Innovation Systems Research Network (ISRN)

Mid-Term Report on the
Major Collaborative Research Initiative

Innovation Systems and Economic Development: The Role of Local and Regional Clusters in Canada

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Overview

There has been a virtual explosion of interest in cluster development in recent years across North America, Europe and newly industrialized countries. This interest has been prompted, in part, by the fascination with the success of Silicon Valley at reinventing itself through successive waves of new technology; and, in part, by the efforts of a growing number of other locales to emulate that success. A growing number of clusters from Scotland to Bangalore and Singapore to Israel all claim direct lineage from the original model in northern California. Clusters can consist of both high-tech concentrations of firms, which often centre around research-intensive universities or institutes, as well as those based in more traditional industries, such as the furniture industry in Denmark. The perceived success of Silicon Valley, and the growing claims by other regions to have replicated the key elements of its formula, has generated a cottage industry of policy analysts and consultants – eager to assist regional and local governments in growing their own clusters. The collective claims made by these analysts of the putative benefits of 'clustering' are rapidly outstripping the empirical evidence available to assess the validity of the claims and their basis as a guide for policy.

A growing body of research has applied the cluster concept both as an analytical tool to analyze the factors that contribute to the relative degree of economic success enjoyed by different regions and localities, as well as a framework to guide policy-makers in the design of initiatives to promote economic development. Following Porter, clusters are defined as geographic concentrations of interconnected companies and institutions in a particular field. The presence of clusters, or more precisely, the tendency of firms in a related range of sectors to concentrate in geographic regions, has provided the basis for suggesting that some of the key factors affecting the competitive advantage of firms may lie outside the boundaries of the firm itself. However, the two strands of research, the empirical and the prescriptive, tend to work at cross-purposes, with the policy goals sometimes predetermining the analysis, rather than the other way around. A key challenge for those interested in applying the concept of clusters from either perspective is to undertake serious analysis of the way in which the presence of clusters actually contributes to economic development in local and regional economies.

The goal of the ISRN's major collaborative research initiative is precisely this – to analyze how the formation and growth of clusters contribute to economic growth and development within a number of regions across Canada by applying the insights derived from these two perspectives. This initiative builds upon the previous experience of the Innovation Systems Research Network as a multi-disciplinary research network. Over the initial period of its support, ISRN developed into a closely-knit national network of scholars, domestic partners at all three levels of government, in the private and not-for-profit sector, and international collaborators. The current project has built upon its unique research capabilities and partnerships to create a coherent research agenda that is investigating how local networks of firms in a selected number of clusters, and the supporting infrastructure of institutions and organizations that comprise the regional innovation system interact to foster economic development.

Theoretical Framework

The theoretical framework for the project draws on the relevant bodies of scholarly literature. From the broader literature on innovation systems in general, and regional innovation systems in

particular, it adopts a focus on the *interactive, social and learning* nature of the innovation process, as well as the notion that geography matters and the institutional infrastructure of a regional or local economy is essential for creating the 'untraded interdependencies' that shape and constrain the innovative capabilities and competitive dynamics of firms located in that region or locality. From the literature on clusters, it adopts the notion that the complexity of innovation in the growing knowledge-based economy creates an increasing degree of both specialization and interdependence among firms. This interdependence channels the innovation process towards greater cooperation among firms located up and down the supply chain within geographically-based clusters. A proper understanding of the strengths and weaknesses of the innovation potential within regional and local economies requires a more detailed analysis and understanding of the nature of the linkages among firms within these clusters and how the emerging division of labour among them both influences (and constrains) their innovation and growth potential. Both bodies of literature share the critical insight that the institutional aspects and formal organizations of the innovation system, as well as the presence or absence of social capital, play a critical role in influencing the climate for innovation and economic growth in cluster-based regional and local economies. This literature identifies a number of key factors whose presence or absence are essential for the growth and expansion of dynamic clusters. This framework forms the theoretical basis for the research methodology outlined in the next section.

Originality and Anticipated Contribution to Knowledge

While the theoretical framework reviewed above – national and regional innovation systems, and the cluster approach – emphasize the historical (and path-dependent) evolution of innovative regionally-organized production systems, there is a decided tendency in the applied work on clusters in the policy sphere to adopt a more static framework oriented around the compilation of lists of factors contributing to the development of innovative local economies. While the methodologies employed in this applied work have been effective in identifying the existence and major elements of local clusters in a variety of regions, they have been less effective in capturing the *dynamics* of their formation and historical evolution to the present day. For both innovation theory and public policy, it is vitally important to address this relatively neglected aspect of existing research.

The literature on clusters and regional innovation systems also suffers from a tendency to focus on the most celebrated case studies and engaging in *ex post facto* reasoning to 'explain' their success. What is frequently missing from this kind of analysis is a systematic comparison between more and less developed regions. Furthermore, this research has tended to focus on newer, more technology-intensive sectors such as microelectronics, computing, telecommunications equipment and, more recently, biotechnology and multimedia. The majority of cluster studies have focused on large metropolitan areas and emphasized knowledge-based clusters, to the neglect of those in non-metropolitan regions. However, a number of scholars have argued that innovation processes are also key to the rejuvenation and growth of 'traditional' economic activities in sectors such as resource-based products and cultural industries. In such cases, innovation systems – both national and regional – may play a central role in stimulating and supporting the renewal process. These sectors, once rejuvenated, constitute a major component of the engine of growth for large metropolitan regions as well as non-metropolitan regions with smaller urban centres.

The research conducted on the nature of clusters in Canada to date has also tended to be somewhat piecemeal. Studies to date have examined individual clusters in different metropolitan areas or regions of the country and provided us with data that identify the extent of individual clusters and, in some instances, benchmark those clusters against similar ones in both Canada and the US. They have not provided us with detailed insight into the internal dynamics and functioning of the respective clusters, nor have they examined in adequate detail the relationship between cluster dynamics and the role of the supporting infrastructure of economic and social institutions. Our research methodology allows us to make systematic comparisons between metropolitan and non-metropolitan locations, and between more and less knowledge-intensive industries. Given the focus of most of the existing literature on metropolitan, knowledge-intensive clusters, this aspect of our research design constitutes a unique and important innovation. Both in our annual meetings with members of the Research Advisory Committee, and in presentations of our research results at international conferences, leading scholars in the field have commented on the rich set of comparative data being generated by the current project.

Furthermore, the current project also combines a strong analytical with a more policy oriented component. In our analysis of specific clusters, we are investigating key questions that concern policy-makers at the regional and local level – how to generate and promote the growth of cluster-based development within the context of their own local economies. To answer this question, we are exploring issues of both history and the degree of path dependency in the evolution of regional innovation systems over time. We are investigating the role that various factors have played in contributing to their innovative capacity, in the current setting. The policy-oriented component of the project is examining the following issues: identify a set of 'best practices' that work elsewhere to assist local and regional development agencies to identify policy instruments and design programs that promote cluster formation and monitor their progress; develop guidelines to design and animate interactive learning and governance in the various parts of local innovation systems, as well as provide narratives and exemplars about trends in firm location decisions; and determine how to leverage existing policy frameworks and programs at all three levels of government to ensure that they make the maximum contribution to cluster formation and economic development. Policy-makers seem increasingly interested in answers to these questions, as evidenced by the number of sessions organized by members of the research team with analysts at all three levels of government, especially the one-day workshop with Industry Canada and the NRC organized on April 30, 2003.

Methodological Issues from the Adjudication Committee

On the Use of Interviews and its Relationship to Our Statistical Analysis

The analysis of Statistics Canada's Innovation Survey (SCIS) has allowed us to measure the number and importance of product and process innovations produced by responding firms (dependent variable) and explore its relationship to a set of independent variables including: the importance of different external sources of innovative ideas, firm size, and the sophistication, internal resources or 'absorptive capacity' of the firm. We are also exploring how this varies by key dimensions such as sector/industry and location (including a differentiation between metropolitan and non-metropolitan regions).

We can then match this information to our selection of industry/region clusters to give us an extensive baseline analysis of the extent of collaboration and cluster-type relations present. We can gain useful information from SCIS about the motivations underlying this kind of collaboration, the benefits arising from it, and the obstacles or challenges preventing further collaboration. The profile of individual industry/region clusters arising from our analysis of the SCIS data has been helpful in providing a preliminary benchmarking of the density, strength, and structure of local cluster relationships using explicit, concrete measures. This facilitates cluster-to-cluster comparisons, as well as comparisons to national and international benchmarks. The results of this analysis can be found in papers presented by Amara, Landry and Ouiment at the ISRN Annual Meeting in 2002 and the Danish Research Unit on Industrial Dynamics (DRUID) Summer Conference in 2003.

Notwithstanding the strengths of the SCIS, it shares the limitations of all surveys. Most notably, it is all but impossible (at least in a large national survey) to learn much about the historical processes and dynamics responsible for determining the character and current conditions of each cluster. It is also very difficult to infer more than rudimentary qualitative information about the strength and nature of relationships between firms, the role of key individuals, intermediaries and institutional players, the role of historical accident and chance, the impact of public policy and programs, and related influences. While the survey analysis has already yielded helpful insights and hypotheses concerning these processes, it is important to delve more deeply into these issues. To collect this kind of information, the interview is the only method available – as a large international literature in management studies, industrial economics, economic geography, industrial sociology and related fields attests.

It is important to add, however, that the qualitative information collected in interviews can be analyzed in systematic ways to permit structured comparisons and generalizations to be made. The principal investigator and co-investigators have extensive experience with such methodologies, and the InnoCom study team based at Simon Fraser has developed an innovative, web-based template for storing the transcribed results of our interviews in a common format that will greatly facilitate qualitative analysis and systematic cross-cluster analysis. We are using both quantitative results from our analysis of SCIS and structured, qualitative results from our interviews to make systematic comparisons between different case studies. Given that we have selected multiple clusters in the same or similar industry/sector, this analysis permits us to better understand the following questions:

- How does each cluster compare to the other(s) in its industry elsewhere in Canada (or to national standards and benchmarks) in terms of competitive performance and the character, strength and structure of cluster relations?
- To what extent do region-specific characteristics determine the characteristics and performance of local clusters in a variety of sectors?

How Will We Determine the Relative Importance of Local and Non-local Forces in the Development of Clusters?

We are very conscious that globalization and new information and communication technologies (ICT) are changing the ways that regional innovation systems work. Their effects are not simple. They seem to be diminishing some previous transaction and communication costs, thereby

allowing greater outsourcing to a greater number of locations and permitting more flexibility in the coordination of spatially distributed productive activities. However, it is also clear that innovative activity is highly concentrated geographically in a small number of places, due to the potential that such places offer for firms to engage in knowledge production, circulation and absorption. Moreover, this pattern seems to be the most pronounced in the most knowledge-intensive activities, the best example being biotechnology. If anything, this geographical concentration shows signs of *increasing*, not decreasing, over time. At the same time, there is some indication in the literature that world-class centres of innovation are also very strongly connected into global flows of knowledge and people (embodied knowledge). A recent paper by Bathelt et al. nicely captures the dual nature of this geography by characterizing it as a combination of *local buzz* and *global pipelines*.

This conceptual approach lies at the very heart of our analysis and case studies. We do not accept uncritically the premise that all innovation-generating relationships must be local. Continental and global relationships play an important part as well. We are interested in determining under what circumstances the local matters, and the extent to which locally generated institutions (public and private) can play a part in strengthening the innovative capabilities of local clusters. But we are also keen to determine the relative importance of *non-local* actors, relationships, and flows of knowledge in shaping the development trajectories of localized innovation and growth. These issues feature prominently in our analysis of the SCIS, in our analysis of Statistics Canada's 1999 Survey of Biotechnology Use and Development, and in the design of our interview guides. The results of the latter analysis were presented in a recent paper by Gertler and Levitte at the DRUID Summer Conference, 2003. Our goal is *not* to 'prove' that the local 'matters'; rather, we are interested in determining if, how, and in what ways it matters – and how this importance compares to the importance of non-local forces and processes.

Elements of a Rigorous Definition of Clusters?

This discussion implies the need to develop and apply a rigorous set of indicators of cluster dynamics – again, to enable us to determine whether or not these are truly present in each of the cases we are examining. In other words, how would we know a cluster when we see one? Much of our effort over the past two and a half years, and much of our consultation with members of the Research Advisory Committee, has been dedicated to providing a solid answer to this key question. Our work thus far, and the theoretical and conceptual literature from which we draw our inspiration, both lead us to emphasize *flows* and *dynamics* over stocks and static measures of innovativeness. They also point quite clearly to the centrality of knowledge and learning processes, both embodied and otherwise. At this stage, our analysis focuses on four categories of indicators: inflows, outflows, local social dynamics, and historical path dynamics.

We argue that one clear way to confirm the existence of unique, distinctive local knowledge-based assets is by tracking three different forms of *inflow*. Capital inflows, in the form of venture capital investments, foreign direct investments, or mergers and acquisitions, indicate that investors have identified the local presence of local knowledge assets and capabilities. This seems to have been true of Ottawa's information technology industries (where non-locally based venture capitalists have continued to invest aggressively in local firms with high growth potential despite the major downturn in both the telecom and photonics sectors), Montreal's biotech sector

(where BioChem Pharma has been purchased by an outside buyer), and Calgary's wireless industry (where Intel has invested directly in new R&D capacity).

Inflows of people are, in our view, an especially robust indicator of local dynamism. It is now increasingly well established that highly educated, talented labour flows to those places that have a 'buzz' about them – the places where the most interesting work in the field is currently being done. One way to track this is through the inflow of so-called 'star scientists', or by tracking the in-migration of tomorrow's potential stars (post-docs). A paper presented by Queenton and Niosi at the ISRN Annual Meeting 2003 developed such measures for biotechnology in Canada. Another approach promoted by Florida, and applied to Canada by Gertler and Florida, utilizes a broadly defined measure of 'talent' to document its strong geographical attraction to the presence of other creative people and activities locally. In-bound talent represents knowledge in its embodied form flowing to the region. Hence, such flows act to reinforce and further accentuate the knowledge assets already assembled in a particular region.

One should also be able to track knowledge inflows directly, in their disembodied form. This would be monitored through licensing of intellectual property produced elsewhere, or through local citation of externally generated patents as is suggested in the case study of the Saskatoon biotech cluster by Ryan and Phillips.

Local social dynamics are the starting point for most of the literature in economic geography and related fields over the past 15 to 20 years. As Maskell and Malmberg have argued, because of the path-dependent nature of such local institutions, they are usually quite difficult to replicate, making them a key component of the region's distinctive and unique asset base. Perhaps the most discerning test of 'true' cluster dynamics is one that assesses the alleged cluster's *resilience and robustness over time*, in the face of severe shocks and dislocations. How has the region fared under such circumstances? How effectively have its firms and institutions adapted and evolved in response to such pressures for change? To what extent can firms take advantage of opportunities to learn from success (manifest in the form of successful spin-offs and demonstration effects from successful competitors and/or role models)? A number of the current case studies, especially those examining ICT clusters, have had the opportunity to follow these developments through the post-2000 recession and are generating some instructive insights on this question.

Related to this idea is another question: how do the local economy and its leading industries cope with failure? In the most dynamic regions, failure is recognized as a learning opportunity, such that entrepreneurs who have failed in the past are seen by potential investors as lower-risk prospects because they have most likely learned valuable lessons in the process. Similarly, the failure or downsizing of large, once-successful firms represents a potential opportunity for regional renewal, since highly educated and experienced knowledge assets are released back into the local economy. Our current case studies suggest that successful clusters capitalize on such events by absorbing these valuable assets back into the productive activity – for example, by facilitating and supporting the process of new firm formation. Less dynamic places will tend to squander such opportunities by permitting or encouraging out-migration. The individual studies underway afford a careful analysis of the historical evolution of each case in order to document such dynamics over time.

Management Structure

The MCRI project is being managed with the structure of the ISRN established under the previous network grant between 1998 and 2001: a national office based in the Munk Centre of International Studies at the University of Toronto, and five regional subnetworks distributed across the country (at Simon Fraser, Ottawa, Toronto, Laval and Fredericton). A senior member of the appropriate subnetwork is conducting each local case study, and funds for each study are distributed to the researcher's university through the national office. Additional funds have been allocated to each of the regional subnetworks to allow them to continue the networking activities established under the initial grant to the ISRN, as a way to strengthen the degree of interaction among team members and to facilitate knowledge transfer with our research partners in government agencies and the private sector.

The *Management Committee* (MC) currently consists of David Wolfe (Toronto), Meric Gertler (Toronto), Adam Holbrook (Simon Fraser University), Réjean Landry (Laval), John de la Mothe (Ottawa) and Charles Davis (UNB-St. John). The Management Committee meets twice yearly, once in the fall/winter and once at the Annual Meeting in May. In addition, it has met by conference call when special circumstances required. It is responsible for a number of critical aspects of the project management. It reviews the current status of the project budget and approves all changes to the initial budget. It also reviews additions to the list of case studies. The MC also reviews the state of deliverables from each of the researchers and plans the program for the Annual Meeting, assuring that the appropriate mix of researchers from across the regions are represented and that the full research team has an opportunity to hear from each of the co-investigators and team members on an ongoing basis. The MC also oversees the involvement and integration of graduate students into the research program and has introduced important innovations, such as the highly successful graduate student sessions held at the past two annual meeting in 2002 and 2003.

Finally, the MC reviews and coordinates the wide range of outreach activities engaged in by team members. While the vast majority of these initiatives have been launched by individual researchers and the regional subnetworks, the MC has reviewed a number of initiatives on a project-wide basis, such as the Letter of Understanding negotiated and signed with the NRC's Industrial Research Assistance Program and the recent one-day policy workshop organized with the Industrial Analysis Centre of Industry Canada and the NRC on April 30, 2003.

Research Advisory Committee

In addition, we have established a *Research Advisory Committee* (RAC), consisting of all the international collaborators listed in the proposal. The Research Advisory Committee consists of the following eminent international authorities on the geography of innovation and clustering:

Bjørn Asheim, University of Lund
Philip Cooke, University of Wales, Cardiff
Maryann Feldman, Johns Hopkins (recently moved to U of T)
Richard Florida, Carnegie Mellon University
Hervey Gibson, Cogent Strategies International
Anders Malmberg, Uppsala University
Ann Markusen, University of Minnesota
Peter Maskell, Copenhagen Business School
Kevin Morgan, University of Wales, Cardiff
Emmanuel Muller, University of Heidelberg
Claire Nauwelaers, MERIT, Maastricht
AnnaLee Saxenian, University of California, Berkeley
Don Scott-Kemmis, Australian National University
Blanka Vavakova, INRS, Paris
Clifford Wymbs, Baruch College, CUNY

The Research Advisory Committee first met with members of the management committee in Toronto on May 9, 2001, in a day-long session to discuss the conceptual and methodological framework for the project. They have met subsequently at the two Annual Meetings in Quebec City on May 11, 2002 and in Ottawa on May 3, 2003. All but one committee member has attended at least one of the annual meetings of the research group, and we have benefited from the advice provided on such occasions. RAC members have given us clear direction on both conceptual and methodological issues; we have listened carefully to their advice each year and worked hard to incorporate their ideas and suggestions into our research.

At the initial meeting in Toronto RAC members emphasized the following issues:

- We should be careful to treat 'cluster' as an ***hypothesis***, not an assumed fact;
- We needed to think about how to capture dynamics in our analysis;
- We should develop our understanding of the importance of knowledge flows into, out of, and within local clusters (and how to track these);
- We needed to capture and reflect the importance of random events and increasing returns as we track the path-dependent evolution of each case study;
- We can learn from cases of failure as well as success stories;
- We should be careful to emphasize both local and non-local dynamics and relationships;
- Competition and co-operation: we need to capture both in our case studies, since each provides its own rationale for clustering

At the annual meeting in Quebec City, the RAC returned to the theme of location and the role of proximity, encouraging us to develop a more nuanced understanding of its importance. In doing so, we would need to capture the tension between local and non-local relationships, flows. The

Committee also encouraged us to reject a 'one-size-fits-all' approach in favour of specificity, respecting regional, national, sectoral, historical variation between our individual cases. In short, we were encouraged to remain open to the possibility that different cases would support different conclusions about the role of proximity, the importance of universities, local customers/suppliers, and so forth. They also returned to one of the core issues discussed at the May 2001 meeting: the importance of maintaining a skeptical orientation in our case studies, treating the idea of 'clusters' as a hypothesis, rather than assuming the existence of local clusters *a priori*: hence, the need to develop clear indicators. We were encouraged to focus on the key drivers underlying successful cases, as well as the elements missing from less successful ones.

At our most recent meeting in Ottawa, we received positive feedback from RAC members concerning the progress our research teams have made in incorporating the suggestions from earlier meetings outlined above. In particular, the RAC expressed their approval of the attention given to: local vs. non-local linkages/flows/processes, the specific nature and histories of each of our cases, our attempts to develop a set of cluster indicators, and our efforts to produce a typology of cluster types. They were impressed with our team members' experimentation with methodologies for measuring and analyzing social networks based on information collected through the interviews. They also expressed considerable enthusiasm concerning the interview database we are assembling, noting that it will contain a rich array of information that will allow us to make empirical assessments of pressing conceptual issues. This database will perform an important function in helping us to integrate our findings across the various cases by combining the knowledge collected through as many as 1,000 interviews.

They have encouraged us to remember the basic questions driving this research concerning innovation and learning, upgrading and competitiveness, wealth creation, and prosperity. How do firms sustain competitiveness, and what is the role of the local environment in doing this? How does clustering contribute to the real goal of enhancing the competitiveness, innovative capability, and upgrading of firms? The RAC proposed that we continue to refine our typology of clusters based on the findings emerging from our cases. They are struck by the variations between different sectors, as well as variations within sectors but between regions (e.g. the very different geographies of knowledge flows in the Saskatoon and Montreal biotech cases). They have encouraged us to extend this analysis by focusing on key questions such as the role of local universities and government labs in leading (or lagging behind) local cluster development.

Some RAC members have suggested that we investigate more systematically the role that the firms and industries in our case studies play in the overall economy and competitiveness of Canada by developing indicators concerning how much of the nation's value added, exports, world market share, etc. is accounted for by these cases. In response to this suggestion we have engaged a student researcher to explore the extent to which existing data sources will allow us to generate the data required for such measures.

Research Methodology and Progress to Date

The research is proceeding along three lines of inquiry as laid out in the original proposal: a statistical analysis of the data in Statistics Canada's 1999 Innovation Survey (SCIS) and the biotechnology survey conducted in 1999; detailed case studies of 26 individual clusters in each region; and a cross-cluster/cross-region comparative analysis in the latter stages of the project.

I. Statistical Analysis

A subcommittee chaired by Meric Gertler at Toronto and Réjean Landry at Laval is coordinating the statistical work. Two postdoctoral students have been engaged in the substantive work – Yael Levitte at Toronto and Nabil Amara at Laval. There was a meeting of the full statistical subcommittee (including postdoctoral students) with staff at Statistics Canada, during the first national meeting in Toronto, May 9-11, 2001, to co–ordinate this phase of the analysis.

The profile of individual industry/region cluster arising from our analysis of the SCIS data is also providing a preliminary benchmarking of the density, strength, and structure of local cluster relationships using explicit measures. This facilitates cluster-to-cluster comparisons, as well as comparisons to national and international benchmarks. One of the PhD students organized the descriptive analysis of results from the *1999 Survey of Innovation in Manufacturing* for the industries corresponding to the ISRN-MCRI case studies. Customized summary tables were distributed to PIs in January 2002.

This statistical work with the Innovation Survey (SCIS) enables us to measure the number and importance of product and process innovations produced by firms (dependent variable) and explore its relationship to a set of independent variables including: the importance of different external sources of innovative ideas, firm size, and the sophistication, internal resources or 'absorptive capacity' of the firm. We are also exploring how this varies by key dimensions such as sector/industry and location (including a differentiation between metropolitan and non–metropolitan regions). Despite the relatively large sample size (6,000 manufacturing firms and 800 natural resource firms), we are unable to disaggregate the sample to the level of the individual sectoral and regional clusters in our study, due to potential problems of small cell counts. Much of the analysis is therefore at the national and provincial level. As noted above, the initial results of this analysis have been presented at meetings of the ISRN in 2002 and the DRUID Summer Conference in 2003.

In addition we have also conducted a detailed statistical analysis of the data contained in the 1999 Survey of Biotechnology Firms with special emphasis placed on the role of patents and financing. Results of this study were also presented at the DRUID Summer Conference in June, 2003. Additional work using other data sources has also been conducted on venture capital financing of biotechnology firms by other team members.

II. Cluster Case Studies

For the second line of inquiry, we are conducting 26 individual case studies, an increase from the number proposed in the Milestones and Framework document. The additional studies have been made possible with supporting grants from the Ministry of Enterprise, Opportunity and Innovation in Ontario, FedNor, Agriculture and Agrifood Canada and the Canadian Space

Agency, as well as one Ph.D. student undertaking a case study for his doctoral research. The list of cases was determined through detailed discussions among the members of the Management Committee on the basis of existing research expertise and areas of interest, relevance to the local and regional economies across the country and the need for comparability. Most studies will take three years to complete, with the exception of several being conducted within a two-year time frame. One or two of the case studies have delayed slightly from the original schedule, either for personal or administrative reasons. Table 1 presents a list of case studies and their timelines.

All investigators are employing a common research framework and interview guide developed by the Management Committee and finalized through discussions with the full project team and RAC at the May 2001 annual meeting. The company version of the interview guide is attached to this report as Appendix B. The case studies are based on at least 50 individual interviews/cases spread across five groups of stakeholders. The interview guides have been customized for each of these stakeholder groups:

a. 'Lead' firms (large, technologically dynamic, export-oriented) and smaller and mid-sized firms, including suppliers;
b. Industry associations, chambers of commerce, local political leaders and 'civic entrepreneurs'
c. Government agencies (federal, provincial, local)
d. Universities: offices of technology transfer; relevant departments and colleges and other training institutions;
e. Financial sector (venture capitalists, banks, other)

Many of the completed interviews are being recorded in a secure, online database maintained by a research team member at Simon Fraser University. The creation of the database will allow team members to undertake other forms of analysis of the qualitative data being assembled. A full list of interviews completed to date is presented in Table 2.

Two sets of papers from the studies have been presented at the National Meetings in Quebec City, 2002 and Ottawa, 2003. The complete agenda for these meetings is attached to this report as Appendix C. A selection of papers from the 2002 meeting are published in *Clusters Old and New: The Transition to a Knowledge-Based Economy in Canada's Regions* along with an introductory chapter that provides an update on recent developments in the literature, identifies emerging themes of special relevance for our project and identifies some of the key themes emerging from our own research. This overview paper was also presented at the DRUID Summer Conference in June, 2003 and a special workshop on cluster formation in Stockholm in June, 2003. A selection of the papers from the 2003 meeting are currently being revised for publication in our annual edited volume with the Queen's School of Policy Studies and distributed by McGill-Queen's University Press. A wide range of other papers are also being published in scholarly journals by individual team members. An updated list of the scholarly output of team members is found in the attached appendix.

Table 1

Timelines for Cluster Studies

Cluster #		2001		2002				2003				2004				2005			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Wood Products (Schuetze)																		
2	Wine (Padmore)																		
3	Wireless (Langford)																		
4	Multimedia (Smith)																		
5	Vancouver Biotechnology (Holbrook)																		
6	Sask. Biotechnology (Peter Phillips)																		
7	Steel (Warrian)																		
8	Wine (Mytelka)																		
9	Auto Parts (Holmes/Rutherford)																		
10	Waterloo ICT (Wolfe)																		
11	Multimedia (Britton)																		
12	Toronto Biotechnology (Gertler)																		
13	London Biotechnology (Dean Hennessy)																		
14	Food and Beverage (Donald)																		
15	Sudbury Mining Supplies (David Robinson)																		
16	Space - Montreal/Ottawa (David Arthurs)																		
17	Telecom Equipment (de la Mothe/Chamberlin)																		
18	Photonics (de la Mothe/Chamberlin)																		
19	Biomedical Equipment (Dalpe/Niosi)																		
20	Aerospace (Niosi)																		
21	Montreal Biotechnology (Niosi)																		
22	Multimedia (Tremblay)																		
23	Photonics (Landry)																		
24	New Brunswick ICT (Schaefer/Davis)																		
25	Cape Breton Telecom (Johnston/Haddow)																		
26	Halifax LifeSci/Biotech (Rosson/McLarney)																		

III. Comparative Analysis

The comparative analysis of our case studies will begin in Year 4. We will look at clusters within a region, clusters across the country, new sectors versus traditional sectors (e.g. wireless versus wood products), and metropolitan versus rural issues. Our goal is to generate a set of comparative papers across regions and clusters in years four and five. The heads of each regional subnetwork will be responsible for coordinating the cross-cluster analyses in their own region. Additionally, we will undertake cross-regional comparative analyses for the five major sectors for which we are conducting studies in more than one region: biotech/biomed (Gertler, coordinator); multimedia (Smith, coordinator); ICT/photonics/wireless (Wolfe, coordinator); food/beverage/wine (Donald, coordinator); auto/steel/aerospace (Warrian, coordinator). We initiated this process with a set of five workshop meetings in Ottawa in May, 2003 as part of our national meeting.

We will use both the quantitative results from our analysis of SCIS and the biotechnology survey, as well as qualitative results from our case studies to make these systematic comparisons. Given that we have selected multiple clusters in the same or similar industry/sector, this analysis will permit us to better understand the following questions:

1. How does each cluster compare to the other(s) in its industry (or to national standards and benchmarks) in terms of competitive performance and the character, strength and structure of cluster relations?
2. To what extent are the character, strength and structure of cluster relations dependent on the dominant industrial sector?
3. To what extent do location-specific characteristics, ie. path dependent features, determine cluster characteristics and performance?

Finally, we aim to produce a study of 'lessons learned', with a strong policy focus examining the following issues:

1. identify a set of 'best practices' that work elsewhere to assist local and regional development agencies to identify policy instruments and design programs that promote cluster formation and monitor their progress;
2. develop guidelines to design and animate interactive learning and governance in the various parts of local innovation systems, as well as provide narratives and exemplars about trends in firm location decisions;
3. provide universities and public research laboratories with better insights into their roles in cluster formation and how they can participate more effectively.

Schedule for Completion

The statistical analysis is proceeding on schedule. All of the case studies are proceeding on the revised timeline set out in Table 1. As noted above, the comparative analysis is set to begin in Year 4, but initial analysis by team members was commenced in the workshops held in May, 2003 and will continue in further meetings later this year. We anticipate the full project proceeding to completion on schedule.

Training (Role of Graduate Students)

Each of the researchers participating in this proposal is engaged in an active individual research program that attracts high-quality graduate students. Network researchers draw their graduate students from a broad range of disciplinary and interdisciplinary areas. As well, two post-doctoral students have been involved in the statistical phase of the research enterprise. In the fall of 2003, a new postdoctoral student will join the team to assist with the comparative analyses and the overall integration of the research results. Graduate students are also continuing their role in maintaining network research listservs and helping to disseminate research results through electronic newsletters. The full number of students working on different aspects of the project is documented in Table 3.

With the launch of the MCRI, support for students has been increased and regularized, allowing the network to expand the number of training opportunities for graduates and compete effectively with comparable programs in Europe and the US to attract the best candidates. Graduate students attend and participate in both the regional subnetwork workshops and the annual network conferences. Some subnetworks have initiated graduate student workshops and seminars. Special sessions at network meetings provide opportunities for graduate students to explore common research interests, to feature their work to partners (and possible future employers) and to build their interdisciplinary skills. One of the great successes of the project has been the graduate student session instituted at the annual meeting where team members have been consistently impressed with the high quality and sophistication of graduate student presentations.

For students participating in the MCRI study, the opportunity to interview senior managers, CEOs and community leaders offers invaluable experience, fostering a set of skills that are essential to both social science research and non-academic work alike. In conducting the interviews, students are acquiring the ability to communicate effectively with senior personalities and learning how to direct the conversation so as to draw out the relevant information. Since interviews often do not unfold as planned, this requires flexibility on behalf of the student and a substantive understanding of the issues being discussed so as to gain as much from the interview as possible.

Perhaps as important, though unrelated to the research itself, is the exposure students acquire to the different types of companies, their management styles and organization. Accessible only through experience with companies and their senior management, such information helps enrich students' overall understanding of industry, and gives them a better sense of the opportunities that exist for them should they wish to pursue work opportunities outside academia.

Table 3 Number of Students Employed As Of June 30, 2003

CLUSTER	RESEARCHERS	STUDY TIME LINE	TOTAL # OF STUDENTS	LEVEL			
				UND	MA/MSC/ MBA	PHD	POST DOC
INNOCOM (British Columbia):							
Wood Products	Schuetze	Q3/01 – Q4/04	2		2		
Wine	Padmore	Q3/01 – Q2/05	1		1		
Wireless/Photonics	Langford	Q3/01 – Q2/04	3		3		
Multimedia	Smith	Q3/01 – Q2/04	3		2	1	
Biotechnology	Holbrook	Q4/01 – Q3/04	4		3	1	
ONRIS (Ontario):						1**P**	
Steel	Warrian	Q3/01 – Q2/03	1			1	
Wine	Mytelka	Q2/02 – Q1/04	1			1	
Auto Parts	Holmes/Rutherford	Q2/02 – Q1/05	1			1	
Waterloo ICT	Wolfe	Q3/02 – Q2/05	3		1	2**P**	
Multimedia	Britton	Q3/02 – Q2/05	1			1	
Biotechnology	Gertler	Q1/03 – Q4/05	2		1	1	
Food and Beverage	Donald	Q1/03 – Q4/05	1			1	
PROMIS (Ottawa):							
Telecom Equipment	de la Mothe/Chamberlin	Q3/01 – Q2/04	1		1		
Photonics	de la Mothe/Chamberlin	Q3/02 – Q2/05					
Biomedical Equipment	Dalpe/Niosi	Q3/01 – Q2/05	2			2	
RQSI (Quebec):							
Aerospace	Niosi	Q3/01 – Q2/04	5			5	
Biotechnology	Niosi	Q3/01 – Q2/04					
Multimedia	Tremblay	Q3/02 – Q2/05	3		1	2	
Photonics	Landry	Q3/02 – Q2/05	4		2	1*	1*
ACISN (Atlantic):							
New Brunswick ICT	Schaefer/Davis	Q3/01 – Q2/04	3	1	2		
Cape Breton Telecom	Johnstone/Haddow	Q3/01 – Q2/04	2	2			
Halifax Life Sciences/Biotech	Rosson/McLarney	Q2/02 – Q1/05	2		2		
Statistical Analysis	Gertler/Landry	Q3/01 – Q2/03	1			2*	1*
National Secretariat	Wolfe/Gertler		1				1
INNOCOM Network	Holbrook						
RQSI Network	Landry						
ACISN Network	Davis						
TOTALS			**47**	**3**	**21**	**21**	**2**

P1 Ontario photonics student (PhD) also prepares the ONRIS newsletter – counted once only in Total

*2 Quebec photonics students (1 PhD/1 PDF) also involved in Statistical Analysis – counted once only in Total

Findings to Date

This sections draws upon papers published in the latest volume of the ISRN series and presented to the DRUID Summer Conference in June, 2003. The complete paper is attached as Appendix D. The interim findings of our case studies to date reveal a surprising degree of consensus and common experience concerning the forces shaping each region and their individual clusters' evolution over time. Five themes stand out in particular.

Learning

Learning has been found to be the key economic process unfolding in each of our cases. Learning is instrumental in enabling old industries as well as new ones to become more successful innovators. The learning processes have been identified as present both within individual firms and across firm boundaries in the form of learning from other firms, research institutions, industrial associations, and related institutional elements of the cluster. Moreover, we have uncovered instances of both local and non-local learning relationships across our range of case studies.

Labour

One of our most consistent findings thus far concerns the centrality of skilled labour as the single most important local asset. The local endowment of 'talent' in the labour force is emerging as a crucial determinant of regional-industrial success. This endowment is itself created and maintained by the retention and attraction of highly-educated, potentially mobile workers who are drawn to thick, deep, opportunity-rich local labour markets. Critical mass also appears to be important here: until this is achieved, local employers will fight a losing battle in attempting to retain or attract the skilled talent they need. Once it is achieved, this sets in motion a positive, self-reinforcing circle through which regions with a critical mass of highly skilled workers in a particular sector are able to attract still more workers of this kind.

Leadership

While one of the hallmarks of cluster-based development is its highly decentralized, socially organized network of relationships between local economic actors, the research thus far has highlighted the role that leadership can play in differentiating one firm (or one region) from another. Moreover, this is exercised at two different but equally important scales. First and foremost, the quality and nature of leadership within the firm has been shown to be crucial in explaining the different strategic approaches taken by firms in the same industry and region, as well as their ultimate competitive success. Perhaps the most vivid example of this comes from the steel industry case study in which the different paths taken by leading firms such as Stelco and Dofasco – both integrated steel producers operating from the City of Hamilton – have been strongly shaped by radically divergent attitudes towards co-operation with local research organizations. Similarly Bombardier, Canada's leading aerospace producer has differentiated itself from the competition (and its home base in Montreal from other aerospace-producing regions around the world) by its corporate strategy of buying assets (tangible bricks and mortar as well as intangibles such as knowledge) and managing them skillfully, rather than by building them from scratch.

Leadership is also expressed at a social scale: at the level of the community. Here, our early findings point to the key role of 'civic entrepreneurs' in catalyzing the development of new and emerging industries such as telecom equipment in Ottawa, wireless equipment in Calgary or the emerging multimedia cluster in Nova Scotia's Cape Breton Island. These community leaders – who are more often than not from the private sector –animate local processes of strategic visioning, galvanize socially organized activities to upgrade the innovative capabilities of local firms, and represent the common, collective interest of firms in the industry when required.

Legislation, laws, and laboratories

Our cases also reveal the subtle but pervasive influence of institutional forces, exerted in a number of ways and at a number of spatial scales. While private sector initiative is of obvious importance, provincial and national institutions play a key role in shaping the trajectory of regional-industrial evolution by constraining or channeling strategic choices by firms. They also play a role in building the knowledge infrastructure in different regions: universities, colleges, government labs, and other technology-transfer organizations. Through the creation of crown corporations or government labs, they produce knowledge-based assets for the region. Examples such as NovaTel and its role in fostering the Calgary wireless industry demonstrate the potential of publicly funded entities in the emergence of new industries firms. Similarly, the NRC laboratories in Saskatoon, Montreal and Ottawa have generated significant numbers of spin-off firms. Finally, publicly funded agencies play a crucial role as 'animateurs', working to organize reflexive learning processes at the level of industries and communities.

Location

While our work began from the premise that 'geography matters', we recognized the perils of presupposing the importance of place, rather than revealing it through systematic study. What is emerging from our cases is a more nuanced understanding of the importance of location to the creation and maintenance of learning dynamics for firms and industries. The case studies document a consistent tension between local and non-local relationships and knowledge flows – in other words the dynamic tension that exists between *local buzz* and *global pipelines*. Moreover, they are leading us to appreciate the specificity of particular case study circumstances, in which regional, national, sectoral and historical variation is significant.

Preliminary Conclusions

The approach taken in this project differs from most of the work performed under the rubric of 'cluster studies' in one important way. As noted above, our approach is to treat the possible existence of cluster dynamics as an hypothesis to be investigated and either verified or rejected. Our large sample of case studies that cut across a broad cross-section of mature and emerging industries in highly urbanized and smaller centres provides a solid basis for comparison and allows us to use a robust set of indicators or tests. We continue to ask ourselves throughout this project: when, or under what circumstances does spatial proximity matter, and why? The answers to these questions will provide a useful base for policy advice that does not oversubscribe to the cluster brand nor oversell what can be delivered.

Dissemination Activities

The members of the network are engaged in a wide range of dissemination activities that are much too extensive to document in detail. We highlight a number of activities undertaken by members of the network but stress that this is highly selective and for illustrative purposes only.

RQSI

The Réseau du Québec sur l'étude et la promotion des systèmes d'innovation (RQSI) is probably the largest and most extensive of our five regional subnetworks. Under the direction of Rejean Landry at Laval University the network has grown to 650 members, including approximately 25 researchers, 25 students and 600 partners in governmental and private organizations. The RQSI publishes our initial and highly successful weekly electronic newsletter, Le bulletin INNOV**,** distributed to the 650 members of the network interested in research issues on innovation and the promotion of innovation in the manufacturing sector, particularly at the regional and local level.

Innocom

A main goal for InnoCom has been to disseminate and publicize the activities of the ISRN network and the InnoCom subnetwork. InnoCom members participate in community and cluster events by presenting and disseminating research findings. Consultations and presentation include working with federal departments (particularly Industry Canada), provincial governments, regional development agencies and local civic promotional agency for the high technology sectors. Innocom meets semi-annually to discuss research findings and disseminate information to other interested parties and collaborators in industry and government. In 2002/03 meetings were held in Calgary/Kananaskis (in February) and Vanciuver/Bowen Island (in September). These meetings provided the opportunity for graduate students, principal investigators and guests, including representatives of the private sector, government agencies and the not-for-profit sector to discuss research findings and collaborate on strategies for data analysis.

ONRIS

The Ontario Network on the Regional Innovation System meets annually each fall to discuss ongoing research by the members of the subnetwork and to analyze findings of the individual case studies being conducted under the MCRI. Regular participants in our workshops include members of the relevant provincial ministries, now combined into Enterprise, Opportunity and Innovation, local IRAP ITA's and representatives of NRC. In addition, members of the subnetwork have engaged in a wide range of outreach activities with local economic development officials in Toronto, York Region and Waterloo, as well as the Ontario region branches of Industry Canada and Human Resources Development Canada. In addition, members of the subnetwork are conducting research jointly with Ontario's Institute for Competitiveness and Prosperity and have disseminated their research findings through the Institute.

Now in its third year, the OREDI newsletter, with funding support from the provincial Ministry of Enterprise, Opportunity and Innovation, reports on the latest research and reports related to economic development and innovation. Subscription to the OREDI Newsletter has grown to 600 in all levels of government, academia and business. Although most of the international subscribers are US-based, there are enthusiastic supporters in Europe and as far as New Zealand.

> "For anyone interested in cultivating the fullest understanding possible of the wide world of tech-based economic development, I believe one of the best newsletters/websites is *Ontario's Regional Economic Development and Innovation (OREDI) Newsletter*, a free biweekly e-publication of the Ontario Network on the Regional Innovation System (ONRIS) at the Centre for International Studies, University of Toronto."
>
> *State Science & Technology Institute, February 22, 2002*

The editorial content includes recent reports, research papers and upcoming events relevant to policy makers and academics concerned with economic development trends, innovation and science and technology policy. A typical entry refers to work that is freely available on the Internet and accessible to a broader audience. Regularly featured are the latest theoretical developments in economic development, clusters and innovation, university-industry linkages as well as major sector studies, the latest statistics on regions, e-commerce, and venture capital.

With a diverse, international audience, the challenge is to reflect the wider interests of the subscribers while maintaining its relevancy as an Ontario newsletter. This balance is maintained by including regional events and announcements of new programs and the latest research from Ontario academics. Appealing to our international readership is equally important since they give Ontario and its researchers' visibility on a broader policy stage. For example, the recent 2002 Ontario Index of Innovation, having been summarized in the OREDI newsletter, was later featured in the larger US-based newsletter from the State Science & Technology Institute (SSTI).

ACISN

Members of the Atlantic Canada Innovation Systems Network also meet annually on a regional basis to discuss their research findings and disseminate results to regional partners. In addition, a major activity of team members in New Brunswick has been the conduct of a baseline survey of 189 firms in the New Brunswick IT industry under contract with NRC and ACOA.

PROMIS/PRIME

PRIME was contacted in the Fall of 2001 by the Canadian Advanced Technology Alliance (CATA) to design and manage a new research project on Canadian cities. The project, titled the CATA's TechAction Town Halls, is an ambitious attempt to measure the relative strengths of a number of communities with respect to the environment that technology firms face. A total of 10 meetings were conducted from St. John's to Vancouver. The program consisted of both a telephone survey as well as an interactive response system at the one day TechAction Town Hall meetings. The CATA project is very much connected to the ISRN cluster studies of PRIME and both have benefited from this connection.

PRIME has been involved in a number of outreach activities since the inception of the ISRN project that are a direct result of the work being completed. These activities include membership on the Ottawa Task Force on Commercialization a multi-institutional initiative aimed at improving the business environment in Ottawa in order to grow more successful firms. PRIME has also had on-going involvement with the Ottawa Centre for Research on Innovation (OCRI) that has included hosting visiting delegates from Arizona, Washington D.C. and Raleigh-Durham North Carolina. These activities have developed important new linkages presently being utilized for comparative studies as well as economic development locally in Ottawa.

Appendix A: Publications Resulting from the Research

Academic Publications – Recent and Forthcoming

Britton, J.N.H. 2002, "Regional Implications of North American Integration: A Canadian Perspective on High Technology Manufacturing," *Regional Studies* 36, 359-374

Britton, J.N.H. (forthcoming), "Network structure of an industrial cluster: electronics in Toronto," *Environment and Planning A*

Chamberlin, Tyler and John de la Mothe (2003), "Northern Light: Ottawa's Technology Clusters," in David Wolfe, ed., *Clusters Old and New: The Transition to a Knowledge Economy in Canada's Regions,* Montreal and Kingston: McGill-Queen's Press.

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Doutriaux, Jerome (2003). "University-Industry Linkages and the Development of Knowledge Clusters in Canada", Working Paper No. 03-06, School of Management, University of Ottawa

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Dalpé, Robert, 2003. "Interaction between Public Research Organizations and Industry in Biotechnology," *Managerial and Decision Economics,* 24:2-3, pp. 171-85, Mars-Mai.

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Gertler, Meric S. and David A. Wolfe, (forthcoming 2003), "Local Social Knowledge Management: Community Actors, Institutions and Multilevel Governance in Regional Foresight Exercises," *Futures*.

Gertler, Meric S. and David A. Wolfe, (forthcoming 2003), "Ontario's Regional Innovation System: The Evolution of Knowledge-Based Institutional Assets," in *Regional Innovation Systems*, 2nd. Ed., eds Philip Cooke and Martin Heidenreich (London: Taylor and Francis).

Holbrook, J.A.D. and D.A.Wolfe, eds, 2002. *Knowledge, Clusters and Regional Innovation: Economic Development in Canada*, Montreal and Kingston: McGill-Queen's University Press.

Holbrook, J.A.D. and L.P.Hughes, 2002."Innovation, Training and the Management of Highly Skilled Personnel", in *Innovation and Entrepreneurship in Western Canada: From Family Business to Multinationals*, ed. J.J.Chrisman, J.A.D.Holbrook, and J.H.Chua, Calgary: University of Calgary Press.

Holbrook, J.A.D., L.P. Hughes and J.Finch, 2002, "Characteristics of Innovation in a Non-Metropolitan Area: the Okanagan Valley of British Columbia," in *Systems and Policies for the Globalized Learning Economy*, eds by P. Conceicao, D.V.Gibson, M.V.Heitor and C.Stolp, Greenwood Publishing Group, Westport CN, USA.

Holmes, John. "Re-scaling Collective Bargaining: Union Responses to Continental Economic Integration and Outsourcing in the North American Auto Industry" *Geoforum* (accepted subject to revisions August 2002 - peer reviewed journal). 29pp.

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Adam Holbrook, Presentation to Science Council of BC (SCBC) international Committee, Jan 8, 2002

Adam Holbrook, Presentation to CWN policy theme head, G. Daborn, Acadia, Jan 21, 2002

Adam Holbrook, Presentation to CANARIE, Jan 31, 2002

Adam Holbrook, Presentation to House of Commons Committee on S&T, Feb 6, 2002

Adam Holbrook, Presentation to CANARIE/InnoCom at Kananaskis, Feb 18-21, 2002

Adam Holbrook, Presentation to SCBC, Mar 20, 2002

Adam Holbrook, Presentation to Briefing to APEC in NS, May 13, 2002

Adam Holbrook, Presentation to CANARIE meeting, May 22, 2002

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Adam Holbrook, Presentation to Genome BC management, July 31, 2002

Adam Holbrook, Presentation to Observatoire de S-T, Sept 5, 2002

Adam Holbrook, Presentation to Visiting Chinese Academy of Science, Sept 12, 2002

Adam Holbrook, Presentation to IndCan Innovation Strategy Meeting, Sept 19, 2002

Adam Holbrook, Presentation to THECIS, Sept 24, 2002

Adam Holbrook, Presentation to NRC foresight workshop, Oct 1, 2002

Adam Holbrook, Presentation to NRC Fuel Cells Cluster, Oct. 6, 2002

Adam Holbrook, Presentation to Office of Western Diversification, Oct 22, 2002

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Adam Holbrook, Presentation to BC Ministry of Agriculture DG – Innovation, Jan 31, 2003

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Adam Holbrook, Presentation to Canadian Water Network First National Symposium, St. John, NB, Mar 23-26, 2003

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John Holmes, Invited Participant, Federal Government Roundtable Consultation on the Future of the Automobile Industry, Toronto, June 2002

John Holmes, Attended the Annual Convention of the Automotive Parts Manufacturers Association, Hamilton, Ontario, April 2002 to network and develop contacts for the project.

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Landry, R. et R. Gauthier., 2002, Présentation et discussion du rapport de veille stratégique et étalonnage des modes d'organisation et de soutien du cluster de l'optique et de la photonique aux membres du GOPQ (Groupe sur l'optique et la photonique de Québec) Québec, Hôtel Germain les Prés, 26 mars 2002.

Landry, R., 2002, Présentation et discussion du plan de veille sectorielle sur les mesures de soutien à l'innovation de l'Observatoire GATIQ Technorégion aux partenaires de l'Observatoire du GATIQ Technorégion, Château du Lac Beauport, 14 mars, 2002

Landry, R. et Giner, M., 2002, Présentation et discussion du rapport préliminaire de l'évaluation du programme des Initiatives stratégiques de Développement économique Canada aux membres du comité aviseur de l'évaluation, Montréal, 04 mars 2002

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P. Rosson and C. McLarney, "Biotechnology Cluster Research," presented to Nova Scotia Business Inc. (September 2002) and the Government Biotechnology Roundtable (December 2002).

N.V. Schaefer, "How Does a Cluster Work ... Cluster Theory and Model" presented at the New Brunswick E-Business/Information Technology Sector Conference, Saint John, NB, January 7&8, 2002.

N.V. Schaefer, "How Clusters Work and The New Brunswick E-Business/Information Technology Sector", presented at the NRC/IRAP Maritimes Regional Meeting, Saint John, NB, February 13, 2002.

N.V. Schaefer, "Initial Results from NB IT Cluster Study" presented at Simon Fraser, Harbour Center, to Faculty, NRC representatives, graduate students, Dec. 2002.

David Robinson, Participation in the Ontario Mining Cluster Forum sponsored by the Ministry of Northern Development and Mines.

David Robinson, Participation in creation of the Laurentian University Mining cluster Team to develop the university component of the local Supply and services Cluster

David Robinson, Participation with The Sudbury Regional Development corporation in developing a cluster strategy

Peter Warrian, "Is There a Steel Cluster", Presentation to Steel Research Centre Workshop, McMaster University, February 4, 2003

Peter Warrian, “What’s Next in Steel” Public Lecture”, Algoma College and United Steelworkers of America, Sault Ste. Marie, May 7-8, 2003

David Wolfe, “Innovation Systems and Economic Development: Local and Regional Clusters in Canada,” presentation to the Policy Sector Branch, Industry Canada, Ottawa, March 18, 2002.

David Wolfe, “Incubators and their Role in Cluster Creation,” invited presentation to the Conference on Incubating Incubators, Accelerating Acclerators, Canadian Association of Business Incubators, Toronto, May 2, 2002.

David Wolfe, “Clustering of Clusters: The Next Step in Cluster Development,” invited presentation to the Workshop “Shaping Our Future” Canadian Photonics Consortium, Ottawa, May 8, 2002.

David Wolfe, “Implications of the New Economy for Mid-size Cities: Innovation and Clusters,” invited presentation to the symposium on Managing the Transition to the New Economy in Mid-size Cities, Waterloo, June 25, 2002.

David Wolfe, “Implications of the New Economy for Smart Cities: Innovation and Clusters,” invited presentation to the Symposium on Thinking Smart Cities, Institute of Political Economy, Carleton University, Nov. 15, 2002.

David Wolfe, “Innovation Strategy from a Community Innovation Perspective,” Keynote presentation to a Joint Meeting of the Executive Group, Ontario Region, Human Resources Development Canada and Industry Canada, Sunnybrook Estates, Toronto, April 17, 2003.

David Wolfe, “Clusters Old and New: Policy Lessons from the ISRN Study of Cluster Development,” Keynote Presentation to a Joint Industry Canada, National Research Council and Innovation Systems Research Network Workshop on Cluster Development: What are the Policy Implications for the Federal Government? Minto Place Suites, Ottawa, April 30, 2003.

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Appendix B: Agenda of ISRN National Meetings, 2002-2003

Fourth Annual Meeting

Thursday, May 9, 2002

9:00 am Greetings

9:15 - 10:45 **Session I: Innovation Strategies: National or Regional?**

David Wolfe, University of Toronto
"ISRN: A Successful Experiment in Regional Networking"

John de la Mothe, University of Ottawa
"The National Innovation Agenda"

10:45 - 11:00 Coffee Break

11:00 - 12:30 **Session II: Statistical Analysis of Cluster Dynamics**

Nabil Amara & Rejean Landry, Universite Laval
"Cluster Analysis in the 1999 Innovation Survey"

Yael Levitte & Meric Gertler, University of Toronto
"Characteristics of Innovating Firms in Canadian Biotechnology"

12:30 - 1:30 pm **Lunch**

1:30 - 3:00 **Session III: Heavy Metal Clusters**

Peter Warrian, University of Toronto
"The New (Economy) Steel: Learning at the Regional and Firm Levels"

Jorge Niosi, UQAM
"The Montreal Aerospace Cluster"

3:00 - 3:15 Coffee Break

3:15 – 5:00 **Session IV: Graduate Student Panel**

Alison Blay-Palmer, University of Waterloo
"Innovation and Multi-scale Influences: Comparing Agri-biotechnology and Organic Agriculture

Johanne Queenton, Université du Québec à Montréal (UQAM)
"La Croissance des PME Canadiennes de Biotechnologie en Santé Humaine: Évaluation des Réseaux du Système Biotechnologique et Stratégies des Acteurs Prééminents"

C.D. (Cami) Ryan, University of Saskatchewan
"Intellectual Property Structures in the Agricultural Biotechnology Cluster"

Tara Vinodrai, University of Toronto
"Innovation and the City: Talent, Diversity, and Quality of Place"

Jaime Wood, University of Calgary
"Innovation Systems in the Calgary Wireless Cluster: Mapping as an Explanatory Model"

Friday, May 10, 2002

9:00 - 10:30 **Session V: New Economy Clusters: Biotechnology**

Phil Cooke, CASS, University of Wales, Cardiff
"Towards Regional Science Policy? A Rationale from Biosciences"

Lynn Mytelka, UNU INTECH, Maastricht
"Biotechnology Clusters on the Periphery of France"

10:30 - 10:45 Coffee Break

10:45 - 12:15 **Session VI: Canadian Biotechnology Clusters**

Peter Phillips, University of Saskatchewan
"The Saskatoon Biotechnology Cluster"

Robert Dalpe & Jorge Niosi, Universite de Montreal et UQAM
"Biotechnology Clusters in Montreal and Ottawa"

12:15 -1:30 pm **Lunch**

1:30 -3:15 **Session VII: Clusters: Landlocked and Wireless**

Cooper Langford, University of Calgary
"The Development of the Calgary Wireless Cluster"

Tyler Chamberlin and John de la Mothe, University of Ottawa
"The Ottawa Telecom Cluster"

3:15 - 3:30 Coffee Break

3:30 - 5:00 **Session VIII: New Clusters in Old and New Regions**

Charles Davis & Norm Schaefer, University of New Brunswick (St. John and Fredericton)
"The New Brunswick IT/E-commerce Cluster"

Richard Smith, Simon Fraser University
"Visualizing Social Capital - Insights from the New Media Cluster in Vancouver"

Harvey Johnstone & Rod Haddow, University College of Cape Breton and St. Francis Xavier U.
"The Cape Breton IT Cluster"

5:00 pm Adjournment

Fifth Annual Meeting

Thursday, May 1, 2003

9:00 - 9:15 **Greetings**

9:15 -10:30 **Session I: Implications of ISRN Research**

David Wolfe/Meric Gertler, University of Toronto
"Trends in Cluster Theory and Relevance of the ISRN Case Studies"

Réjean Landry, Université Laval
"Policy Lessons of Regional Research and Cluster Studies"

10:30 -10:45 Coffee Break

10:45 -12:30 **Session II: Wireless/Photonics/Telecom**

Tyler Chamberlin/John de la Mothe, University of Ottawa
"The Telecom and Photonics Clusters in Ottawa"

Mélanie Kéroack/Mathieu Ouimet/Réjean Landry, Université Laval
"The Photonics Cluster in Quebec"

Charles Davis, Norbert Schaefer, University of New Brunswick
"The ICT Cluster in New Brunswick"

12:30 -1:30 Lunch

1:30 - 3:00 **Session III: Multimedia Clusters**

John Britton/Gerry Legare, University of Toronto
"The Multimedia Cluster in Toronto"

Diane-Gabrielle Tremblay/Serge Rousseau, Télé-université, Université du Québec à Montréal
"The Multimedia Cluster in Montreal"

Richard Smith, Simon Fraser University
"Multimedia in Vancouver"

3:00 - 3:15 Coffee Break

3:15 - 5:00 **Session IV: Graduate Student Panel**

Dean Hennessey, University of Toronto
"The Emergence of a Cluster? The Biotech Community in London, Ontario"

Caroline Hickton, Simon Fraser University
"The Production of Pleasure: The Wine Cluster in the Okanagan Valley"

Matthew Lucas, University of Toronto
"Creating Incentives for Knowledge Sharing Between Universities and Firms"

Tara Procyshyn/Camille Ryan, University of Saskatchewan
"Hard Measures and Soft Issues: A Potential Model For Incorporating Metrics Into Cluster-based Analysis"

Johanne Queenton, Université du Québec à Montréal
"Bioscientists and Biotechnology: A Canadian Study"

Friday, May 2, 2003

9:00 - 10:45 **Session V: New Economy Clusters: Biotechnology**

Adam Holbrook, Simon Fraser University
"The Biotechnology Cluster in Vancouver"

Phillip Rosson/Carolan McLarney, Dalhousie University
"Biotechnology in Halifax"

Robert Dalpé, Université de Montréal/Jorge Niosi, Université de Québec á Montréal
"Industrial Networks in Canadian Biotech"

10:45 - 11:00 Coffee Break

11:00 - 2:30 **Session VI: Breakout Groups**

Biotechnology	Steel/Auto/Aerospace
IT/Telecom	Photonics/Wireless
Multimedia	Wine/Food/Wood/Mining

2:30 - 2:45 Coffee Break

2:45 - 4:30 **Session VII: Clusters in New and Old Industries**

Hans Schuetze, University of British Columbia
"Wood Products in Western Canada"

John Holmes/Susan Fitzgibbon, Queen's University
"The Ontario Auto Parts Cluster"

Cooper Langford, University of Calgary
"The Wireless/GPS Cluster in Calgary"

4:30 - 5:00 Wrap-Up

5:00 Adjournment

Appendix C: Paper presented at the DRUID Summer Conference 2003

on

Creating, Sharing and Transferring Knowledge.
The role of Geography, Institutions and Organizations.

Copenhagen June 12-14, 2003

Theme C
Co-location: Labour Market Effects and Knowledge Sharing Institutions

Clusters from the Inside and Out: Lessons from the Canadian Study of Cluster Development

David A. Wolfe and Meric S. Gertler

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This paper surveys some of the current methodologies employed to analyze cluster development, as well as some of the key themes emerging from both the analytical and prescriptive literature noted above. It uses this survey as the context in which to present a synthesis of the initial findings of the current national study of industrial clusters in Canada, conducted by the Innovation Systems Research Network. Our national study is comprised of twenty-seven cases, which aim to identify the presence of significant concentrations of firms in the local economy and understand the process by which these regional-industrial concentrations of economic activity are managing the transition to more knowledge-intensive forms of production. The central questions in each case are: (i) what role do local institutions and actors play in fostering this transition, (ii) how important is interaction with non-local actors in this process, (iii) how dependent are local firms on unique local knowledge assets, and what is the relative importance of local versus non-local knowledge flows between economic actors, (iv) how did each local industrial concentration evolve over time to reach its present state, and what key events and decisions shaped its path, and finally, (v) to what extent do these processes, relationships and local capabilities constitute a true cluster, and how would we recognize a cluster if we saw one?

Keywords: Clusters, Knowledge Flows, Cluster Policy, Canada

1.0 Introduction

There has been a virtual explosion of interest in cluster development in recent years across North America, Europe and newly industrialized countries. This interest has been prompted, in part, by fascination with the success of Silicon Valley at reinventing itself through successive waves of new technology; and, in part, by the efforts of other regions to emulate the Silicon Valley model. A growing number of clusters around the globe, from Scotland to Bangalore and from Singapore to Israel, claim direct lineage to the original model in northern California (Miller and Coté 1987; Bresnahan, Gambardella, et al. 2001; Rosenberg 2002). Clusters can consist of both high-tech concentrations of firms, which often centre around research-intensive universities or institutes, as is the case with Silicon Valley as well as those based in more traditional industries (Maskell, Eskelinen, et al. 1998). The perceived success of Silicon Valley, and the claims by other regions to have replicated its formula for success, have generated a cottage industry of policy analysts and consultants – all eager to assist national, regional and local governments in growing their own clusters. The collective claims made by these analysts of the putative benefits of 'clustering' are rapidly outstripping the empirical evidence available with which to assess both the validity of the claims and the basis for using them as a guide for policy development.

The great irony is that the cluster bandwagon has gathered this head of steam just as its primary source of inspiration, Silicon Valley, has experienced one its most severe economic downturns. The latest report on the status of the Valley by Joint Venture Silicon Valley indicates that from the beginning of 2001 to mid-2002, employment declined by nearly 10 per cent or roughly half the jobs gained during the height of the Internet boom from 1998 to 2000. The job losses were most acute among those industry segments perceived to be the driving clusters of the Valley's economy – software, semiconductors and computer and communications hardware. But underlying the cyclical downturn in the regional economy is a more profound shift in the demand for its products, driven by the growing commoditization of key segments of the IT industry and the shift from hardware production to software as the greatest source of value added. The key challenge facing the firms and institutions in Silicon Valley will be how well they weather the current downturn and reposition themselves to take advantage of the sources of growth in the next economic upturn (Joint Venture 2003). The seriousness with which this challenge currently is viewed in Silicon Valley should serve as a warning to its would-be emulators.

Current academic fascination with the concept seems more in tune with the aspirations of the emulators than with the troubles of their role model. A growing body of academic research has applied the cluster concept both as an tool to analyze the factors that contribute to the relative degree of economic success enjoyed by different regions, as well as a framework to guide policy-makers in the design of initiatives to promote economic development. The presence of clusters, or more precisely, the tendency of firms engaged in related fields of economic activity across a range of sectors to concentrate in proximate geographic regions, has prompted the suggestion that some of the key factors affecting the competitive advantage of firms may lie outside the boundaries of the firm itself. However, the two strands of research, the empirical and the prescriptive, tend to work at cross-purposes, with the policy goals sometimes predetermining the analysis, rather than the other way around. A key challenge for those interested in applying the concept of clusters from either perspective is to respond to the concerns articulated by Martin and Sunley that academic analysts are being seduced by the lure of the 'cluster brand' at the

expense of serious analysis of whether the presence or absence of clusters actually contributes to sustained economic development in local and regional economies (2003).

This paper surveys some of the current methodologies employed to analyze cluster development, as well as some of the key themes emerging from both the analytical and prescriptive literature noted above. It uses this survey as the context in which to present a synthesis of the initial findings of the current national study of industrial clusters in Canada, conducted by the Innovation Systems Research Network.[1] Our national study is comprised of twenty-seven cases, which aim to identify the presence of significant concentrations of firms in the local economy and understand the process by which these regional-industrial concentrations of economic activity are managing the transition to more knowledge-intensive forms of production. The central questions in each case are: (i) what role do local institutions and actors play in fostering this transition, (ii) how important is interaction with non-local actors in this process, (iii) how dependent are local firms on unique local knowledge assets, and what is the relative importance of local versus non-local knowledge flows between economic actors, (iv) how did each local industrial concentration evolve over time to reach its present state, and what key events and decisions shaped its path, and finally, (v) to what extent do these processes, relationships and local capabilities constitute a true cluster, and how would we recognize a cluster if we saw one?

2.0 Methodological Approaches to Cluster Studies

The paper begins with a brief review of major approaches emerging in the cluster literature. Broadly speaking the recent studies can be broken down into three different methodological approaches. The first, and most ambitious, deploys a diverse set of empirical tools, of differing sophistication, to measure the degree of clustering found in local and regional economies. A second approach involves the conduct of case studies of individual clusters or several clusters on a comparative basis. These case studies can involve a diverse range of clusters all located within one country or a select group of similar clusters located across different countries. The intent is usually to use a standard research methodology to compare the individual cases or benchmark them against the presumed leader or role model for the clusters, most frequently Silicon Valley. The third broad approach consists of policy analyses of individual clusters or sets of clusters, frequently undertaken for a regional or municipal development authority with the explicit goal of benchmarking the status of the region's clusters and providing broad policy prescriptions on what the region and its clusters must do to improve their competitive status. This last category includes a number of more general guides for policy-makers and local economic development authorities on how to promote cluster development. Obviously these categories are not watertight as some studies combine elements of all three approaches.

2.1 Empirical Approaches to Cluster Analysis

Within the range of empirical approaches used by analysts to study clusters there is evidence of a number of different methodologies. One of the most common techniques employed by analysts to identify the presence of clusters within a specific geographic locale is the use of the location

[1] The Innovation Systems Research Network is a cross-disciplinary, national network of researchers in Canada funded by the Social Sciences and Humanities Research Council of Canada, with additional support from other federal and provincial departments and agencies. In 2001 the ISRN launched a five year study of industrial clusters across Canada. More details on the network, its members, and the current cluster study can be found at the web site: http://www.utoronto.ca/isrn.

quotient which is a ratio of employment shares: the regional industry's share of total regional employment over the national industry's share of total national employment. A quotient of higher than one indicates a higher degree of specialization in the activities that comprise the cluster, which is usually interpreted to mean that it reflects the existing competitive advantage enjoyed by the locality.

A more sophisticated version of this method of analysis is found in the 'growth-share matrix' used by some analysts to provide a maximum amount of information about the relative strength of a local cluster. The growth share matrix diagram indicates the number of employees in a cluster within the region, the average annual job growth rate for the cluster and the location quotient for the cluster in the region. The representation of the growth-share matrix in graphical form provides a powerful visual medium for depicting the relative economic strengths of a regional or local economy. This methodology is used by ICF Consulting which has undertaken cluster analyses of a number of US regions and cities over the past decade and recently extended the analysis to four leading Canadian urban centres. The consultants initially identify the leading clusters in an urban centre based on three criteria: the leading producers of goods for export out of the locality; a clear historically based competitive advantage in the industry; and status as a major employer within the region (ICF Consulting 2000b, 32–33). The use of the growth share matrix provides an easy way to benchmark local and regional economies against other localities where the analysis has previously been done and is useful for highlighting the relative strengths and competitive challenges facing a region (Information Design Associates 1997, 41–45). A critique of this methodology is its reliance on the use of location quotients as a critical part of the analysis; location quotients are largely an industry-based technique derived from traditional statistical categories and consequently, offer little insight into the interdependencies between sectors. Ultimately, they are only useful if employed in association with other methods that provide some degree of information on industrial interdependence (Bergman and Feser 1999, ch. 3).

A more sophisticated version of this technique is represented in the ambitious undertaking by Michael Porter through the Institute for Strategy and Competitiveness at the Harvard Business School. The Institute's Cluster Mapping Project uses statistical techniques to profile the performance over time of regional economies in the United States with a special focus on clusters. Economic profiles of the 50 US states and the District of Columbia were prepared for the National Governors Association Initiative "State Leadership in the Global Economy" using this approach. The detailed profiles of each state provide analyses of major concentrations of employment across the state by both traded and untraded clusters. The Cluster Mapping Project uses information drawn from the County Business Patterns data on employment, establishments and wages by four digit SIC codes, plus patent data on location of inventor, to identify the core clusters in a region using the correlation of industry employment across geographic areas. The dominant clusters in a region are identified using a locational analysis to identify those that are relatively more concentrated based on the region's total employment. Applying this methodology the Cluster Mapping Project has identified 41 types of clusters in US economy, differentiated between traded, resource-driven and local oriented clusters (Porter, Monitor Group, et al. 2001, 18–28).

The analysis developed in the US Cluster Mapping Project has recently been adopted and applied in work undertaken by the Institute for Competitiveness and Prosperity in Ontario, under the direction of Roger Martin. Using Porter's methodology, the Institute mapped the 41 clusters identified for the US economy onto Ontario's. The results indicated that Ontario has a higher share of employment in the traded clusters as opposed to the local ones than was the case for the US economy. Overall, some of the clusters which ranked highest in significance for the Ontario economy were similar to those in the US, such as business services, financial services, education and knowledge creation and hospitality and tourism. However, the automotive cluster, which plays a major role in Ontario's economy, ranked considerably higher than it did for the US economy as a whole. The Institute's analysis also allowed them to identify the leading clusters by the major Census Metropolitan Areas across the province (Institute for Competitiveness and Prosperity 2002).

A final methodological approach is the more rigorous analytical techniques espoused by Bergman and Feser. They maintain that measurement issues play a critical role in identifying the presence of clusters or the potential for cluster development. They suggest that there are six basic analytical techniques that can be employed to identify cluster strengths in a specific region or locale: expert opinion, location quotients, trade-based input-output analysis, innovation-based input-output analysis, network analysis and surveys. Given that the only consistent and detailed sources of data on cross-industry linkages are input-output tables, Bergman and Feser argue that the use of factor analysis of input-output tables to construct value-chain templates of the trading patterns within regional economies is the most effective means to identify clusters. A related technique that they suggest is of great value is the analysis of innovation interaction matrices, derived from surveys such as Statistics Canada's Innovation Survey or the Community Innovation Survey of Eurostat to describe flows of innovations between innovation producers and innovation users. The key benefit of such matrices is their focus on the extent of innovation interdependency and the actual degree of interaction between industry groups in the innovation process (Bergman and Feser 1999; DeBresson 1996). While these techniques offer cluster analysts potential tools of some sophistication, their applicability suffers from the limited availability of data in some instances and the costliness of undertaking the data analysis where it is available.

However, despite the apparent sophistication of these techniques, they are not without their critics. First, the empirical approaches to cluster identification tend to overlook the nature of cluster life cycles. Clusters frequently go through specific stages of development and the identification of the stage of development for an individual cluster is very important to an analysis of the cluster dynamics. Empirical methodologies that focus on exclusively on a statistical snapshot of the cluster at a specific point tend to ignore an analysis of its trajectory of development (Breschi and Malerba 2001). Empirical analyses that incorporate the rate of growth of employment in the cluster can partially compensate for this shortcoming, but failure to account for this factor means that two clusters on a radically different development path may appear to be quite similar in a statistical snapshot at one point. More generally, their value is limited by the fact that the use of input-output tables only measures traded (or market-based transactions) and overlooks the critical contribution made by soft factors, such as trust and social capital, as well as the organizational dynamics of the cluster. Thus, they only hint at the role played by non-market based factors, or untraded interdependencies (Storper 1997).

Critics also point to the fact that the notion of a cluster has become somewhat elastic in usage and that there is no consensus on a definition. Even in cases where a clear definition of a cluster exists, the statistical grounding for the concept is weak. This is because all existing statistical measures of clusters are based on either SIC or NAICS codes, which are by definition sectoral in character. This raises the issue of whether these statistical approaches are therefore in fact measuring sectoral dynamics as opposed to cluster dynamics. If in fact they are measuring sectoral dynamics, the question becomes whether using the concept of sectors would not be a more efficient analytical strategy. The use of input-output tables to construct value chain templates of trade relationships does attempt to overcome this limitation, as does Porter's analysis of correlations between employment growth in individual local sectors. Finally, skeptics also point to the fact that the spatial boundaries of clusters are not clearly specified, a major shortcoming for what is, after all, an essentially geographic concept. In part, this reflects the statistical issue again. Clusters can, at times, go beyond political boundaries, yet the statistics used to describe clusters are collected according to such political boundaries. Furthermore, these broad empirical categories require considerably more investigation and analysis to explain how the statistical aggregation of firms in related industries within a specific geographic area contributes to their improved competitiveness and economic performance and the benefit of the local or regional economy more broadly.

2.2 Case Studies

Many analysts dismiss the criticism that clusters must be identified with more statistical precision and consistency before they can be adequately studied. They downplay the importance of this criticism, noting that clusters can be studied by using expert opinion, self-identification or other qualitative research techniques, including detailed interviews with a broad cross-section of cluster participants or ethnographic accounts of the cluster's dynamics by leading members. The application of these techniques can provide a rich insight into how clusters operate. Most frequently this technique has been used to undertake a detailed study of an individual cluster, such as Silicon Valley, but recently it has been complemented by a series of cross-cluster and cross-national studies.

The most common approach in this category is the intensive case study of an individual cluster – the most studied subject being Silicon Valley. The original model was Saxenian's case study of Silicon Valley undertaken in the early 1990s and the comparison she provided with Route 128 in Massachusetts. Saxenian drew upon the growing body of literature on the dynamics of regional network-based industrial systems to highlight the similarities and the differences between the two regions. Firms in network systems compete in global markets and collaborate with distant customers and suppliers, but their most strategic relationships are often local because of the critical importance of face-to-face communication for rapid product development (1994, 5; 1990). The variable that determines the relative performance of firms in different regionally-based networks is the nature of its industrial system, which includes three important dimensions – the indigenous mix of institutions and culture in the region; the structure of the industrial system; and the internal organization or industrial culture that prevails in firms in the region. The range of relevant institutions can include both public and private ones, such as universities, business and professional associations, local training or industrial institutes and other associations that may contribute to a dynamic local culture in the region. The industrial structure of the region refers to the inter-firm organization of its production system, especially the extent

and nature of the relations between suppliers and customers within the individual sectors or networks of interrelated sectors, and the role played by the larger firms within the regional economy. Finally the internal organization or industrial culture of the firm includes the extent to which the production system is organized on traditional hierarchical lines or is more decentralized, the degree to which relations between management and the workforce are characterized by a cooperative or conflictual approach and the relative importance attached to training and the continuous upgrading of skills (Saxenian 1994, 7).

The distinguishing aspect in the economic performance of the two regions in the downturn of the 1980s was the change in the character of their respective industrial systems. The new firms in Silicon Valley responded to the crisis by building their production networks from the bottom up. They concentrated their efforts on their core competencies, particularly the design and assembly of the final system, and purchased the remainder of their inputs from specialized suppliers. In the process, they created a supply network that spread the costs of development over a range of firms and reduced product development times. The new form of partnerships that emerged as a result broke with the tradition of adversarial supplier relations that predominated in the mass production companies. "They came to view their relations with suppliers as long-term partnerships rather than short-term procurement arrangements. They saw collaboration as a way to speed the pace of introduction of new products and to improve product quality and performance" (Saxenian 1994, 146). The outcome of this shift in the structure and operation of inter-firm relationships was the development of an industrial system that was more than a mere agglomeration of locally based firms. Key executives of the leading firms came to recognize the complex balance between between competition and cooperation as a strategic asset that benefited all firms in the Valley.[2]

Saxenian's study of Silicon Valley and the insights it affords have been complemented recently by two more detailed volumes edited by Martin Kenney and Chong-Moon Lee et al. Both volumes provide a series of studies that enrich our understanding of the historical trajectory of development for the Silicon Valley cluster, its institutional underpinnings and its operating dynamics. The papers in these volumes trace some of the critical junctures in the history of the Valley and especially, the central role played by key anchor firms in stimulating the growth of related firms, whether it be Federal Telegraph Corporation, Hewlett-Packard or Fairchild Semiconductor, at different stages in the Valley's evolution. The central role played by different spatial scales is discussed, in particular key support mechanisms provided by the federal government including defence procurement and critical funding for pre-commercial research. The nature of entrepreneurship, inter-firm relationships and the role of knowledge flows in the Valley are also covered. They discuss the central role of Stanford University, as well as the contributions that specialized firms make in supporting new startups – including legal and accounting firms, executive search firms and consultants – and the evolution of the Silicon Valley venture capital community from its earliest forms, relying on personal and family funds to its current limited-partnership format. Several essays offer competing explanations of the underlying dynamics that have sustained the growth of the Valley's firms through successive waves of technological revolutions. The explanations converge around the point that its

[2] Saxenian's work has not been without its critics as well. For a sample of the debate that has ensued, cf (Florida and Kenney 1990; Saxenian 1990; Kenney and von Burg 1999; Saxenian 1999).

dynamism can be attributed to the nature of its 'ecosystem' which involves the recurring creation of a multitude of diverse, specialized firms and support organizations that constantly interact with each another to accelerate the innovation process (Kenney 2000; Lee, Miller, et al. 2000).

Although the consensus in the case studies on the underlying strengths is quite strong, Route 128 has suffered for the past decade from the rather negative depiction of Route 128 presented in Saxenian's original study and repeated with increasing frequency in virtually every reference to that work. This depiction of the Massachussetts cluster has been challenged by Michael Best who argues that the region was successfully able to learn from its negative experience in the 1980s and undewent a significant transformation in the 1990s. He sees the shift to the open-system network form of business organization as critical to the resurgence of the Route 128 cluster in the 1990s. Open-system networking is the counterpart found at the inter-firm level to the increasing degree of specialization witnessed in many highly innovative and entrepreneurial firms. It facilitates the process of new product development and innovation. Rapid product development entails a sophisticated process of coordinating activities among a group of specialized companies operating at different points along the value chain. Open-system networking reduces both the costs and uncertainty associated with new product development for individual firms by sharing the risks and the benefits along the network of firms in the value chain. Best argues that historically, this model of industrial organization was more prevalent in the design-led industrial districts, such as the Third Italy (Best 1990). However, the development of new systems integration capabilities in technology-based industries facilitated their adoption of the open-systems networking model as well (Best 2001).

Saxenian and a number of colleagues recently completed a broad comparative case study of a number of emerging regions attempting to emulate Silicon Valley. The regions covered in this study include Ireland, India, Cambridge in the UK, Israel, Scandinavia, Taiwan and Northern Virginia within the US. The study included both nascent ICT clusters as well as more established ones. The development and trajectories of the clusters were compared in terms of agglomeration economies and external effects, the process of seeding the cluster, the contribution of a thick labour market of highly skilled labour, the critical contribution of managerial talent, the process of new firm formation within the cluster, links from the cluster to external markets, and the key policy issues that emerged from the comparative study. The authors conclude that the key factor driving the growth of the clusters studied is the low opportunity cost of gaining access to ready supply of skilled human capital that attracts managerial talent and entrepreneurs into the cluster. Public policy can support this tendency in a number of ways, but they are highly critical of attempts to jump start clusters or make top down or directive efforts to promote them (Bresnahan, et al. 2001).

Other case studies include the five detailed studies undertaken by Michael Porter for the US Council on Competitiveness. The Council's Clusters of Competitiveness Initiative examined five regions in the US: Atlanta, Pittsburgh, the Research Triangle, San Diego and Wichita, which were selected to provide a diverse sample based on the criteria of size, geography, economic maturity and relative degree of economic success. The case studies used a variety of research methodologies to obtain data on the five regions, including data from the Cluster Mapping Project described above, a set of regional surveys designed and conducted specifically for the Initiative, and in-depth interviews with business and government leaders in each region. The

study identified a set of factors that contribute to the evolution of regional economies. Successful regions leverage their unique mix of assets to build specialized clusters. They do not try to pick winners, but build on their existing assets to create unique economic strengths that offer competitive advantages to firms based in the region. Building strong regional economies is not an overnight phenomeon; it takes decades and involves developing existing assets and creating new ones; linking firms to the regional asset base; and attracting inward investment to the cluster. Finally, they concluded that collaborative institutions play a critical role in building regional economies by facilitating the flow of information, ideas and resources among firms and supporting institutions (Porter, et al. 2001, x-xiii).

Another recent study, comparable to that of the Council on Competitiveness is the analysis of biotechnology centres across the US undertaken for the Brookings Institution (Cortwright and Mayer 2002). The study examined the location and intensity of biotechnology activity in the 51 US Metropolitan Statistical Areas with populations of one million or more. It systematically assessed a range of measures of both biomedical research and biotechnology commercialization in those metropolitan areas to identify the ones with the most significant concentration of biotechnology activity. It concludes that the biotechnology industry is concentrated in just nine metropolitan clusters which together account for three fourths of the US' largest biotechnology firms. Two of the metropolitan areas, Boston and San Francisco, have been research leaders in the biotechnology industry since its founding in the 1970s, while two others, Philadelphia and New York, have developed substantial concentrations of biotechnology activity based on their role as the headquarters for the country's largest pharmaceutical manufacturers. In the past two decades three other centres have been able to leverage their strong base as well-funded medical research establishments to emerge as significant centres of the biotech industry – San Diego, Seattle and Raleigh-Durham – while two remaining areas also exhibit a significant number of biotech firms – Washington/Baltimore and Los Angeles. The leading biotech regions have acquired their status due to the presence of two key factors: a strong and established research base in the relevant fields and the availability of continuing private sector investment to sustain the lengthy and costly process of product development (2002, 3). These findings are consistent with the importance attached to the emerging European and US research-based megacentres and their contribution to the emergence of dynamic biotechnology clusters in Philip Cooke's recent contribution to the subject (2003).

The case study metholodogy provides an important source of information into the nature and dynamics of regional industry clusters. The strength of this approach is the understanding it affords into the elements that contribute to the success of regional clusters. The most successful case studies transcend the limitations of the purely statistical approach to provide insights into the underlying social and institutional dynamics that create the extra-firm dimensions of the cluster's strength. The limitation of these studies, however, is their lack of comparability. While the best of them illuminate the relative strengths of a particular cluster, the lack of comparability limits our appreciation of why certain clusters succeed to a greater extent than others. The comparative study by Bresnahan et al., as well as Michael Porter's work for the Council on Competitiveness, which introduced a degree of comparability into the case studies, takes an important step in overcoming this limitation. It provides a useful model for other studies in the design of their own research methodologies.

2.3 Policy Studies and Analysis

The third methodology to consider is the large number of 'how-to-manuals' that outline the key steps involved in promoting the formation of clusters. Such studies encompass both the development of high-tech clusters and the promotion of cluster development in less favored regions. Both the number of consultants providing these services to regions and municipalities and the demand for their services has exploded in recent years. The highly publicized stories of successful cluster initiatives has spurred demand for these consulting services. In the 1990s a number of consulting firms, many of whom trace their roots back to SRI International in California, emerged in the US with a focused specialization on creating regional and local economic development strategies based on cluster analysis.

One such initiative that attracted a great deal of attention in the early 1990s was the effort by the state of Arizona to analyze its economic strengths and develop cluster strategies. In the early 1990s Arizona faced the same challenges of globalization, economic restructuring and technological change as many other regions in North America. In response, it launched a public-private partnership to analyze the current economic prospects for the state and develop an economic strategy for moving it into the 21st century. The partnership retained SRI International and the Morrison Institute for Public Policy at Arizona State University to provide consulting services for the initiative. The overview document provided a strategic framework for the underlying cluster concepts used to develop the Arizona Strategic Plan for Economic Development (ASPED). The document, in turn, laid the basis for a strategy formation process drawing in over 1000 participants across the state that included representatives from the five sponsoring business organizations, nine industry cluster advisory groups, six foundation working groups focused on broad cross-cutting issues, and a variety regional town halls and public forums. The development strategy employed the cluster concept in three distinct, but interrelated ways: as an ***analytical*** tool to understand the current strengths and prospects for the state economy, as an ***organizational*** tool to recruit industry leaders to participate in the development of the regional strategy and promote increased communication within and across clusters; and as a ***service delivery*** tool to provide a window for improved provision of specialized services to industries in the state. In the words of one consultant who participated in the initiative, "a best practice to emerge from Arizona's experience with cluster analysis is the use of cluster working groups to help policy makers better understand an industry, the challenges it faces, and the most valuable assistance government can provide" (Waits 2000, 39).

Another consulting firm that has developed a similar approach is ICF Consulting, elaborated in a report sponsored by the Economic Development Administration of the US Dept of Commerce (Information Design Associates 1997). The ICF approach provides its clients with a comparative assessment of their current regional performance, an in-depth analysis of both their industry clusters and their accompanying input foundations. The ICF approach identifies key clusters in a metropolitan or regional economy, including the export performance of the clusters and the historically high share of employment in the cluster. Once the principal clusters are identified, ICF evaluates their overall performance using a mix of qualitative measures and the concept of the growth share matrix discussed above. It combines this analysis with a collaborative process that identifies and develops distinct actions that will form, expand, and attract enterprise within each cluster – both existing and emerging. Their approach generates a continuum of actions that can be adopted by the regional or local government and the creation of a consensus among the

strategic partners involved in the planning process around a set of concrete actions that the local government can promote – including new technology commercialization institutes, 'deal generator' initiatives to produce new ventures, skills 'pipeline' partnerships to meet labour demand, collaborative marketing mechanisms, or new technology parks that enable the convergence of public and private economic interests and capabilities. ICF also provides its clients with an analysis of how their clusters compare with comparable clusters in leading North American centres. ICF's work is of particular interest to us as it has recently completed major studies in four Canadian cities: Toronto (2000b)[3] and Ottawa[4] (2000a) in Ontario and Edmonton[5] and Calgary in Alberta.

A final approach that has garnered a great deal of attention in both the US and Europe is that developed by Regional Technology Strategies in North Carolina. In recent reports undertaken for the National Governors Association in the US and one for the European Union, Stuart Rosenfeld of RTS uses the cluster approach to develop regional or state-wide economic development strategies (National Governors Association 2002; Rosenfeld 2002). The Guide written for the National Governors Association suggests that states can better understand the nature of their economies through an analysis of their clusters. Cluster analysis can help state governments be more strategic, systematic and effective in their expenditure of limited public resources. Building on the insights of the Arizona experience it suggests that cluster analysis assists governments to better understand the fundamental dynamics of their economies, to identify market weaknesses and find points for effective intervention. It can foster the kind of networking and interactive learning processes that contribute to the competitive strength of state industries. The development of effective cluster strategies includes a number of essential elements: actions for identifying the key clusters, mapping the systematic relationships within them and benchmarking their performance against competitors; working with cluster associations to respond to industry needs and improve inter-firm collaboration; reorganizing the delivery of information and services to strengthen and promote the relationships identified by cluster analysis by disseminating information about available government services through the clusters, establishing one stop points of entry for cluster members, and creating cluster teams to focus on solutions that cut across departmental and agency boundaries; and finally use clusters as the focus for upgrading labour skills and qualifications to create the thick labour markets that strengthen the competitive base of firms in the cluster and attract new ones to it (Rosenfeld 2002).

3.0 Key Themes in the Cluster Literature

This brief survey of some of the current approaches to cluster analysis and policy prescription provides a glimpse of the sheer volume of information generated on the subject in recent years. Despite the differences in conceptual approaches and methodological tools analyzed above, it is possible to identify a number of common themes emerging in the literature. These are refined to three broad categories. The first is the issue of path dependence: how do clusters get started? and can they be seeded, particularly through the action of public sector agencies? This issue is obviously uppermost in the minds of most cluster analysts, whether they be relatively detached academics or engaged consultants and policy analysts. The current fascination with clusters

[3] http://www.toronto.ca/business_publications/tocompetes.htm
[4] http://www.ottawa2020.com/_en/growthmanagement/es/top-econgen.shtml
[5] http://www.ede.org/EDECorporate/clusters/clusters/background.asp?lni=1&lnsi=1

arises from their perceived link to economic performance and competitiveness. Despite the broad empirical base of case studies now available, there remains considerable uncertainty over just how clusters are started and to what extent their emergence can be the product of conscious design or policy actions. In the case of the most celebrated cluster, Silicon Valley, there is not even a clear consensus on when it dates from. The common launch event for many is the decision by William Shockley to move to California and establish his semiconductor company in 1956 and the subsequent decision by seven of his key employees to leave to establish Fairchild Semiconductor, which became the source of origin for most of the major semiconductor firms in the Valley or at the earliest, the decision by David Packard and William Hewlett to found their company in a garage in Palo Alto in 1939, yet Timothy Sturgeon argues that the real roots of the cluster should be dated as far back as the formation of the Federal Telegraph Company in 1909 with the ensuing spinoffs laying the basis for the Valley's early electronics industry (Kenney 2000, 3–4). Without agreement on such a basic fact in the famous cluster's history, it is little wonder that the broader issue of how clusters are rooted remains controversial.

The second key theme is the nature of knowledge and learning in clusters. Within economic geography, clusters have generally been treated in one of two ways. The first approach, going back to the work of Alfred Marshall, views clusters as products of traditional agglomeration economies. The second view places more emphasis the role of knowledge and learning processes in creating clusters, often on the basis of tacit knowledge flows. This second approach emphasizes that knowledge flows in clusters are not necessarily restricted to the local level – there can be international sharing of knowledge within and between clusters. This draws attention to the need to understand where local clusters stand within an international hierarchy in those cases where the local knowledge base provides one element in a more complex knowledge chain.

The final theme concerns the levels of analysis. What is the nature of the relationship between the concept of a cluster and other analytical units, such as national or regional innovation systems? As was noted above, the question of cluster boundaries remains highly problematic at the empirical level. Yet if we accept that clusters should be defined primarily in local terms, then the issue of how they fit into broader conceptual or institutional frameworks must be addressed. In the eyes of some, clusters can be defined in relatively self-contained terms, with little attention paid to the role that higher levels of spatial analysis contribute to the success of local clusters. Given the parallel interest in the concept of innovation systems – at the national, regional, and sectoral levels – it is not surprising that some analysts have attempted to specify the nature of the linkages and the relative contributions made by the different spatial levels to economic competitiveness. The essential issue is to understand how clusters are inserted within these larger units of analysis and how their operation both supports and constrains the trajectories for growth and development within the cluster.

3.1 Path Dependency and the Creation of Clusters

According to Porter, clusters are seeded by a variety of methods; however, their growth can only be facilitated by building upon existing resources. They cannot be built just anywhere from scratch. The key assets that determine the viability of a cluster are firm-based. Of particular importance is the emergence of an anchor firm for the cluster. Whole clusters can develop out of the formation of one or two critical firms that feed the growth of numerous smaller ones.

Examples of the role played by this kind of anchor firm can be found in the case of Medtronic in Minneapolis, MCI and AOL in Washington, DC, or NovAtel in the case of the Calgary wireless cluster. In other instances, the presence of major anchor firms in a local cluster can act as a magnet, attracting both allies and rivals to locate in the region to monitor the activities of the dominant firm. This is the case with San Diego, where Nokia, Ericsson and Motorola all located their CDMA wireless research efforts to benefit from Qualcomm's leadership in the field or in Ottawa, where Cisco and Alcatel both acquired local firms to benefit from the optical and telecommunications expertise in the region (Porter, et al. 2001; Langford, Wood et al. 2003; Chamberlin and de la Mothe 2003). Other analysts place greater emphasis on the role that highly skilled labour, or a unique mix of skill assets, play in seeding the growth of a cluster. Either way, the process also requires a long time to take root.

This does not mean that the public sector has no role to play in seeding cluster development. The public sector encompasses federal, state or provincial, and local governments; as well as public research institutes like Canada's National Research Council and institutions of higher education. The impact of public sector interventions on cluster development can be positive, negative or inadvertent in character. Those public interventions which seem to have the most effect in seeding the growth of a cluster are ones that contribute to the expansion of the asset base of skilled knowledge workers. A series of examples serve to illustrate this point. Among the cases currently being examined in the ISRN national cluster study, the case, which demonstrates this effect most directly, is the contemporary information technology cluster in Waterloo, Ontario. All accounts of the origins of this cluster link its roots to the farsighted vision of a key group of business leaders to create a new university in the region in the late 1950s in a period when the provincial government (with financial support from the federal government) was expanding the post-secondary education system. Even more influential were the subsequent decisions to focus the core strengths of the university in the sciences, math and engineering and to establish what has become one of the most successful co-op education programs in North America. The founders of many of the firms that populate this cluster are graduates of the university and many started their companies with core technologies developed while they were at the university. An illustration of the inadvertent role that public policy can sometimes play is provided in the case of the telecommunications cluster in Ottawa which has its origins partly in the judicial decision in the US to force the Western Electric Company to divest itself of its subsidiary, the Northern Electrical Manufacturing Company (now Nortel) in the late 1950s. Cut off from its sources of innovation and research, Northern Electric searched for a location to establish its own facility. It eventually bought a substantial tract of land on the outskirts of Ottawa to be the home of Bell Northern Research, largely because it viewed the presence of the National Research Council laboratories and the Communications Research Centre in the nation's capital as a substantial draw for the highly skilled research scientists and engineers it expected to populate its research facility. Many of the leading entrepreneurs in the Ottawa telecommunications and photonics cluster began their careers as researchers for BNR (Chamberlin and de la Mothe 2003).

The central role that the federal laboratories played in seeding the Ottawa cluster is paralleled to some extent in Maryann Feldman's account of the emergence of the current telecommunications clusters in the Washington-Baltimore corridor. Feldman's analysis emphasizes the importance of entrepreneurship in seeding the development of that cluster. She traces the roots of the entrepreneurial drive to the massive wave of downsizing and outsourcing that occurred in the US

federal government in the late 1970s and 1980s. As a result of this trend, employment conditions in the federal public service became less secure and future prospects deteriorated. In the same period, public sector pay scales lagged behind those for executives in the private sector. An increased emphasis on outsourcing goods and services for the federal government provided a further inducement for prospective entrepreneurs to leave the government and start firms to supply goods and services back to their employer. Other policy initiatives launched in the early 1980s facilitated the licensing and transfer of technology from federal laboratories and provided further support for innovation in small businesses. "Enterprising scientists licensed technology out of their own university or government research labs to start new companies and chose to locate the new companies near their existing homes" (Feldman 2001, 878). Although cluster creation was clearly not a driving concern in the policy decisions that she cites, the inadvertent role played by public policy in the formation of the cluster cannot be overlooked. The lesson here is that the path dependencies for cluster creation are highly variable, but that public sector involvement can affect cluster trajectories in a variety of ways, though the impacts are often unpredictable, and even, in some instances, unintended. Whether intended or inadvertent, one of the most effective public policies for seeding cluster development is a sound investment in building the research and skilled labour base in a region.

3.2 Knowledge and Learning in Clusters

Much of the literature on the economic benefits of clusters stresses the fact that the key advantages are derived from the agglomeration economies afforded by the cluster. These agglomeration economies arise primarily from the ready access afforded to firms by co-locating with key suppliers. Porter stresses that the location of a firm within a cluster contributes to enhanced productivity by providing it with superior or lower cost access to specialized inputs, including components, machinery, business services and personnel, as opposed to the alternative, which may involve vertical integration or obtaining the needed inputs from more remote locations. Sourcing the required inputs from within the cluster reduces the need to maintain costly inventory and the consequent delays that can arise with shipments from distant locations. It also facilitates communication with the key suppliers in the sense that repeated interactions with the supply firms in the value chain creates the kind of trust conditions and the potential for conducting repeated transactions on the basis of tacit, as well as more codified, forms of knowledge. Clusters offer distinct advantages to firms in terms of the availability of specialized and experienced personnel. The cluster itself can act as a magnet drawing skilled labour to it or conversely the location of specialized training and educational institutions in the region provides a steady supply of highly qualified labour to the firms in the cluster (Porter 1998).

While not diminishing the importance of these agglomeration economies, a more recent stream of analysis suggests that the underlying dimension, which confers competitive advantages on the firms located in the cluster, is ready access to a common knowledge base. The central argument in this literature is that the joint production and transmission of new knowledge occurs most effectively among economic actors located close to each other. Proximity to critical sources of knowledge, whether they are found in public or private research institutions or grounded in the core competencies of lead or anchor firms, facilitates the process of acquiring new technical knowledge, especially when the relevant knowledge is located at the research frontier, as in the field of biotechnology research, or involves a largely tacit dimension. Knowledge of this nature is transmitted most effectively through interpersonal contacts and interfirm mobility of skilled

workers. From this perspective, “a key feature of successful high-technology clusters is related to the high level of embeddedness of local firms in a very thick network of knowledge sharing, which is supported by close social interactions and by institutions building trust and encouraging informal relations among actors” (Breschi and Malerba 2001, 819).

Building on this stream of the literature, Peter Maskell has proposed a knowledge-based theory of the cluster, but extends this approach to both high-technology and conventional clusters. He suggests the primary reason for the emergence of clusters is the enhanced knowledge creation that occurs along two complementary dimensions: the cluster affords firms benefits along a horizontal dimension through the reduced costs of coordinating dispersed sources of knowledge and overcoming the problems of asymmetrical access to information for different firms; as well as facilitating the actual flow of knowledge between firms along the vertical dimension. The horizontal dimension of the cluster consists of those firms that produce similar goods and compete with one another. The advantages of proximity arise from continuous monitoring and comparing what rival firms are doing, which acts as a spur to innovation as firms race to keep up with or get ahead of their rivals. The vertical dimension of the cluster consists of those firms that are complementary and interlinked through a network of supplier, service and customer relations. Once a specialized cluster develops, firms within it increase demand for specialized services and supplies Further, once the cluster has emerged, it acts as a magnet drawing in additional firms whose activities require access to the existing knowledge base or complement it in some significant respect (Maskell 2001, 937).

A knowledge-based theory of the cluster necessitates an awareness of the fact that knowledge flows present in a cluster frequently involve a combination of both local and global sources. Bathalt, Malmberg and Maskell maintain that successful clusters are effective at building and managing a variety of channels for accessing relevant knowledge from around the globe. However, the skills required when dealing with the local environment are substantially different than the ones needed to generate the inflow and make the best use of codified knowledge produced elsewhere and these differences must be managed by the cluster. They maintain that an accurate model of the knowledge-based cluster must account for both dimensions of these knowledge flows (Bathalt, Malmberg and Maskell 2002). They refer to these two kinds of knowledge flows as *local buzz* and *global pipelines* respectively. According to Storper and Venables buzz arises from the fact of physical co-presence. It incorporates both the broad general conditions that exist when it is possible to glean knowledge from intentional face-to-face contacts, as well as the more diffuse forms of knowledge acquisition that arise from chance or accidental meetings and the mere fact of being in the same location. Buzz is the force that facilitates the circulation of information in a local economy or community and it is also the mechanism that supports the functioning of networks in the community (Storper and Venables 2002, 32). In this context, it is almost impossible to avoid acquiring information about other firms in the cluster and their activities through the myriad number of contact points that exist. Pipelines, on the other hand, refer to channels of communication used in distant interaction, between clusters and external sources of knowledge. Important knowledge flows are generated through network pipelines. The effectiveness of these pipelines depends on the quality of trust that exists between the firms in the different nodes involved. The advantages of global pipelines derive from the integration of firms located in multiple selection environments, each of which is open to different technical potentialities. Access by firms to these global pipelines can feed local

interpretations and the usage of knowledge that developed elsewhere into a cluster. Firms need to access to both local buzz and the knowledge acquired through international pipelines. The ability of firms to access such global pipelines and to identify both the location of external knowledge and its potential value depends very much on the internal organization of the firm, in other words, its 'absorptive capacity'. The same can be said of local and regional clusters (Bathalt, Malmberg and Maskell 2002).

3.3 *Placing clusters in a broader context*

The final theme to explore concerns the location of clusters within a broader social, economic and spatial context. A number of studies have recently focused on the relationship between the concept of the cluster and others used to analyze the innovative capacity of regional and national economies, principally the innovation systems approach. Bunnell and Coe argue for a shift in focus away from forms of analysis that privilege one particular spatial scale as the basis for analyzing and understanding the nature of innovation towards those which emphasize the relationships that exist between and across the different spatial scales. They adopt the concept of 'nested scales' from Swyngedouw, but suggest that this should not be conceived in a hierarchical or deterministic sense, but rather as involving effects that can move in multiple directions across the scales (2001, 570).

Thus clusters can be seen as nested within, and impacted upon, other spatial units of analysis, including regional and national innovation systems, and the kind of global pipelines discussed above, each of which adds an important dimension to the process of knowledge creation and diffusion that occurs within the cluster. Various elements of each of these spatial levels of analysis may have significance for the innovation process. For instance the national innovation system, as analyzed by Nelson (Nelson 1993) or Lundvall (Lundvall 1992) may play a preponderant role in establishing the broad framework for research and innovation policies, in establishing the rules of corporate governance that influence firm behaviour, in setting the rules of operation for the financial systems that determine the availability of different sources of financing for new and established firms, and finally in some settings, for setting the broad framework for the industrial relations, employment and training systems that influence job paths, interfirm mobility and skill levels for the labour force. Levels of regional specialization as encompassed in the concept of regional innovation systems developed by Phil Cooke and others play an important role in affecting cluster performance through the provision of the regional/state/provincial research infrastructure, specialized training systems, the broad education system, policies for physical infrastructure and the investment attraction dimensions (Cooke, Uranga, et al. 1997; Cooke 1998). At the local level, levels of civic associationalism particularly the business-higher education link influence cluster development. The local level can also play an important role in the provision of infrastructure such as roads and communication links, as well as in the governance of the primary and secondary education system.

We can see how these differing levels impact the performance of clusters clearly in the case of Silicon Valley. The cluster exists within the distinctive features of the US system of innovation – with its unique system of laws, regulations and conventions governing the operation of capital markets, forms of corporate governance, research and development and other relevant factors. A number of these features are absolutely central to the story of Silicon Valley's growth and

development. Among these are the highly decentralized nature of the post-secondary education system with complementary and interlocking roles for both the federal and state governments. Changes introduced in the 1970s and 1980s in capital gains rates and the tax treatment of stock options, as well as the rules governing investments in venture capital by pensions funds, stimulated the growth of the venture capital industry, a critical factor for the development of the ICT cluster. The federal government also played a central role as the initial customer for many of the early products of the cluster. And finally, it was primary funder for much of the critical research and development that has underpinned the growth of these clusters (Rowen 2000). In recent years efforts by the local community to mobilize itself more effectively through organizations such as Joint Venture Silicon Valley have worked to enhance the level of social capital and deal with some of the social and environmental problems that extensive growth has brought. Thus the concept of 'nested scales' of analysis deepens our understanding of the multiple factors that influence the development trajectory of a cluster and ultimately, its economic performance. From a policy perspective, it also draws attention to the role that higher levels of government play in creating the conditions that support cluster development.

4.0 ISRN Case studies in progress: what have we learned so far?[6]

The ISRN's national study of cluster development has been designed to allow us to examine – whenever possible – the same type of industry in two or more different regions in Canada. At the same time, we are also able to document multiple industrial cases in the same region. Each cluster is being examined using a common research methodology, largely based on in-depth interviews with key cluster participants. Each cluster analysis is designed to elucidate a common set of factors, including: i) the size and composition of the cluster; ii) the history of the cluster's evolution, including key events (intentional and accidental); iii) the relationships between firms; iv) the relationship between the cluster's firms and the research infrastructure; v) the geographical structure of these relationships; vi) the role of finance capital (especially angel investors and venture capitalists); vii) the role of local social capital and 'civic entrepreneurs'; and viii) other factors contributing to the growth of the cluster. In this way, we hope to discern intra-sectoral commonalities, as well as differences in experience that may have arisen due to regional influences and histories. The selection of industries to study ranges from highly knowledge-intensive activities such as biotechnology, photonics/wireless equipment, telecom equipment and aerospace, to more traditional sectors such as steel, automotive parts, specialty food and beverages, and wood products. Finally, the cases are distributed across both metropolitan and non-metropolitan regions, reflecting the unique geography of Canada's national economy.[7] The first wave of case studies commenced in mid-2001, with most research projects slated to last three years. Two sets of preliminary results have been presented at annual meetings of the ISRN held in May 2002 and 2003. What follows is a discussion of common themes emerging across many of the case studies, a tentative typology of cluster models that seem to be emerging, and some key indicators of cluster dynamics and properties.

[6] The following section is co-authored with Meric Gertler, whose contribution to the analysis is gratefully acknowledged.

[7] The framework and milestones document which provides more detail on the research project can be found at: http://www.utoronto.ca/isrn/clusters.htm

4.1 Common themes emerging

The interim findings of those cases in progress reveal a surprising degree of consensus and common experience concerning the forces shaping each region's evolution over time. Five themes stand out in particular.

4.1.1 Learning

Learning has been found to be the key economic process unfolding in each of the cases. Learning is instrumental in enabling old industries to adopt to changing competitive conditions in the global economy, as well as new ones to become more successful innovators. The learning processes have been identified as present both within individual firm and across firm boundaries in the form of learning from other firms, research institutions, industrial associations, and related institutional elements of the cluster. Moreover, we have uncovered instances of both local and non-local learning relationships across our range of case studies. However, one of the most notable findings to date has been the relative lack of inter-firm relationships within many of our case studies. Not surprisingly, given the strong export orientation of much of the Canadian economy, many of the firms interviewed in our case studies indicate that their markets are overwhelmingly outside the country. This suggests that at least one corner of the famous diamond – the demanding local customers – is largely absent in the Canadian context. Also notable is the fact that there seems to be relatively little of the diverse specialization that characterizes the larger ICT clusters, such as Silicon Valley. However, location within the cluster does serve as a spur to learning and innovation as the *local buzz* within the clusters ensures that firms are relatively well informed about what others are doing. Learning also seems to occur at the cluster-wide level through community-based organizations and both formal and informal processes of mentoring.

4.1.2 Labour

One of the most consistent findings thus far concerns the centrality of skilled labour as the single most important local asset. The local endowment of 'talent' in the labour force is emerging as a crucial determinant of regional-industrial success. This endowment is created and maintained by the retention and attraction of highly-educated, potentially mobile workers who are drawn to thick, deep, opportunity-rich local labour markets. The emergence of a strong, concentrated talent pool in local and regional economies also serves as a key factor in launching individual clusters along the path to sustained growth and development. Critical mass appears to be important here: until this is achieved, local employers will fight a losing battle in attempting to retain or attract the skilled talent they need. Once it is achieved, this sets in motion a positive, self-reinforcing circle through which regions with a critical mass of highly skilled workers in a particular sector are able to attract still more workers of this kind. The initial source of the local talent pool can be highly varied, with both government laboratories and local anchor firms playing a key role in developing the initial talent base. Post-secondary educational institutions also play a central role in many of the health-based biotech clusters, but seem to be less critical for the initial launch of many of the other clusters. In many of the cases we are studying it appears that post-secondary institutions are followers, not leaders in key areas of technology. However, once industry has demonstrated leadership in the area and the cluster begins to grow, post-secondary institutions seem particularly adept at expanding their programs and offering in the areas of strength required by the cluster. Their capacity to expand the local talent pool thus becomes critical in accelerating the pace of cluster development.

4.1.3 Leadership

While one of the hallmarks of cluster-based development is its highly decentralized, socially organized network of relationships between local economic actors, the research thus far has highlighted the role that leadership can play in differentiating one firm (or one region) from another. Moreover, this is exercised at two different but equally important scales. First and foremost, the quality and nature of leadership within the firm has been shown to be crucial in explaining the different strategic approaches taken by firms in the same industry and region, as well as their ultimate competitive success. Perhaps the most vivid example of this comes from the steel industry case study (Warrian and Mulhern 2003), in which the very different paths taken by leading firms such as Stelco and Dofasco – both integrated steel producers operating from the City of Hamilton – have been strongly shaped by radically divergent attitudes towards co-operation with local research organizations. Similarly Bombardier, Canada's leading aerospace producer, has differentiated itself from the competition (and its home base in Montreal from other aerospace-producing regions around the world) by its corporate strategy of buying assets (both tangible bricks and mortar as well as intangibles such as knowledge) and managing them skillfully, rather than by building them from scratch.

Leadership is also expressed at a social scale: at the level of the community. Here, our early findings point to the key role of 'civic entrepreneurs' in catalyzing the development of new and emerging industries such as telecom equipment in Ottawa (Chamberlin and de la Mothe 2003), wireless equipment in Calgary (Langford, Wood, et al. 2003) or the emerging multimedia cluster in Nova Scotia's Cape Breton Island (Johnstone and Haddow 2003). These community leaders – who are more often than not from the private sector – help animate local processes of strategic visioning, galvanize socially organized activities to upgrade the innovative capabilities of local firms, and represent the common, collective interest of firms in the industry when required.

4.1.4 Legislation, laws, and labs

Our cases also reveal the subtle but pervasive influence of institutional forces, exerted in a number of different ways and at a number of spatial scales. While private sector initiative and ingenuity is of obvious importance, provincial and national institutional frameworks play a key role in shaping the trajectory of regional-industrial evolution by making certain kinds of strategic choices by firms easier, and others more difficult. They have also played a leading role in building the knowledge infrastructure in different regions of the country: universities, colleges, government labs, and other research and technology-transfer organizations. Through the direct creation of crown corporations or government labs at both the federal and provincial levels, they help produce critical knowledge-based assets for the region. Examples such as Alberta Government Telephone and its role in fostering the Calgary wireless industry demonstrate vividly the potential influence of publicly funded entities in triggering the emergence of new industries and firms. Similarly, the presence of the National Research Council labs in Ottawa, Montreal and Saskatoon have served as important attractors of private firm investment – in telecoms, health-based biotechnology and agricultural biotechnology – as well as a generator of significant numbers of spin-off firms started up by former employees. Finally, publicly funded agencies have been found to play crucial roles as 'animateurs', working side by side by private and not-for-profit organizations at the local level to organize reflexive learning processes at the level of industries and communities.

4.1.5 Location

While our work began from the premise that 'geography matters', we recognized the perils of presupposing the importance of place, rather than revealing it through systematic study. What is emerging from our cases is a more nuanced understanding of the importance of location to the creation and maintenance of learning dynamics for firms and industries. The cases document a consistent tension between local and non-local relationships and knowledge flows – in other words the dynamic tension that exists between *local buzz* and *global pipelines*. Moreover, they are leading us to appreciate the specificity of particular case study circumstances, in which regional, national, sectoral and historical variation are significant.

4.2 Two emerging 'models'

It is perhaps still too early to offer any definitive typologies or general lessons from the work of the research team. Nevertheless, it is possible to discern at least two distinctive characteristic formations into which the cases examined thus far seem to fall.

4.2.1 Type I: regionally embedded and anchored

In some of the case studies, while global knowledge flows are certainly important to the competitive success of local firms, the local knowledge/science base represents a major generator of new, unique knowledge assets. Local universities and research institutes constitute an important part of this base as 'anchors' that generate highly skilled graduates, spin-off start-ups, and new, publicly available knowledge (often developed interactively with other local partners outside the sphere of the university). In many cases, there appears to be one or a few 'anchor' firms or 'lead' institutions that play a critical role in these processes. Examples from our ongoing work include biotechnology in Montreal, telecom and photonics in Ottawa (Chamberlin and de la Mothe 2003), steel in Hamilton, particularly as produced by Dofasco (Warrian and Mulhern 2003), and the evolving information technology cluster in New Brunswick. The New Brunswick cluster is of particular interest because of efforts by the provincial government to use the local telecommunications firm (NBTel) as the 'anchor' for an emerging ICT cluster and the recently adopted strategy by the federal government's National Research Council to accelerate the cluster's growth by locating a branch of its Institute for Information Technology in the provincial capital, Fredericton (Davis and Schaefer 2003).

4.2.2 Type II: 'entrepôt'

In other cases, it appears that much of the knowledge base required for innovation and production is simply acquired through straightforward market transactions, often from non-local (even global sources). Nevertheless, there is still an important role to be played by local institutions and actors that enable local firms to exploit this knowledge effectively and combine it with other local assets and capabilities for success. The clearest examples of this come from the study of Montreal's aerospace industry, Saskatoon's agri-biotech sector (Phillips 2002), Calgary's wireless industry (Langford, Wood, et al. 2003), and Sault Ste. Marie's steel industry (Warrian and Mulhern 2003).

4.3 Key cluster indicators: how do we know a cluster when we see one?

Given our central interest in being able to identify those of our cases that seem to have the attributes of a 'true' cluster, we need some systematic methodology for discriminating between the bona fide cases and the impostors. The research completed thus far, and the theoretical and

conceptual literature from which we draw our inspiration, both lead us to emphasize *flows* and *dynamics* over stocks and static measures of innovativeness. They also point quite clearly to the centrality of knowledge and learning processes, both embodied and otherwise. At this stage, the analysis focuses on four categories of indicators: inflows, outflows, local social dynamics, and historical path dynamics.

4.3.1 Inflows

One clear way to confirm the existence of unique, distinctive local knowledge-based assets is by tracking three different forms of inflow. Capital inflows, in the form of venture capital investments, foreign direct investments, or mergers and acquisitions, indicate that investors have identified the local presence of local knowledge assets and capabilities. This seems to have been true of Ottawa's information technology industries (where non-locally based venture capitalists have continued to invest aggressively in local firms with high growth potential throughout the post-2000 downturn in both the telecom and photonics sectors), Montreal's biotech sector (where BioChem Pharma has been purchased by an outside buyer), and Calgary's wireless industry (where Intel has invested directly in new R&D capacity).

Inflows of people are, in our view, an especially robust indicator of local dynamism. It is now increasingly well established that highly educated, talented labour flows to those places that have a buzz about them – the places where the most interesting work in the field is currently being done. One way to track this is through the inflow of so-called 'star scientists', or by tracking the in-migration of tomorrow's potential stars (post-docs). Another approach, promoted by Florida and colleagues (Florida 2002; Gertler, Florida, et al. 2002) utilizes a more broadly defined measure of 'talent', and has documented its strong geographical attraction to the presence of other creative people and activities locally. Of course, in-bound talented labour represents knowledge in its embodied form flowing into the region. Hence, such flows act to reinforce and further accentuate the knowledge assets already assembled in a particular region.

One should also be able to track knowledge inflows directly, in their disembodied form. This would be monitored through licensing of intellectual property produced elsewhere, or through local citation of externally generated patents as is suggested in the case study of the Saskatoon biotech cluster (Phillips 2002).

4.3.2 Outflows

Dynamic, innovative clusters of economic activity should also be discernible by the things that flow outward to the rest of the world. Of course, Porter's own methodology for identifying clusters starts with this point, by attempting to document locally produced goods and services that are traded on world markets. But a more complete analysis would need to go beyond these relatively tangible flows, to consider some important but intangible outflows. Foremost among these would be outflows of knowledge, as monitored through various formal modes of intellectual property transfer (such as licensing or patent citations). We would argue that this kind of activity provides perhaps the best indicator of wider recognition of the unique capabilities and knowledge assets of a region.

4.3.3 Local social dynamics

This is the starting point for most of the literature in economic geography and related fields over the past 15 to 20 years. This literature has tended to focus on local social dynamics almost to the complete exclusion of all else, including the important non-local flows discussed above. Relevant here, of course, is evidence of co-operation and network-based behaviour, particularly those forms that promote the circulation of knowledge locally. But, as Malmberg and Maskell point out, competition is as much a part of the story as is collaboration (Malmberg and Maskell 2001). The dense local clustering of competing firms provides a vitally important opportunity for mutual monitoring and observation, itself a crucial form of knowledge flow. The case studies are also beginning to document the circulation of labour and entrepreneurs between local firms (or other organizations such as research institutes) through the collection of information on career histories, spin-off activity and the process of new firm formation. As noted above, the case study evidence to date suggests that informal monitoring of other firms' activities as well as learning through the circulation of labour among firms are relatively more important sources of knowledge flows than formal collaborations among the local firms or dense networks of buyer-supplier relationships. Other key markers of local social dynamics include the presence of community-level institutions for associative governance (public, private, and hybrid). Such institutions have the potential to promote social interaction and reflexive behaviour leading to successful adaptation and resilience in the face of competitive challenges from abroad. And as Maskell and Malmberg (1999) have argued, because of the path-dependent nature of such local institutions, they are usually quite difficult to replicate, making them a key component of the region's distinctive and unique asset base.

4.3.4 Historical path dependencies

Following on from the previous point, perhaps the most discerning test of 'true' cluster dynamics is one that assesses the alleged cluster's resilience and robustness over time, in the face of severe shocks and dislocations. How has the region fared under such circumstances? How effectively have its firms and institutions adapted and evolved in response to such pressures for change? To what extent can firms take advantage of opportunities to learn from success (manifest in the form of successful spin-offs and demonstration effects from successful competitors and/or role models)? In an important respect, the post-2000 meltdown in the telecom and information technology sectors is providing an important laboratory for studying how individual clusters respond to these 'external' shocks and the degree to which the 'extra-firm' institutional supports afforded by the location within a cluster serves to cushion the shock and facilitate both the adjustment strategy on the part of individual firms, as well as a broader process of firm collapse and regeneration within the cluster at large.

Related to this idea is another question: how is failure handled? In the most dynamic regions, failure is recognized as a learning opportunity, such that potential investors see entrepreneurs who have failed in the past as lower-risk prospects because they have most likely learned valuable lessons in the process (Saxenian 1994; Best 2001). Similarly, the failure or downsizing of large, once-successful firms represents a potential opportunity for regional renewal, since highly educated and experienced knowledge assets are released back into the local economy. Our assertion is that successful clusters capitalize on such events by absorbing these valuable assets back into the productive activity – for example, by facilitating and supporting the process of new firm formation. Less dynamic places will tend to squander such opportunities by permitting or

encouraging out-migration. One case that we are following closely is that of Ottawa's telecom and photonics cluster where local surveys indicate that close to 20,000 jobs have been shed since the onset of the downturn, the number of firms linked to the cluster has increased by 300. No one in the local economy expects all of these to survive and grow, but the rate of new firm formation as well as the continued inflow of venture capital during the downturn are widely seen as indicators of the cluster's vitality.

5.0 Conclusion

It should be clear from the above discussion that the approach adopted in this project differs from most of the work performed under the rubric of 'cluster studies' in one important way. Much of the previous work in this field presumes the importance of 'the local', and then sets out to find indicators that confirm this. In contrast, our approach is to treat the possible existence of cluster dynamics as an hypothesis to be investigated and either verified or rejected. The relatively large sample of case studies or potential clusters that cut across a broad cross-section of both mature and emerging industries in highly urbanized and smaller centres provides a solid basis for comparison and allows the use a robust set of indicators or tests. For the same reason, we continue to ask ourselves throughout this project: when, or under what circumstances does spatial proximity matter, and why? The answers to these questions will provide a useful base for policy advice that does not oversubscribe to the cluster brand nor oversell what can be delivered.

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