THE INNOVATION SYSTEMS RESEARCH NETWORK: AN EXPERIMENTAL DESIGN FOR KNOWLEDGEMENT MANAGEMENT

1. Introduction

Many of the members of the Innovation Systems Research Network first came together at a seminar in Ottawa in March 1997, organized by John de la Mothe of the University of Ottawa and sponsored by Statistics Canada. The success of the seminar led to a series of discussions between some of the participants and the National Research Council, the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council about the need for increased support to further the academic and policy-related research in this field. In 1998, the three councils jointly issued a call for proposals from groups of researchers across the country interested in forming sub-networks of a national network on innovation systems research. The primary objective of the program was to improve our understanding of the innovation process in the context of regional systems of innovation within Canada. This call for proposals was designed to bring together many of the researchers who had been working together in smaller groups to build a critical mass of researchers in Canada and to enhance the overall the overall research capability in in this field.

With the support of the three federal councils, The Innovation Systems Research Network (ISRN) was launched in 1998 as an *experiment* in the management and dissemination of interdisciplinary research. The original call for proposals defined the objectives of the program as:

- Encouraging the creation of linkages and the exchange of ideas and information among the academic community, private sector firms and associations, government policy makers that will lead to a better understanding of the nature of innovation in the Canadian context;

- Developing agendas for research on the relationship among innovation, the new knowledge-based economy, and regional economic clusters;

- Fostering a multidisciplinary approach to the research that includes a variety of disciplines such as business, economics, urban planning, public administration and science and technology management;

- Encouraging the development of graduate students with the interests and skills necessary to contribute to future research in this area and/or to practice as managers of science-based innovation; and

- Improving innovation systems and thereby strengthening Canadian competitiveness, by influencing public policy and corporate strategy.

The major purpose of the Network was to support interaction among researchers and their partners, and to promote the diffusion of findings to public and private sector practitioners. From the perspective of the researchers awarded the

grant, a major reason for participating in the program was to improve our understanding of how the innovation process functions in the context of Canada's diverse regional economies. The initial mandate of the network was to integrate our analyses of the essential elements of the regional systems of innovation across the country and to identify their points of commonality and difference with particular emphasis on comparisons between metropolitan and non-metropolitan areas. The network was also mandated to identify appropriate policy responses for the respective levels of government and to communicate the research findings of its members to the academic community, policy makers, business leaders and relevant civic and community leaders.

The members of the ISRN were organized in five subnetworks from BC to Atlantic Canada, loosing linked in a national network. The primary locus of activity took place in the regional subnetworks. The original call for submissions emphasized the importance of studying regional systems of innovation from a multidisciplinary approach. Members of the network reflected this breadth, bringing a wide range of academic disciplines to the study of Canada's regional innovation systems. The disciplinary backgrounds of the network members include political science and public administration, administrative studies, communication, evolutionary and institutional economics, engineering, economic geography and industrial relations. The multidisciplinary background of the network members ensured that our work was informed by a wide range of approaches and facilitated our development of a more synthetic understanding of regional innovation systems.

Similarly, ISRN's regional node structure allowed the subnetworks to focus on the study of their immediate geographic regions and cultivate research partnerships with the most appropriate regional actors. The regional structure of the ISRN, in effect mirrors the innovation systems being studied, allowing each sub-network to proceed in a fashion most appropriate to regional social, cultural and political considerations. It provided a firm foundation for comparative studies and ensured that our conclusions about innovation in Canada were not unduly influenced by the large mass of economic activity in Ontario and Quebec. It also enabled specific policy issues to be studied and policy advice to be given appropriate to the region, which, in turn, facilitated acceptance of that advice. This facilitated buy-in, to what was essentially a federal (or national) project, by provincial administrations and regional and local economic development agencies.

Through the first three years of its existence, from September, 1998 to August, 2001, members of the Innovation Systems Research Network continued their extensive array of research on a wide range of subjects related to the nature and operation of regional innovation systems. Members of the subnetworks met regularly on a local and regional basis to compare and synthesize research finding. The subnetworks frequently organized workshops in conjunction with officials of federal regional development agencies, provincial ministries, local economic development agencies, as well as several of our international collaborators. The success of these workshops contributed substantially to the growth of the networks' membership and its reputation. These workshops which combined representatives of government agencies with academic members of the network and students served as an invaluable means to strengthen the links between the

network and its stakeholders. Finally, two of the networks produced a very successful electronic newsletter, one on a weekly basis in Quebec and the other on a biweekly basis in Ontario. A third newsletter published by The Centre for Innovation Studies (a partner of the InnoCom subnetwork) has recently been launched in Alberta. The newsletters have proved to be an invaluable mechanism for disseminating the research findings of network members, updating the network members and their stakeholders on the latest research results from around the world and expanding the membership of the network. In the case of the Quebec subnetwork, it began in 1998 with twenty members, mostly students and academics. Through its networking activities, it grew to involve almost 300 people, 40 per cent from government agencies, 40 per cent from universities, and the remaining 20 per cent from intermediary organizations.

In addition to their networking activities, members of the network collaborated on a number of different research projects at the regional level. The results of this research were shared among members of the network at regional workshops and seminars, as well as a number of conferences organized by the five subnetworks. Many of the academic and policy-oriented outputs of those collaborations are included in the expanded bibliography on the ISRN web site: http://www.utoronto.ca/isrn. The members of the five subnetworks come together once a year in a national meeting to present research findings, and compare and contrast their experience across the country. A selection of papers presented at the three national meetings held in May 1999, 2000 and 2001 have been edited and published in two volumes by J. Adam Holbrook and David A. Wolfe. Although this research program was not targeted at an integrated set of research questions and did not employ a common research methodology, it generated a number of insights into the nature of regional innovation systems in Canada.

Virtually all of the subnetworks report that membership in the ISRN contributed to their standing with provincial, regional and local economic development agencies and officials. Subnetwork meetings provided an important forum at which representatives of all three levels of government can meet and interact around a common set of research issues and policy concerns. Participation by government officials in network activities raised the visibility of the network members and resulted in their being called upon with increasing frequency to share academic research findings, undertake policy oriented studies for regional and local officials, and provide policy advice. For instance, a number of the researchers in the RQSI in Quebec have produced surveys and reports on innovation at the regional level with regional partners for six regions in Quebec. The reports produced are all available on the RQSI web site. In New Brunswick, members of the Atlantic Canada network are working with the NRC's new information technology lab on a study of the current status of the industry and its capacity to absorb and develop the knowledge produced by the lab. This two way flow of knowledge and information has dual benefits: on the one hand, it has afforded provincial and local economic development officials access to a broader base of academic research – both Canadian and international – to inform their policy decisions; and it has allowed ISRN researchers the opportunity to test the insights derived from their academic research in a more applied policy context and setting. As a consequence, more applied research on innovation related questions is being undertaken at the regional and local level because the relevant

officials are now aware of the academic and policy related competence available through the network. The following discussion 'extracts' the key policy insights derived from this research in the form of a number of lessons learned.

2. The Innovation Systems Approach

Governments in most jurisdictions support research and development programs in the belief that these investments have a positive, if indefinable, effect on economic growth. The growing recognition of the increasing role of knowledge as a key factor in sustaining growth adds a further stimulus in this direction. Higher levels of investment in R&D or increases in knowledge alone cannot fully explain the capacity to generate innovations within a society or to stimulate growth. It is easy to confuse investments in technological innovation with investments in science and technology, and more particularly, R&D. Investments in R&D are undoubtedly elements of technological innovation, but they are only part of the process. Technological innovation may originate from any of a number of sources, many of which are not technology-based, nor is innovation restricted to technology-based industries in the manufacturing sector. Innovation can, and does, occur in the resources sector, smoke-stack industries and all parts of the services sector. The key to successful innovation is the capacity of a firm or organization to apply knowledge in a new or different way than it has in the past. As the base of knowledge expands and greater social and economic resources are dedicated to its expansion, the capacity to continuously learn and adapt to rapidly changing conditions underpins the innovative capacity of firms, regions and countries.

Early analyses of the economic benefits derived from increased investments in research and development were based on the 'linear' model of innovation (developed initially by the National Science Foundation), where an investment in research was seen to lead eventually to the generation of greater wealth or a social benefit. This perspective was extended by the pathbreaking work Richard Nelson and Kenneth Arrow in the economics of innovation. The linear model recognized the existence of intervening steps where the technologies resulting from research and development were developed and commercialized, but the model itself suggested that resources expended on research and development inevitably result in some economic benefit at the end of the chain, and that the application of incremental resources to the research will result in incremental benefits. Keith Pavitt argues that a key feature of the US innovation system was the massive and pluralistic public funding of institutions of high academic quality, and a willingness to make long-term investments in basic research leading to the development of new, often multidisciplinary fields, such as biomedical- and ICT-related areas of research. However, he warns against relying exclusively on the linear, or informational, conception of the benefits that flow from this investment. More recent theories take a broader view of the innovation process, recognizing that research and development is only one of several inputs to wealth generation and social progress. Learning capabilities are grounded in a broad range of social institutions that constitute the environment in which firms operate. "Learning is necessarily an interactive and socially embedded process. Without a minimum of social cohesion the capability to learn and master new technologies and new and more flexible forms of social organization will be weak" (Lundvall).

These studies of the innovation process point to the interdependence of economic, political, and cultural factors, and the increasing importance of proximity, in influencing the innovation process. ISRN members adopted the 'systems of innovation' approach to analyze the relationships among firms and the broader institutional setting that support their innovative activities. This approach emphasizes the dynamic and cumulative nature of the innovation process and the complex range of activities in an economy that may contribute to its innovative capacity. In some economies, the actual level of research and development may be relatively low, but the level of investment in related activities may be much more substantial. This recognition of the complexity of the innovation process, and the importance of linkages and interaction among the various factors that contribute to it, is a key insight of the innovation systems approach.

Investments in basic or fundamental research do not take the form of information that is expensive to generate, but effectively costless to reproduce and use, thereby exhibiting the qualities of a true public good. Much of the knowledge transfer from public research organizations to other parts of the innovation system is person-embodied. The effective exploitation of that knowledge depends on the capacity of firms to absorb and apply research results, not all of which is transmitted in a codified form. Knowledge is therefore not a freely available good, but involves a large tacit component of skill and capabilities embodied in people, products, and procedures. These capabilities also depend on the specific institutional arrangements and cultural setting within which knowledge is disseminated – including the mechanisms for coordinating and organizing non-market dimensions of inter-firm relationships, the nature of the financial system, the organization of the education and training system, and not least of all, the role of government policy. This constitutes the key contribution of the innovation systems literature.

Although most of the original work on innovation systems focused on the national level, a growing body of research, including that by members of the ISRN, has examined the role of the regional and local level. This shift grew out of the recognition that innovative capabilities are sustained through local and regional communities of firms and supporting networks of institutions that share a common knowledge base and benefit from their shared access to a unique set of skills and resources. Many of the factors that are critical for developing an innovative capacity and sustaining competitive advantage remain place bound, ie. embedded in local networks and communities of firms and the supporting infrastructure of research and training institutions, financial intermediaries, government agencies and community and business associations that comprise the regional innovation system. Competitive advantage is not reducible to the acquisition of codified knowledge and capital that are available world wide; it is more and more dependent on institutional and social capital that fosters the acquisition and utilization of codified and tacit knowledge at the regional level.

The regional level is critical to this process because the factors of space and proximity contribute to the kind of tacit knowledge and the capacity for learning that support innovation. Definitions of the regional innovation system vary, but central is the notion of how the institutional and cultural environment of a region interacts with the activities of private firms to influence the innovation process. A definition used by some members of

ISRN is "the set of economic, political and institutional relationships occurring in a given geographical area which generates a collective learning process leading to the rapid diffusion of knowledge and best practice" (Nauwelaers and Reid).

This emphasis on the region as a locus of innovation and the value of geographic proximity for the learning process also reflects the attention paid to the emergence of a number of dynamic, clusters in key locales around the globe. Michael Porter defines clusters as a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. Clusters include concentrations of interconnected companies, service providers, suppliers of specialized inputs to the production process, customers, manufacturers of related products and finally governmental and other institutions, such as national laboratories, universities, vocational training institutions, trade associations and collaborative research institutes. Clusters operate within the distinctive features of the national and regional innovation systems and the process of cluster development is embedded within a complex set of economic, social and institutional relationships at both the regional and national levels. Growing recognition of the importance of clusters was a critical factor in the research design and the methodology developed for the ISRN's new Major Collaborative Research Initiative, recently funded by the Social Sciences and Humanities Research Council.

The regional innovation systems approach is particularly valuable in understanding how the innovation process operates in the context of Canada's diverse regional economies. Attempts to analyze the nature of the innovation process, and develop policy to support it, at the national level exclusively may founder on this problem of diversity. Innovation in Canada cannot be described as a single national system of innovation, due to its size, diversity and cultural variations. For example, two-thirds of Canada's industrial capacity is concentrated in the Québec City-Windsor corridor, with a consequent bias of national statistics and other measures of national innovative capacity. Statistics Canada has found, through the data collected in its 1999 Survey of Innovation, that not all regions are equally successful in inventing, adopting and adapting new technologies, as has been reported in several papers presented at ISRN meetings and published in the annual volume. A regional focus helps to overcome this problem and provides a better way of grounding our understanding of the innovation process within the diverse realities that make up the national economy.

3. Insights from National and Regional Innovation Surveys

Studies by ISRN members have analyzed these dynamics in greater detail. Some of these studies have used the results of Statistics Canada's 1999 Survey of Innovation to examine the characteristics of innovative firms in Canada. One such study tested the hypothesis that access to a larger variety of sources of information increases the novelty of a firm's innovations. They argue that patterns of use of information sources can be expected to vary according to the knowledge-intensity of the industry. The principal finding is that 'world first' innovators do indeed use a larger number of sources of information (both internal and external to the firm) to support their innovation activities. They are more likely to engage in networking/collaborative behaviour (beyond pure contracting-out),

and to engage in R&D. Finally, world-first innovation appears to be more prevalent amongst larger firms and those in high- and medium-technology sectors.

Another study used the 1999 Survey of Innovation to determine differences between innovators and non-innovators and between successful innovators and unsuccessful ones. In line with the above results, it found that the odds of being innovative increase substantially when firms are involved in cooperative or collaborative agreements and undertake R&D. Furthermore, actively adopting a range of innovative activities strongly increases the likelihood of being a successful innovator.

A key question that has preoccupied ISRN researchers is: does innovation proceed in the same way in across Canada's diverse regions? For the most part, Statistics Canada data are not robust enough in the western provinces to answer this question directly as part of their national survey efforts, so ISRN researchers in BC have undertaken a number of individual survey exercises to examine this issue more closely. In general, they have found that innovative firms share similar characteristics, regardless of whether they are high-tech or resource-based. Similarly, a high-tech firm in the west is not automatically innovative. The interrelation between innovativeness, however defined, and the management of human capital appears to be very strong, and suggests an important line of further research. They conclude that there is a separate and culturally distinct system of innovation in the west, and it is necessary to understand that difference in order to understand the Canadian innovation system as a whole.

ISRN researchers have also conducted a number of surveys of innovation at the sub-provincial level. The data generated by these surveys have been used in an original manner to generate new insights into the nature of innovative behaviour at the local and regional level. One such study deals with two key questions: does social capital determine innovation in manufacturing firms? and if so, to what extent? To answer these questions, they reviewed the literature on innovation in order to see how social capital is added to the other forms of capital as an explanatory variable of innovation. In doing so, they concluded that social capital cannot be captured through a single indicator, but that it actually takes many different forms, which be accounted for separately. Therefore, they added five forms of structural social capital (business network assets, information network assets, research network assets, participation assets, relational assets) and one form of cognitive social capital (reciprocal trust). Based on on survey data administered from April to June 2000 to 440 manufacturing firms of diverse industries in a region in the South-West of Montréal, they found that 68.5% of the firms surveyed developed product or process innovations during the three years preceding the survey. Assuming that innovation is not a discrete event, but a complex process, they modeled the decision to innovate as a two-stage decision-making process: in the first stage, the firms deal with the decision about whether to innovate or not; whereas at the second stage, the firms that have decided to innovate make decisions about the degree of radicalness of the innovation to undertake. The study provides strong evidence that diverse forms of social capital influence the decision to innovate or not and, more importantly, that marginal increases in social capital, especially in social capital taking the forms of participation assets and relational assets, contribute more than any other explanatory variable to

increase the likelihood of innovation by firms. As for the decision made at the second stage, concerning the degree of radicalness of the new product or process innovations, the study provides evidence that diverse forms of social capital determine the radicalness of innovation. To be specific, social capital in the form of research network assets contributes more than any other variable to explain the radicalness of innovation while the second variable exerting the strongest impact on the radicalness of innovation is the number of different advanced technologies employed by firms for production.

Additional survey research undertaken by ISRN members has examined the impact of globalization and deepening trade relations on the innovative behaviour of firms in the regional innovation system and the linkages they establish with research facilities. Two conflicting views dominate the debate on the impact of globalization on innovation: the first contends that globalization reduces the significance of the home base as the primary site for innovation, as firms increasingly source and apply their innovations on a global basis; while the second contends that the institutionally-embedded nature of the innovation process demands a continued, and even accentuated, role for the local context. A study by ISRN members examined the innovative practices of 242 indigenous and multinational establishments in Ontario with respect to in-house technological capabilities, innovative processes, external sources of innovative ideas, and the nature and the extent of innovative interfirm practices. The findings indicate that indigenous firms are more likely to perform innovative activities locally and are more embedded in the Ontario economy than their multinational counterparts, as they exhibit higher R & D intensity, have a larger proportion of scientific, technical and managerial employees, adopt innovative interfirm practices more extensively, and are more likely to source innovative ideas from local customers. The multinational establishments, in contrast, tend to exhibit lower R & D intensity, are more reliant on their in-house marketing units, and continue to rely on their parent companies as a primary source for innovative ideas. These results suggest that local context still exerts a significant influence on the nature and extent of innovative activities in the knowledge-based economy.

Another study examined the impact of expanding trade ties in North America on the innovative strategies and behaviour of firms in four high tech industries in the Toronto region. The central conclusion of this research is that there have been substantially different responses by firms to the increased permeability of the international boundary of the regional innovation system. While large (domestic) establishments responded strongly by increasing their degree of outsourcing and reducing in-house production, the choice of foreign affiliates was to simplify their production tasks (reduce the product range) as they experienced much more highly integrated relationships with their parents even when a global or North American product mandate was gained. Paradoxically, small domestically-owned firms did not outsource as strongly as our knowledge of non-Canadian regional production systems suggests is possible. This implies that small high technology manufacturing firms predominantly remain as regionally focused performers of R&D and production activities and are not strongly influenced in their production arrangements by the new trade agreements. This conforms to the proposition that SMEs are less capable of adjusting, even in one of Canada's most industrially developed regions. The most favourable inference from this research finding is that the Toronto

region has a small number of high technology manufacturers that have responded to the new trade regime. The domestic firms among them have joined the group that had invested in the U.S. market and global sourcing systems at a much earlier stage and whose actions preempted any significant response to the FTA or NAFTA. The foreign affiliates that responded have product mandates and resemble the foreign firms that earlier decided that the Toronto RIS contains human resources that merit a specialized technological mission by the parent firm. For the majority of firms, however, the effects of the new trade regime seem to be modest, supporting the inference that the Toronto region has relatively few firms that are strongly competitive in international markets.

4. Knowledge Flows and Transfers within the Innovation System

Further research undertaken by ISRN members underlines the highly regional nature of knowledge flows within the innovation system. ISRN researchers developed a model for describing and assessing the strengths and weaknesses of industrial clusters from a regional perspective. The model is a symmetrical framework combining dimensions of the Porter competitiveness 'diamond' with an equally explicit accounting of infrastructure and markets, important in a regional framework. Measures are organized under the headings of Groundings, Enterprises and Markets, which gives the model its name: GEM. The characteristics of regional innovation systems are contained in the overall competitiveness framework. The GEM determinants are organized in a way that facilitates subjective scoring and allows a mapping onto a more conventional production-system structure. The researchers developed scoring criteria for each of the six determinants that relate to overall competitiveness of the cluster and established an heuristic competitiveness function (GEM Assay) that captures the substitution/complementarity relationships among the determinants. The GEM model was employed in an assessment of the role of three enabling technologies – information technology, biotechnology and advanced materials/advanced manufacturing – both as suppliers to the driving clusters in western Canada and as emerging clusters in their own right. Elements of the GEM model were subsequently employed in designing the research methodology for ISRN's comparative study of regional clusters in Canada.

Other ISRN researchers have also conducted studies of the clustering aspects of specific industries. Knowledge-intensive industries in Canada, as in most other industrial countries, tend to be geographically concentrated, due to the many spillovers that they generate. Its competencies are strongly clustered around a few large and medium-sized urban agglomerations, such as Toronto, Montreal, Vancouver, Edmonton, Ottawa and Calgary. Smaller clusters have also developed around Quebec City and Saskatoon. A key study by an ISRN member confirmed the theory of the competencies of regions using biotechnology, information technology and industrial materials as case studies. In these three cases, government laboratories (as well as universities and a few large firms) act as entry attractors. Using quantitative data, the study examined the relative competencies of the regions in these three areas of technology. The data was based on an empirical analysis of patents granted in the United States to Canadian corporations in three technological areas: biotechnology, industrial materials and information technologies. The study confirmed that economic competencies, as demonstrated by the incidence of patents, were highly concentrated in major regional centres. In biotechnology, economic

concentration of competencies is paralleled by regional concentration: over two thirds of the patents are held by only twelve firms. Six of them are located in Toronto, two in Montreal, and one each in Vancouver, Edmonton, Ottawa, and Saskatoon. In information technology, Ottawa deserves its label as 'Silicon Valley North', as it concentrates more patents than Toronto, Montreal and Vancouver together. Toronto appears also as the undisputed leader of Canadian industrial materials, followed by Montreal, Calgary and Edmonton. However, the Canadian landscape is probably much less concentrated, both geographically and economically, in industrial materials than it is biotechnology or information technology due to the fact that most large Canadian materials corporations conduct process R&D in Canada, close to their main chemical, primary metals or pulp and paper plants, and advanced materials research abroad, close to large markets.

A follow-on study examined the location of government-supported research facilities and cluster development in the aerospace and biotechnology clusters. Canada's first aerospace pole, Montreal, was created in the 1920s through market forces, mostly on the basis of the follow-the-leader behaviour of foreign aircraft body and engine producers. The federal government did not create the cluster, but it supported its renewal, development and consolidation during WWII and the postwar period. However, government laboratories remained located far from the industrial clusters, eventually reducing the innovative synergies in industry. The strategy was successful in terms of employment, production and exports, and created employment, but generated little innovation in Montreal.

In the promising field of human health biotechnology, the government has rightly supported university research and venture capital across Canada. However, it has located only one (out of three) of its main laboratories – Montreal's BRI – in one of the three poles where firms, venture capital and university research are concentrated. This may suggest some kind of governmental blindness, sometimes acting against the market, instead of reinforcing market trends and avoiding the dispersion of efforts. Canadian governments have implemented horizontal policies that helped science-based companies in all regions and all industries to grow. However, ISRN research findings suggest that in selecting regional innovation systems, they have ignored the dynamics of the clusters in the two science-based industries under consideration. Canadian federal laboratories may sometimes be located far from the locus of the regional clusters they are supposed to strengthen.

Research undertaken by ISRN members has also probed various dimensions of the evolving nature of the relationship between universities and industry. One study highlighted the significant increase in industry funding of university research across the country, while a second study documented the many different dimensions or mechanisms of knowledge transfer between universities and industry, but also drew attention to the significant measurement problems encountered in documenting the extent of these knowledge flows. Part of the difficulty in managing the process of knowledge transfer arises from the fact that much of the knowledge created in universities is either tacit in nature or relies on tacit knowledge to be fully understood and applied. To deploy this knowledge in a commercial setting, firms need to capture both its tacit, as well as its

more explicit, or codified, component. The difficulty in doing this arises from the fact that the tacit component of university-based research is embedded in the skills, motivation, goals, equipment, materials, and background knowledge that make up the context of the research laboratory. To understand and appropriate the tacit dimension, firms need to establish a common ground with university researchers around these factors. This would help link the knowledge created in the university to a firm's existing knowledge base – an important factor in the firm's ability to absorb new knowledge.

This study examined the factors that contribute to effective knowledge transfer in university-industry collaborations. It underlined the fact that the mere act of establishing a formal partnership or collaboration is not sufficient to ensure an effective process of knowledge transfer from the research facility to the potential adopter of that knowledge. An often-overlooked dimension of the knowledge transfer process is the skill sets, equipment, materials, data, and procedures that the firm invests in the partnership. These embodied forms of knowledge may facilitate communication between partners by providing a common point of reference and mediate knowledge transfer by becoming a mixing ground for the firm's old knowledge base and the new knowledge created through the research partnership. The sharing of a firm's codified knowledge, expertise, materials, data, and equipment with its university partner helped to build common ground between the context of the university laboratory and the firm. This links the knowledge created in the partnership to the firm's existing knowledge base and helps to bridge differences in working culture, language, and perspectives on the project by providing a space and impetus for communication across institutional boundaries. Learning takes place when communication reconfigured and augmented the firm's existing knowledge base by mixing it with the new knowledge being created in the university laboratory. While this most often consisted of personnel communication between the partners, it also occurs through shared expertise, equipment and material that embodied a certain amount of the firm's existing stock of knowledge. The application of this reconfigured knowledge base to old and new problems was the first step in the product and process innovations.

Further research by ISRN members has examined the dyanamics found in newly emerging clusters such as the multimedia clusters in Montreal, Toronto and Vancouver. The Vancouver metropolitan area has a substantial multi-media/entertainment technologies industrial cluster. Part of this is based around 'Hollywood North', the movement of US productions to the nearest (low-cost) Canadian venue. However this does not appear to be the sole explanatory factor – entertainment software and specific entertainment technologies have rooted in the Vancouver environment as part of the entertainment cluster. The factors leading to this are complex, but may well be best explained by Richard Florida's observations about the attractiveness of metropolitan areas that have the three 'T's: technology, talent and tolerance. Current research by ISRN members will generate the data needed to compare leading Canadian census metropolitan areas with those examined by Florida for the US.

The initial development of the Toronto multimedia cluster is attributed not only to the presence of a strong corporate sector, which was the primary customer for multimedia services, but also to the existence of technological infrastructure, educational institutions,

and support for cultural industries, which have largely been supplied by governments. The growth of the multimedia industry is largely a function of the demand for new media products from locally headquartered national and international corporations and multimedia firms have agglomerated in Toronto because the headquarters of Canada's major national and multinational corporations are located in the city. The advertising, banking, financial services and corporate management industries are key multimedia clients. Other factors have also contributed to the growth of the Toronto multimedia cluster. Academic and consultants' studies identify the quality of Toronto's labour force, which in turn is a consequence of the concentration of universities and colleges in the GTA, as a key factor. Recent government and private sector initiatives have provided further funding for training programs in computer science and new media. The multimedia cluster has multiple links to the cultural industries, which are also concentrated in Toronto. Toronto is the third largest film production centre in North America, and the second largest television production centre. The concentration of cultural industries in Toronto has provided a training-ground for multimedia entrepreneurs and employees; the sector provides much of the content for multimedia production; and finally, it is a major client for the industry.

ISRN members are also involved in an ongoing study of efforts by the provincial and municipal governments in Montreal to stimulate the growth of their nascent multimedia cluster through the Cite du Multimedia initiative. The study to date has raised some interesting concerns that although involvement by the state agencies has created conditions conducive to the growth of an 'innovative milieu' in multimedia, it may have come at the expense of greater involvement by firms and industry associations in the undertaking. They also find a problem with the absence of linkages between the various networks, firms and organizations. This raises concerns about whether the full potential of the multimedia cluster will be realized in the form of a greater degree of networking and associative behaviour among its members. A virtue of this particular project is that the study was launched near the outset of the multimedia initiative itself and the ISRN researchers will continue to monitor its impact as part of their ongoing study of the Montreal multimedia cluster.

5. Innovation on the Periphery: Non-metropolitan and Technologically 'Thin' Regions from BC to Atlantic Canada

A central insight of ISRN-based research on innovation systems is the significance of differences between the central regions of the country and more peripheral and non-metropolitan ones. While there several technology-based clusters in the west, the provincial economies continue to be dominated by resource-based clusters. ISRN researchers have found that smaller firms in the resource-based industries, such as wood manufacturing, face unique challenges with respect to innovation. The business environment (or the 'regional system of innovation') plays an important role in the ability of firms to access information and know-how and to use them efficiently. While it is obvious that a physical infrastructure such as paved roads, waste disposal, or dry kilns is important, the case studies indicate that less tangible factors such as the business climate or regional coherence and local culture are equally important parts of the environment in which firms operate. A key issue is the supply and development of human resources

needed in the industry, another intangible factor with very tangible effects. The research also examined how government regulation and intervention have affected the business. The most positive effects have not been through direct intervention, but through building up an information, knowledge and education infrastructure that is of equal, if not greater, value than the physical infrastructure.

Detailed studies by members of the ACISN have highlighted the unique problems and difficulties of sustaining knowledge-intensive firms in technologically 'thin' regions such as New Brunswick and other parts of Atlantic Canada. On the positive side, their research demonstrates that there are successful knowledge-intensive companies in Atlantic Canada. Frequently there are several firms in the same industry sector, including specialized service providers. On the negative side, government agencies frequently exaggerate data about the number of such companies and their technological prowess. A closer inspection reveals that the portion of competitive firms on official lists is relatively modest. This indicates that the existing basis for developing technology-intensive clusters in parts of the Atlantic region may be less substantial than is believed. ACISN research suggests that caution should be exercised in identifying a cluster. A number of companies in the same industry sector in close proximity to a number of university departments do not constitute a cluster. For example, an earlier study by a consulting firm suggested the presence of a 'geomatics' cluster in New Brunswick, where at best parts of it existed.

Michael Porter's model of the 'competitive diamond' as an innovation system has the following dimensions: 1) local/regional companies competing vigorously with each other but cooperate when necessary; 2) local regional demanding customers; 3) sophisticated local suppliers and world competitive companies in related industries; and 4) specialized local factor conditions (research labs, university research departments, specialized service providers, etc., that provide specialized knowledge to the local industry sector) that are difficult to access from outside the region. If all four dimensions have to be present, there are few, if any, clusters or innovation systems in Atlantic Canada. However, research by ACISN members suggests that the conditions for effective innovation in these nascent clusters may take a different path than that posited by Michael Porter's classic diamond. Neither the scholarly literature nor their discussions with companies indicate that all four parts of the diamond need to be present for local companies to be world competitive. In some industries innovation is slow and predictable enough to be readily accessed from outside the cluster. In others unpredictability and rapid change may exist at any point in the value chain.

Full-blown clusters may be the exception, not the norm. Porter's model may be conceptualized as a supply chain with inputs, processes, production, outputs, and customers. The four components of the diamond may need to be present in one location in a highly volatile emerging industry in which technologies and market demands are emerging, not yet standardized, and constantly changing. To manage the uncertainties of crucial diffused and emerging knowledge and to access tacit information through local competitors, proximity with customers and suppliers may be necessary for survival. However in older industries dealing with tangible products, the cost of inputs, labor, and transportation are important factors in determining patterns of location.

On the other hand, the various segments of value chains can be located in places offering strategic advantages such as communications infrastructure, proximity to knowledge-intensive milieux, or proximity to key business partners. Typically regions with lower knowledge-intensity capture the lower-value-added production and routine service segments and regions with higher knowledge-intensity capture the creative design and administrative control functions. This raises the issue of the nature of the 'technology ladder' or learning opportunities that may exist in peripheral regions. Research in Atlantic Canada on this point strongly confirms the findings of a similar body of research in the US, as well as other parts of Canada. There is a strong pattern of interaction between different components of the regional innovation system, such as the infrastructure of public research organizations, and the industrial structure of the regional economy. Over time, the knowledge-producing activities of most publicly funded research and educational institutions become aligned with the knowledge procurement patterns of the specific production segments of industry located in the region. In the case of Atlantic Canada, this has tended to be the lower value-added segments of industry found in the region. Policy frameworks for cluster formation that miss this point may risk being less than successful in stimulating economic development in the region. Policy initiatives to foster the growth of clusters in these regions must address not only the development trajectories that are characteristic of regions with new technology-based firms, but also the development trajectories that may be induced in lower-value-added production or service segments of value chains that have located in the region because of cost factors or proximity to natural resources.

The future thrust of their research will determine: at which phase of the value chain a cluster type structure is advantageous or necessary for local companies to be world competitive? Does such a structure exist in the region under study? What policies, public or private, could create, imitate or strengthen such a cluster? Answers to such questions may well create opportunities for technologically thin parts of the country to prosper economically.

6. Policy Implications

The OECD has concluded that the study of national innovation systems offers new criteria for evaluating the effectiveness of government science and technology policies. In the past, government policies have been oriented towards overcoming or compensating for *market failures*; however, the insights afforded by studies of the national innovation system also make it possible to study the nature of *systemic* failures. Applying the innovation systems approach enables policymakers to identify sources of success and failure within the broader mix of institutions that facilitate or inhibit the process of innovation, as well as specific structural gaps in the innovation system. The results of this analysis also prescribe a broader range of policies, which place greater emphasis on the role of social factors and institution building than traditional approaches.
Public research infrastructure, such as post-secondary institutions and government labs are a critical component of regional and local innovation systems, but they are strongly responsive to the industrial structure of their local and regional economies and they operate in the context of other elements of the innovation system. While continuing investments in strengthening research capacity are crucial for the overall operation of the

innovation system, government policies that stress the 'supply side' of the innovation system to the neglect of the 'demand side' of firms in the region, risk missing the point. A more comprehensive framework of policies to support the innovation system must recognize the interactive and interdependent nature of all the elements of the innovation system. Investments in expanding the knowledge base of a local or regional economy without due attention to either the existing industrial structure of that economy or the 'absorptive capacity' of the firms operating in it may risk being squandered. The development of new innovative capabilities is location-based – it occurs in a specific geographic locale and displays a strong regional component. What is essential for the effective upgrading of a system of innovation is the 'embedding' of the business sector into a broader subsystem that involves a greater complexity of interaction and stronger linkages between the actors that comprise the subsystem.

The growing literature on both clusters and regional innovation systems highlights the importance of networks of interrelated firms as key factors in the ability to produce innovative new products or processes in a timely fashion for global markets. Networks of firms in turn rely upon the intangible assets of social capital and trust, or in the North American context, performance-based or 'swift' trust as part of the glue that holds the networks together. Increasingly the key factor that underlies the competitive strength and advantage of these regionally based networks is the underlying strength of the talent pool located in the region or community. The new 'geography of talent' is important in two respects. Increasingly, it is talent, rather than more traditional economic incentives that serves as a magnet to attract existing firms to a region or locality, as well as spinoff new firms in the region or locality. Furthermore, the presence of talent and a critical mass of firms attract other knowledge-based workers to the region or community. The presence of talent is partially a product of the quality of education and training institutions in the region, as well as a more intangible set of lifestyle factors that make a specific region attractive. However, as we have seen in the case of the resource-based industries in BC, human resource development issues are equally critical to the innovative capabilities of the less technologically-intensive sectors as well. Strategies to upgrade the skills of the exisiting labour force or improve access by firms in the sector to a better trained labour force may generate as positive effects for their innovative capabilities as strategies focused exclusively on R&D capabilities.

Policies to enhance the national innovation system must be designed with an eye to the fact that their impact will occur at the local level within the context of industrial clusters and be mediated through the intervening effects of the regional innovation system. Attempts to develop policy exclusively at the national level may founder on the diversity that characterizes the Canadian innovation system. A regional focus helps ground our understanding of the innovation process within these diverse realities. A framework designed to accomplish this requires a broad mix of policies, including those that provide support for upgrading the innovative capabilities of firms across a range of sectors; infrastructure (both physical and technological) policies targeted at promoting the rapid diffusion of new technologies across a range of firms; policies to build the market for new technologies; and policies to support the growth of small- and medium-sized enterprises through increased networking and interaction. This framework must aim to

stimulate the supply of new knowledge, the technology base, and the demand for the technology – the capacity of firms to absorb and utilize the knowledge. Improving the innovation system involves the coordinated upgrading of both the demand for, and the supply of new inputs provided by the research infrastructure.

Many of the essential elements to enhance Canada's innovative capacity are currently in place. The research capacity of public sector research institutions, including universities, research hospitals and government labs has been greatly strengthened in recent budgets, although it must be recognized that our key competitors, such as the US, have been expanding their research capacity at an even faster rate. While these underlying factors play an important role in contributing to the local dynamism of specific regions, a natural endowment of these factors by themselves is not sufficient to promote the growth of the region. Greater attention must also be paid to fostering the growth of dynamic, locally based clusters of innovative firms embedded in regional innovation systems and these strategies must be designed with an eye to the industrial structure and innovative potential of the regions and localities in question. The success of new initiatives, such as those proposed in the recent *Innovation Paper*, in stimulating the growth of clusters in various locales across the country depends, in part, on the capacity of local networks of firms to take up and utilize the knowledge outputs of the these facilities. The availability of innovative financing is critical, especially in more disadvantaged regions, such as Atlantic Canada.

A well functioning innovation system requires that the federal government work with and through regional and local partners to stimulate the development of dynamic clusters at the local and community levels. Critical for the success of such strategies is the presence of leadership and the capacity for learning to promote regional economic development. A key virtue of this approach is the involvement of local actors in thinking about how to design effective innovation strategies within the framework of existing national and regional policies. Building trust among economic actors in a local or regional economy is a difficult process that requires a constant dialogue between the relevant parties so that interests and perceptions can be better brought into alignment. The need for social learning, at the local and regional level is critical to the success of such efforts.