. There was no general consensus as to whether or not cluster maps should be undertaken.

A number of the clusters identified by Industry Canada staff have been discussed in the preceding section of this document. Industries that are part of the global economy were often viewed as boundaryless clusters. For example, the "Oil Patch," concentrated in Alberta and running into

Fort Saint John and South-western Saskatchewan, is viewed as a well working cluster comprised of petroleum companies, their upstream equipment and service suppliers (e.g., geomatics) and upstream manufacturers of petrochemicals and derivative products. The aerospace cluster, which has production nodes in Montreal, Toronto, Winnipeg and Halifax, is similarly viewed as a global cluster due to strong supply chain ties to the Boeing and Airbus family of firms.

d. National Research Council Canada (NRC)

The NRC is a major knowledge provider to clusters.

- It operates specialized regional laboratories around which local cluster have become established in Halifax, Montreal, Ottawa, Winnipeg and Saskatoon;
- It is establishing or strengthening a satellite campus in Halifax for medical diagnostics, a new nanotechnology laboratory in Edmonton, marine technologies in St. John's, and information technologies in Cape Breton;
- Its incubator sites on all its major campuses mentor fledging firms and engender innovation;
- It is active in national and international co-operative scientific networks including the prestigious Worldwide Genomics Network in conjunction with CANARIE, that provides broadband access, critical to analyzing massive amounts of data efficiently;
- It has hundreds of guest residents from industry annually and will exchange personnel with industry, especially to facilitate technology transfers, preferably of scientific platforms, rather than specific products;
- Its laboratories set national standards in housing and test for automobile safety;
- Its IRAP informs SMEs about innovative opportunities and encourages their adoption;
- Its staff are well networked with other knowledge workers through cross appointments with universities and networks of excellence; and
- It helps community leaders identify municipal strengths and encourages synergistic action planning and is therefore a catalyst in the formation of social capital.

NRC's community-based projects are not based solely on redistribution goals. Innovation, based on the NRC model is best developed through the collaboration and input from local representatives. The NRC projects are generally tied to the strengths and resource endowments of the participating community. For example, the biotechnology research that occurs in Saskatoon is consistent with its agriculture economic base.

Similarly, in St. John's, Newfoundland, the Institute of Marine Dynamics and the Ocean Tech cluster stems from the regions strong marine and ocean industries economic base.

With the NRC as the genesis of its telecom cluster, Ottawa is a best practices model of private and public research expertise feeding growth. It represents what can happen when focused NRC activities are commingled with considerable and increasingly diversified private sector expertise and determined efforts to build social capital.

While there are calls for it to play a more proactive role in Toronto, the NRC also recognizes that the University of Toronto, York University and the other colleges in Metro are already contributing to clusters in that area. Its basic thrust in that region is one of co-operation rather than building new NRC facilities in Toronto.

e. Western Economic Diversification (WED)

WD sponsored a major 1996 study on clusters in Western Canada using DRI/KPMG's *General Evaluation Methodology (GEM)* approach, which is similar to Michael Porter's diamond. Through federal provincial agreements, WD is directly or indirectly contributing to the development of various cluster studies for major municipalities in Western Canada. Major studies for Edmonton and Calgary have been completed. Studies for Regina and Winnipeg are in process. Other cites in Western Canada may be supported through this mechanism.

The study funded by WED and provincial governments on clusters in Western Canada concluded that the agriculture/biotech cluster in Saskatoon was the only cluster in the region that met the minimum requirements to be a sustainable cluster[91]. The biotech agriculture cluster in Saskatoon was seen as offering strong potential for success, yet WD report that in 2001 this cluster has not reached commercial success.

f. Atlantic Canada Opportunities Agency (ACOA)

Due to the lack of critical mass in the Atlantic region, a Canadian approach to development based strictly on Michael Porter's version of clusters would be viewed as a policy mostly benefiting Central Canada. Nevertheless, clusters are important to the Atlantic Canada even if most clusters in the region are at early stages (birth or emerging). If a given community acquires knowledge and best practices, it is argued the investment money from the private sector will follow. The Atlantic Canada

[91] Building Technology Bridges: Cluster-based Economic Development for Western Canada, 1996 by KPMG, DRI/McGraw-Hill and IMPAX Policy Services International.

Opportunities Agency and the NRC are following this approach in Atlantic Canada through the Atlantic Canada Investments Partnerships program.

In 1997, ACOA commissioned a clusters study by Nordicity et al. The six clusters in this study included:

- Information Highway;
- Geomatics;
- Aquaculture;
- Ocean technology;
- Medical devices and services; and
- Food processing.

If a cluster study was commissioned today, in addition to the six examined by Nordicity, ACOA would likely assess: biopharmaceuticals; seafood; value added wood products; neutraceuticals; agri-horticulture; traditional agriculture around the Agricultural College in Truro; biotechnologies; and emerging clusters involving the NRC.

The NRC are developing cluster-related initiatives or innovation centres in St. John's, Newfoundland (ocean technology), Halifax, Nova Scotia (marine biosciences), Cape Breton, Nova Scotia (information technology), New Brunswick (e-commerce) and Prince Edward Island (information technology).

g. Canada Economic Development

In co-operation with the province of Québec, Canada Economic Development has given clusters-driven development initiatives high priority in stimulating innovation in that province. It explicitly recognizes the government's role as facilitating development of clusters in providing expert consul and supporting the growth of social capital. It sees the latter as a critical success factor.

Québec studies have shown that its regions with the strongest social capital have stronger clusters of cohesive firms and higher levels of industrialization and living standards.[92]

h. Statistics Canada

There is some interest at Statistics Canada in capturing data at a municipal or census division level. The inter-provincial input-output tables are an excellent source for identifying the flows of goods and services among sectors. While the structural aspects of these tables tends to lag a few years behind the economy, it is possible to partially update

[92] Op. Cit. Jacob.

them by using current demand vectors for both domestic consumption and exports. Provincial input-output tables are available for 1997 and 1998 data will be released soon based on NAICs. When complementary tables are available for the United States, analysts should be better be positioned to delineate North American clusters.

Statistics Canada has further expanded its database by supplementing its surveys on scientific and research and development and instituting a Survey of Innovation. The later deploys OECD definitions of innovation so analysts can draw international comparisons. The Agency has cross-referenced each of these with its Survey of Manufacturing to provide rich, sample based, data sets. It is in the process of using these databases to extrapolate results that facilitate the development of empirical measures for census divisions.

Statistics Canada can also make various administrative files (taxation, etc.), at suitable levels of aggregation, available, albeit expensively.

i. Canadian Manufacturers and Exporters (CME)

The CME facilitates social capital for participating firms by giving high priority to social networking and exchange of best practices. The smaller and midsize companies can learn from the experiences of the larger companies in these networks.

The CME is involved in clusters by working with companies to share best practices in order to reduce the costs and risks of innovation. Nevertheless, CME members expect real value contributions to their bottom lines to materialize. In essence their investment in social capital through participation in the CME needs to pay off.

j. Conference Board of Canada

The Conference Board of Canada has run, and continues to operate, seminars on incubation, innovation and management training that touch on various aspects of clusters. For example, the Board's 2001 Innovation Conference in November is slated to cover:

- How traditional resource and manufacturing companies embrace innovation and investments in innovation;
- The emergence of new economy companies and their investments in innovation;
- The heightened role of universities and colleges in a society that places a premium on innovation and the knowledge-based economy;
- Best practices and lessons learned in research and development and building of an innovative organization;

- Incentives geared to raise levels of innovation in Canada and redress capacity concerns; and
- Recognition of successful collaborations in innovation.

Its earlier conference on incubation, held in January 2001, the Board looked at:

- The basis of incubation;
- Financing;
- Relationships with venture capitalists;
- Impacts of management practices and graduation policies of incubators;
- Urban experiences with incubators;
- Niche incubators; and
- Future directions.

The Board has also carried out some interesting international comparisons on what makes clusters work. Generally companies participating in the clusters in any of the 14 countries felt advantaged by their location in several respects - innovativeness, performance over time, costs, R&D performed, skills, internal technical capabilities, overall competitiveness, access to technology. With respect to access to funding, Europeans felt disadvantaged. All shared concerns for a shortage of skilled workers, but recognized that the problem is universal and therefore impacted adversely on all of them. Except in North America, infrastructure constraints were binding. In addition, in Asia and the newly industrialized countries there was concern about the clusters having the required critical mass as incentives drop-off.

In this international survey, companies did not see the alliances and collaborative networks in which they were involved as being very important. Moreover any alliances that were of some importance were those with non-local companies and ties to local research bases were less important than expected. Contacts within clusters were important sources of competitive information, gathered through direct observation and informal conversations.

European and North American companies preferred focused government support for quality of life and influence on factors, which kept costs down rather than more targeted policies.[93]

Arising out of its 1998 focus groups, the Conference Board developed action plans to improve collaboration between universities and the

[93] Zieminski, Janusz and Jacek Warda, *What Makes Techopoles Tick? A Corporate Perspective*, Members' Briefing 219-97. Pb. Conference Board of Canada.

business community without jeopardizing the universities' ability to be involved with basic research by:

- Better aligning basic university research with private sector needs;
- Increasing the funding for basic research at universities;
- Developing a set of guiding principles for IP generated by collaborative research;
- Improving the technological transfer capabilities of universities;
- Improving information flows between the private sector and universities;
- Improving private sector involvement in curriculum development; and
- Expanding and broadening support for student involvement in collaborative research.[94]

k. Dalhousie University

Dr. James D. McNiven spoke of the role of the professional school at Dalhousie in adult education. Dalhousie has had a long-standing relationship with the Canadian Bankers Association in training of its personnel. Recent developments in e-learning encouraged the banks to opt for a rapid transition form traditional distance learning technologies to e-learning. Having successfully made that transition, Dalhousie's professional school is attempting to expand distance learning into other financial and service areas.

There is a need to improve university salaries and research facilities in order to compete with American schools in attracting staff in fiercely competitive areas and a need to work with business to provide services in return for sufficient funding. Funding from private foundations is changing the market for e-learning courseware. For example, based on a US $11 million grant from the Mellon and Hewlett Foundations, MIT is making nearly all of its course material available for free on the World Wide Web.

l. Innovation Foundation, University of Toronto

The University of Toronto's Innovation Foundation is a not for profit corporation responsible for attempting to commercialize innovations that faculty assign to it and for which it accepts responsibility. It has successfully launched over 100 companies and has another 127 in its current portfolio of firms seeking mentoring and venture capital or

[94] Zieminski, Janusz and Jacek Warda, **Paths to Commercalization: University Collaborative Research**. Pb. Conference Board of Canada 1999.

licensing arrangements. From its significant retained earnings, it can finance up to $10 million on any project that it deems appropriate.

The University is positioned to provide human resources during start-up in the transition from the laboratory to manufacturing since staff can spend up to 20% of their time in non-university activities. In addition, students are encouraged to undertake work terms of anywhere form 12 to 18 months in the midst of their studies.

For its efforts, the Foundation retains 75% of any revenues received from the intellectual property on behalf of the University with 25 per cent accruing to the responsible faculty members.

The process is competitive in that the inventor can take his or her IP to market and retain the 75% interest in IP. In doing so the inventor becomes responsible for all management aspects of the project, including arranging for any and all financing. The competitiveness, inherent in this approach, is good for all parties. It puts pressure on the Foundation to perform and retain the confidence of its client base and puts pressure on faculty, who decide not to use Foundation facilities to do at least as well as the Foundation would have done on their behalf.

The Foundation and the University support Ontario's MARS project in order to have a well-equipped incubation and testing site downtown. The proposed site is in close proximity to both the University and capital markets. Given land prices in Toronto, it will have to be a multistory building with all the inherent difficulties of ensuring health and safety in a multi-disciplined quasi-scientific facility. Such concerns prolong the architectural design process.

m. Greater Hamilton Technology Enterprise Centre (GHTEC)

GHTEC operates a state-of-the-art incubator with a biotech laboratory, meeting rooms and a common lunch area open to the main thoroughfare within the building. The building is designed to encourage synergy among tenants. The resident expert in launching businesses also enhances synergy among the tenants by mentoring and arranging seminars by outside speakers. GHTEC assists firms in arranging for venture capital by assisting tenants in the development of focused business plans and the development of initial customers and clients.

GHTEC has spun-off five companies that appear to be proceeding well. Two of the graduates located in the same industrial park. Generally, graduating firms stay in the area to avoid moving costs and to maintain their social contacts, suppliers and, frequently, their client bases.

GHTEC's present tenants include:

- Advanced Manufacturing;
- Advanced Materials;
- Bio-technologies;
- Environmental Technologies;
- Health Care Technologies;
- Information Technologies;
- Medical Devices; and
- Telecommunications.

GHTEC's intent is to narrow the range to complement the region's and tenants' intellectual property strengths. It is also seriously considering developing an extended care incubator for graduates. The second phase incubator would allow clients to preserve scarce capital for intellectual, management and market development, rather than sinking scarce capital funds into bricks and mortar.

n. Canadian Tourism Commission (CTC)

CTC's operations cover both business and pleasure travel. Tourism is a unique industry because it defines itself in terms of the characteristics of its consumers, "visitors" and "tourists" rather than a distinct industrial or service production process or a distinct product form. The "visitors experience" or "trip" is also is a multi-industry, multi-service and product composite involving travel to and from a destination outside the visitor's usual environment and the consumption of a variety of associated services and commodities as part of the process. The tourism industry thinks in terms of product clusters for business or commercial and pleasure travel comprised of combinations of separable activities offered by various industries, tailored and combined to meet demands, differentiated by market. Over the last 10-15 years in North America and a shorter timeframe in Europe, market-research, has developed a knowledge base of defined activities enjoyed by tourists segmented by geography and the characteristics of the tourist.

Tourism satellite accounts attempt to capture the essence of the tourism industrial cluster as well as the associated tourism product clusters from the collection of what is normally thought of as the economic activity of tourism related or associated industries. For example, these include restaurants, hotels and taxis in the national infrastructure of industrial statistics. The tourism satellite accounts also identify tourism sales activity for non-tourism products such as food in general, or drugs or other retail goods; as well as, "tourism related products" such as retail gasoline sales and parking lots fees. These are attached to the tourism cluster for only a relatively small share of the services offered by the associated production process.

The National Tourism Indicators, an associated extension of the tourism satellite account consisting of some 300 industry performance measures track the evolving dynamics of the performance of various key components of the overall tourism sector in Canada distinct product segments identified above.

Both of these are macro-economic analysis tools and neither, yet, defines the evolution of the sector at the micro-economic level of detail of the sub-market specifics identified above.

The overall tourism cluster has the CTC centre stage in the industry's research program and establishing international standards. Continuing with the intensive use of computerised records as sources of intelligence, the long run nature of the tourism clusters, nationally and internationally, will depend on structuring of one or more portals that will inform and empower tourists to develop their trip plans and to make reservations.

o. Air Transport Association of Canada

The airlines cluster is an alliance among airlines, maintenance firms, suppliers and travel agents. Yet, there is stiff competition for some routes and among reservation systems. Nevertheless there is still insufficient capacity in airline reservation systems to convert them into portals for tourism. This results in the industry's information systems being only weakly linked to other tourism activities. It is unclear who will establish the portal for the industry either in Canada or internationally.

The interesting shift in the cluster involves the increasing use of remote monitoring of equipment and components for deterioration prior to failure. Combined with microprocessors, this innovation is facilitating modular repairs with minimal parts inventories. Eventually, it may preclude the need for major retrofits; thereby, greatly enhancing aircraft efficiency.

Other uses of the knowledge economy are embedded in GPS systems and overall navigation systems. Overcrowding of U.S airways and new access routes to Russia are increasing the congestion in Canadian airspace and making those services increasingly international. Limited open-skies policies are also increasing international competition for long flights within North America. Overly grandiose expansions of Canadian airports and taxes originally imposed for services no longer provided by the government are further disadvantaging Canadian travelers and the industry.

p. Ministry of Industry and Commerce (MIC) Québec

Québec's MIC is driven by cluster concepts. Michael Porter's cluster approaches have been institutionalized in the MIC culture with an added twist of social capital.

MIC views social capital to be a key success factor for growing clusters.

MIC is well aware of the work being carried out by the University of Quebec on how governments can assist in making clusters work effectively by assisting the creation social capital. For example, Real Jacob focuses on the long-term need for skilled personnel and SME access to expertise to meet their needs for modern knowledge management skills. [95]

q. Innovation Systems Research Network (ISRN)

The Social Sciences and Humanities Research Council has granted the ISRN $2.5 million to perform longitudinal research on 22 clusters over three years. The ISRN is seeking liaison and support from Industry Canada, especially from regional offices in close proximity to each cluster.

The industries covered by the ISRN are contained in Figure 15. As noted throughout this report, the 22 studies are not representative of all of Canada and are by no means exhaustive of clusters at various stages in Canada.

Since ISRN's methodology requires 3-5 years, short-term R&D may be needed to support policy changes in a timely manner for the government's innovation agenda.

[95] Op. cit., Real Jacob.

Figure 15: ISRN Cluster Studies

Clusters	BC/AB	Ontario	Ottawa	Quebec	Atlantic
Biotech/Biomed	✔	✔	✔	✔	✔
Culture/ Multimedia	✔	✔		✔	
Photonics/ Wireless	✔	✔	✔	✔	
Wood Products	✔				
Food & Beverage (including Wine)	✔	✔ ✔			
Information Technology			✔		✔ ✔
Auto/Steel/Aerospace		✔ ✔		✔	

V. BOTTOM LINE

Canada has very few large industrial clusters of the Michael Porter variety. However, it has many potential and emerging innovation clusters in each of the five regions of the country. Key success factors for growing clusters include:

- Community involvement in the innovation process;
- Social networking and exchange of best practices between MNE's government labs and SME's; and
- Development of an entrepreneurial spirit where the rewards of success take precedent over the fear of failure.

All of the organizations that were interviewed are involved in cluster development in some form or other. Different philosophies, cultures and approaches, however, are being used to foster the growth of clusters. The chances of success for these players collectively are much greater if they work together cohesively rather than being at odds with each other. In addition to the obvious need to put more effort in mapping and researching clusters, a forum needs to be established for the players to exchange views and to understand each participant's roles and responsibilities better.

Successful clusters are all about social cohesion and networking. The same principles should apply to the organizations trying to foster clusters.

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Review of Knowledge Intensive Industrial Clusters in Canada

Scoping Study

Annex A: Cluster-Related Initiatives of Key Organizations

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Organization	Cluster-Related Initiative	Description
Industry Canada, Life Sciences Branch	Canadian Biotechnology Clusters	Information for clusters for the following biotechnology-related industries is posted on Strategis: ➢ Agriculture; ➢ Aquaculture; ➢ Environment; ➢ Health; and ➢ Industrial Processes. A number of biotech clusters are identified on Industry Canada's Strategis web site. If these clusters were to be examined with Michael Porter's filter, then Montreal would likely be the only city with sufficient critical mass to be considered a cluster. The others are networks. They are lacking in critical mass.
Industry Canada, Information Technology Branch	SITT NME Paper Series: Investing in the Networked Economy: Clusters	The IT Branch has prepared a draft study on clusters that explores several possible clusters in Canada as well as the life cycle of a cluster. The strengths and weaknesses of possible clusters in the following areas were discussed: ➢ Financial services (Toronto); ➢ Telecommunications, Software (Montreal); ➢ Telecommunications (Ottawa); ➢ Computers, Software (San Jose, USA); ➢ Information Technology and Computer Hardware (Boston (Route 128, USA); ➢ Computer Manufacturing (Ireland); and ➢ Software (Ireland).

Organization	Cluster-Related Initiative	Description
SSHRC	Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada	SSHRC Sponsored a $2.5 million, 5-year research projection Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada that will examine the impact and importance of cluster-driven innovation in Canada. The first of its kind in Canada, this study will investigate how local networks of firms and supporting infrastructure of institutions, businesses and people in communities across Canada interact to spark economic growth. Research will focus on more than 20 clusters across the five regions in newly emerging knowledge-intensive areas (i.e.: biomedical, photonics/wireless) as well as in more traditional sectors (i.e.: manufacturing, wood products, food and beverage, automotive and steel). It will focus on large metropolitan settings located near research-intensive universities as well as in rural settings.
Statistics Canada	Mapping Innovation and Connectedness	Key indicators of the knowledge economy have been mapped at the Census Division level.
Canada Economic Development	*Globalization, The Knowledge Economy and Competitiveness: A Synthesis Of The Trends And Strategic Issues For Quebec SMEs*	The study assesses the determinants of success for SME's operating in a global environment. The role of social capital and innovative management practices are considered to be critical.
ACOA	Atlantic Investment Partnership	Five-year $700 million initiative designed to build new partnerships that will increase the capacity of Atlantic Canadians to compete in an increasingly global, knowledge-based economy. Major program investments include: ➢ Atlantic Innovation Fund ($300 million); ➢ NRC facilities expansion in Atlantic Canada ($110 million); ➢ Strategic Community Investment Fund ($135 million); and ➢ Trade, investment, entrepreneurship and business skills development ($123.6 million).

Organization	Cluster-Related Initiative	Description
ACOA	Atlantic Innovation Fund	Overall objective of the Atlantic Innovation Fund is to build the economy of Atlantic Canada by accelerating the development of knowledge-based industry. This will be accomplished by increasing the region's capacity to carry out leading edge research and development that contributes to the development of new technology based economic activity in Atlantic Canada. Sectors being given priority include: ➢ Information technologies; ➢ Ocean technologies (oil and gas, etc.); ➢ Aquaculture; ➢ Biotechnology; ➢ Health and medical technologies; and ➢ Environmental technologies.
ACOA	Prospects for Growing Knowledge-Based Industrial Clusters in Atlantic Canada	The study looked at the following clusters in Atlantic Canada that had been selected *a priori.* ➢ Information Highway (Atlantic); ➢ Geomatics (Atlantic); ➢ Aquaculture (Atlantic); ➢ Newfoundland and Labrador Oceans Technology Cluster ➢ Nova Scotia Medical Devices and Services Cluster; and ➢ NB/PEI Food Processing Cluster.
NRC	Building Technology Clusters	The basic elements of technology clusters include: ➢ Research and Development; ➢ S&T Knowledge Tech Transfer; ➢ Policy Regulations; ➢ Incubation; ➢ Mentoring; ➢ Finance/ Risk Capital; and ➢ Human Resource Skills.

Organization	Cluster-Related Initiative	Description
NRC	Atlantic Canada Clusters	Based on its community-based clusters model, the NRC is making significant new investments in Atlantic Canada over the next five years to expand its existing facilities. The clusters strategy will focus on linking existing local strengths including social capital and opportunities in emerging sectors to NRC's core R&D capacities.
NRC	New Brunswick Cluster	A technology cluster is being developed in New Brunswick on e-commerce and the information technologies that underpin this sector.
NRC	Nova Scotia Cluster	A life sciences cluster is being established in Halifax. Through an expansion of the Institute for Marine Biosciences and the founding of a satellite campus of the medical diagnostic arm of the NRC. Nova Scotia is building on the strength of Dalhousie University's medical school and more than 100 life sciences companies. Halifax is well positioned to attract new biosciences firms. Hosts Canada's only site on the 40 site World Wide Genomics Network using broadband communications for interoperable computers networking universities, hospitals undertaking genomic R&D. The network constitutes an example of a boundaryless virtual cluster.
NRC	Cape Breton Cluster	The NRC is investing in the information technology sector in Cape Breton due to the growing importance of this sector in the region
NRC	Newfoundland Cluster	A cluster on ocean engineering in St. John's Newfoundland is being established. The Institute for Marine Dynamics is situated in St. John's and an expansion of this facility is to be the foundation for the development of the ocean engineering cluster.
NRC	PEI Innovation Centre	The NRC plans to expand its IRAP office in Charlottetown into an innovation centre, which will provide the province with a portal to the NRC and other federal S&T expertise.
NRC	Biotechnology Clusters	Biotechnology clusters exist in Halifax, Montreal, Ottawa, Winnipeg and Saskatoon (Refer to Figure 3).
NRC	Canadian Technology Network	The Canadian Technology Network gives business worldwide expertise at their community level. Local advisors who are in tune with local needs access expertise and resources from across Canada and abroad. The CTN is set up in each major region of Canada. The Internet site summarizes the key strengths of BC, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Maritimes and Newfoundland.

Organization	Cluster-Related Initiative	Description
NRC	National Institute of Nanotechnology (Edmonton)	A new $120 million research center on nanotechnology is being created by the federal and Alberta governments. The center will be located at the University of Alberta. Nanotechnology is the science of building materials and machines at a size that is 1/10,000 of the width of a human hair. Scientists will be able to build machgines and materials one molecule at a time. Nanotechnology is a cutting-edge science that is rapidly advancing areas from health care to computer technologies. It will play a vital role in many areas including health, computing science, energy, biotechnology, education, manufacturing and engineering. The University of Alberta's existing strength in nanotechnology, engineering, medicine and computing science will support the National Institute for Nanotechnology's aim of being internationally competitive with the nanotechnolgy clusters being created in the United States, Europe and Asia.
WED	New Media Innovation Centre (Vancouver)	A world-class New Media Innovation Centre is being established at Harbour Centre in Vancouver to research, develop, produce and commercialize advanced interactive new-media technologies, products and delivery systems. The initiative was supported under the Western Economic Partnership Agreement. Founding partners include the University of British Columbia, Simon Fraser University, the Technical University of British Columbia, IBM, Nortel, Xerox, Electronic Arts, Leboe, Electronic Arts, and INSINC! Interactive Netcasting Systems Inc.
WED	Fuel Cells (Vancouver)	Fuel Cells Canada is being established under the Western Economic Partnership Agreement as a non-profit organization to identify, coordinate, and present fuel-cell demonstration projects.
WED	The CANARIE E-Business Virtual Clusters Program	This program is designed to encourage development projects that will accelerate the adoption and diffusion of e-business applications and services. Ten million dollars has been earmarked to help create collaborations or virtual clusters, involving associated but geographically dispersed organizations that will undertake specific e-business projects.
WED	Technology Clusters in Western Canada	To facilitate the development of emerging technology clusters in western Canada, WED and the four western provinces engaged KPMG, DRI/McGraw-Hill and Impax Policy Services International to examine the state of three emerging technology clusters in western Canada: biotechnology, information technology and advanced materials/advanced manufacturing. The

Organization	Cluster-Related Initiative	Description
		study process sought to clarify the structure of the economy and the role presently and potentially played by these three enabling technology clusters. The ultimate purpose of the project was to find better ways for industry to use technology opportunities to improve the economy and quality of life in western Canada—and to see how to engage both the private and public sectors in concrete actions to create vibrant enabling technology clusters in the region.
Québec	Québec Techmap™	The Québec Techmap™ provides a detailed outline of the evolution of the technology community in Québec. The map outlines the genealogy of technology companies and new company spin-offs in the province and provides a snapshot of the Québec technology cluster.
Québec	A cluster for the development of Quebec's environment industries.	La Grappe is a network of entrepreneurs, decision-makers and opinion leaders who are committed to combining their efforts and resources to ensure the growth of Quebec's environmental industries (QEI).
City of Ottawa	Generators Project	The Ottawa Partnership, a public-private partnership that is intended to co-ordinate economic development and provides policy advice to city council, launched the Economic Generators initiative. TOP is co-chaired by Mayor Bob Chiarelli and Ottawa Senators owner Rod Bryden who also holds controlling interest in World Heart, among other companies. Seven economic clusters have been identified. These clusters — life sciences, microelectronics, photonics, professional services, software, telecommunications and tourism — are believed to be the engines that will drive economic growth over the next decade or more.
City of Ottawa	Ontario Photonics Technology Industry Cluster (OPTIC)	OPTIC is a community of high-tech companies & organizations working to support the Optics & Photonics industry in Ontario.
City of Toronto	Toronto Competes	Toronto Competes assesses Toronto's global competitiveness and benchmarks 10 key export industry clusters (aerospace, apparel, automotive, biomedical & biotechnology, business & professional services, financial services, food & beverage, information technology & telecommunications, media and tourism) against other international cities and city-regions.

Organization	Cluster-Related Initiative	Description
City of Toronto	Arthur Andersen	The independent study, commissioned by the Greater Toronto Marketing Alliance (GTMA) was a collaborative effort bringing together a cross section of partners, including Industry Canada, Weir & Foulds, J.J. Barnicke-Oncor International, Arthur Andersen LLP and Human Resources Development Canada.
City of Toronto	Spadina Bus	Profile of Spadina Bus, a "new economy" cluster of high-tech firms in the King and Spadina area of Toronto. The largest number of companies, nearly one-fifth, specializes in media and content development, with web designers second at 16 per cent and access providers and e-commerce companies rounding out the top three. The vast majority of respondents are Canadian-owned (90%), with 59 per cent operating from offices within Canada only.
City of Montreal	Montreal Technovision Inc	Report by Montreal Technovision Inc. on Performance Indicators 2000, highlighting Montreal's key strengths in "new economy" areas. For example, Montreal ranks first in North American in aircraft engine manufacturing and maintenance, first in biopharmaceutical contract research and fifth in telecommunications equipment manufacturing. Montreal attracts more than 30% of all Canadian high technology venture capital financing, and Montreal ranks with Atlanta, Philadelphia, Toronto, Dallas and Seattle in terms of the number of Initial Public Offerings (IPOs) in the technology sectors.
Kitchener-Waterloo-Guelph.	Bank of Montreal	Report by the Bank of Montreal on Canada's Technology Triangle: Kitchener-Waterloo-Guelph. The report discusses the key industries in the triangle as well as the role of the two universities (Waterloo and Wilfred Laurier).
City of Guelph	Natural Health Products Technology Cluster (NHPTC)	The Natural Health Products Technology Cluster (NHPTC) is an organization dedicated to increasing the size and global competitiveness of the natural health products industry in Ontario. The Cluster focuses on natural health products that can be absorbed into the body via skin, nasal passage, lung or mouth. This includes: herbal remedies, such as those used by traditional herbalists, and by practitioners of traditional North American aboriginal medicine, Ayurvedic medicine and Traditional Chinese Medicine; vitamin and mineral supplements nutraceuticals; some cosmetics; aromatherapy; sports nutrition; and homeopathic remedies. In part, it makes use of the highway 6 corridors connecting it via GHTEC with Hamilton and MacMaster University.

Organization	Cluster-Related Initiative	Description
Southern Ontario	Automotive	Although there are fragments of the automotive industry spread across the country, the Canadian automotive industry is concentrated in Southern Ontario. Identified by Porter as a weak cluster in Canada, it is an integral part of the North American cluster extending from Southern Ontario, Pennsylvania and Ohio west into Michigan and Illinois and south toward Alabama.
Edmonton	The Greater Edmonton Competitiveness Strategy	The following eight industry clusters are considered as key to the Region's future competitive economic growth: • Advance Manufacturing; • Agriculture and Forest Products; • Biomedicine and Biotechnology; • Engineering and Technical Services; • Information and Media Services; • Oil, Gas and Chemicals; • Tourism and Entertainment; and • Transportation and Logistics
Prince George Region	Trends Facing the Forestry, Tourism, and Transportation Clusters	Objectives of study are: ➢ To identify immediate, short, ongoing, and long term trends specific to the business and industry clusters operating in the Prince George region; ➢ To present speculations made by industry cluster representatives in terms of the employment development implications of those trends identified; ➢ To identify the subsets that business and industry representatives feel are most pertinent to focus research efforts upon; and To ascertain where industry cluster representatives feel funding assistance should be directed within the community to maximize employment and economic opportunities in the region.
British Columbia	Photonics Industry	The British Columbia Photonics Industry Association is a relatively young cluster group having been formed in April 99. It is a cross-functional industry association representing all aspects of the Photonics industry. Its members interact directly or indirectly with the

Organization	Cluster-Related Initiative	Description
		Photonics industry (such as suppliers, manufacturers and users of lasers, sensors, lightwave communications, spectrometry, imaging tools, robot vision, infrared and visible sources and detectors). John Deacon from Industry Canada is currently planning to build a technology roadmap with the co-operation of the industry. Gerard Lynch is the CEO of Photonics Research Ontario and a key player in the Ontario Photonics Industry Cluster (OPTIC).