

Knowledge management

The Innovation Systems Research Network: a Canadian experiment in knowledge management

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The Innovation Systems Research Network is a collaborative Canadian initiative to undertake and disseminate research results concerning the diverse nature of regional and local innovation systems across the country. The network was established on the premise that, because of their diversity, regional innovation systems in Canada could not be treated as similar, and that single nation-wide innovation policies would not be successful. This project is, itself, an experiment in research management, in that, because of its regional focus in a geographically diverse federation, it is organized as a federation of regional innovation studies networks. A consequence is that the network has been productive and has provided opportunities for graduate students to meet their peers (and future colleagues) across the country.

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GOVERNMENTS IN THE INDUSTRIAL countries provide substantial support for research and development programs in the belief that these investments have a significant, if indefinable, effect on economic growth. The growing recognition of the role of knowledge as a key factor of production provides further stimulus for these investments. Yet, the overall level of investment in research and development (R&D) alone does not explain the capacity for generating innovations within a society.

The key to successful innovation is the firm or organization's ability to apply knowledge in new or different ways. The innovative potential of firms, regions and countries, in turn, depends on their capacity for continuous learning and the ability to adapt to rapidly changing economic and social conditions; but innovation is ultimately a social process, in which new products and processes emerge out of the ongoing interaction among a range of actors.

More recent approaches adopt this broader perspective, recognizing that R&D is only one of several inputs to wealth generation and social progress. Recognition of the complex and interdependent nature of the innovation process has given rise to several bodies of research literature that examine these relationships.

The literature on innovation systems in general, and regional innovation systems in particular, focuses on the interactive, social and learning nature of the innovation process, and the notion that geography matters and the institutional infrastructure of a regional or local economy is essential for creating

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the 'untraded interdependencies' (see Niosi, 1988; Storper, 1997) that shape and constrain the innovative capabilities and competitive dynamics of firms located in that region or locality. The literature on clusters underlines 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, and between clusters in different geographic locales. 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, and the presence or absence of social or civic capital, play a critical role in influencing the climate for innovation and economic growth in cluster-based regional and local economies.

Innovation systems approach

Governments have long understood that innovation is a key element of economic and social policy, and that promotion of innovation should be a major policy objective, but what policy framework should be used? Over the course of the 1990s a number of leading scholars, tracing their intellectual roots back to Friedrich List's concept of "The national system of political economy" (Freeman, 1995), developed and applied the concept of the national system of innovation, which underlines the importance of interactive relationships between firms and the broader institutional setting that supports their innovative activities.

Building on this groundwork, the OECD (Organization for Economic Cooperation and Development)

launched a major project on national innovation systems (NISs) along two tracks consisting of both general analyses that applied to all its member countries, and more in-depth analyses of key institutional components of the NIS (OECD, 1997; 1999; 2002a; 2002b). The innovation systems 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 more substantial. The innovation systems approach acknowledges that fundamental research is central to expanding the knowledge base available for commercial application, but also recognizes that the effective exploitation of that knowledge depends on the firm's capacity to absorb and apply research results, not all of which are 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 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 insight constitutes the key contribution of the innovation systems literature (Lundvall, 1992; Nelson, 1993; Edquist, 1997).

Although the initial work on innovation systems focused on the national level, an emerging body of research has applied the concept to the regional and local levels (Braczyk *et al.*, 1998; Cooke *et al.*, 2004). The development path for the regional innovation systems approach grew out of regional science and economic geography. Indeed, initially, there was some conceptual tension between those wedded to the 'Listian' notion of the national system and the upstart view that regions were taking on a greater significance in an increasingly globalized world (Cooke, 2001).

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 access to a unique set of skills and resources. Many of the factors critical for developing an innovative capacity remain 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. Sustaining innovative capacity is not reducible to the acquisition of codified knowledge and capital that are sourced globally; it is also dependent on institutional and social capital that fosters the acquisition and utilization of codified and tacit knowledge at the regional level.

Definitions of a regional innovation system vary, but central is the notion of how the region's institutional and cultural environment interacts with the activities of private firms to generate a collective learning process that facilitates the rapid diffusion of knowledge and best practice (Nauwelaers and Reid, 1995). A regional innovation system "consists of interacting knowledge generation and exploitation sub-systems linked to global, national and other regional systems for commercializing new knowledge" (Cooke, 2004, page 3).

The regional innovation systems approach is particularly appropriate for understanding how the innovation process operates in diverse regional economies such as those found in the Canadian federation.¹ Attempts to analyze the nature of the innovation process exclusively at the national level (and develop policy to support it) may founder on the problem of diversity. Innovation in Canada cannot be described as a single national system because of the country's size, diversity and cultural variations.

The extent of this diversity, and its implications for regional policy, are well documented in the OECD's recent *Territorial Reviews: Canada* (OECD, 2002b). For this reason, over the past decade a number of Canadian researchers interested in the dynamics of innovation have adopted key aspects of the regional innovation systems approach in their work. In the late 1990s, supported by three federal research councils, they came together to form a novel national research initiative — the Innovation Systems Research Network.

The Process

The Innovation Systems Research Network (ISRN) is a collaborative Canadian initiative to undertake and disseminate research results concerning the diverse nature of regional and local innovation systems across the country. Several members of the network first met at a workshop organized by the Program on Innovation Management and Economy at the University of Ottawa and Statistics Canada in March 1997.²

The success of the seminar led to a series of discussions among the participants and the National

Research Council (NRC), the Social Sciences and Humanities Research Council (SSHRC) and the Natural Sciences and Engineering Research Council (NSERC) about the need for increased support to further academic and policy-related research in this field. In 1998, the SSHRC 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 was to improve understanding of the innovation process in the context of the Canadian regional systems of innovation. The original call for proposals defined the objectives of the program as:

- encouraging the creation of links and the exchange of ideas and information among the academic community, private-sector firms and associations, and Government policy makers, leading to a better understanding of the nature of innovation in Canada;
- developing agendas for research on the relationship among innovation, the knowledge-based economy, and regional economic clusters;
- fostering a multidisciplinary approach to the research that includes fields 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 for contributing to future research in this area and/or practicing as managers of science-based innovation; and
- improving innovation systems and strengthening Canadian competitiveness by influencing public policy and corporate strategy.

This call for proposals resulted in the formation of the ISRN, an experiment in the management and dissemination of interdisciplinary research in the social sciences in Canada. The major purpose of ISRN is to support interaction among researchers and their partners, and promote the circulation of findings to public- and private-sector practitioners.

From the perspective of the researchers involved in the network, a key reason for participating is to improve our understanding of how the innovation process functions in the context of Canada's diverse regional economies. Another key aim of the network is to identify the appropriate policy responses for various levels of Government and communicate the research findings to those practitioners who can most effectively utilize the insights.

ISRN members are loosely organized into five regional nodes from British Columbia to Atlantic Canada. The primary locus of activity takes place at the regional level, with the full network coming together once a year for a national meeting. In accordance with its mandate to study regional systems of innovation from a multidisciplinary perspective, the network includes members in political science and public administration, administrative studies, communications, evolutionary and institutional economics,

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engineering, economic geography and industrial relations. The varied backgrounds bring a wide range of approaches to bear on the work and facilitate the development of a more integrated understanding of regional innovation systems.

ISRN's regional structure allows its members to focus on their immediate geographic regions and cultivate research partnerships with the most appropriate actors from all three levels of Government in the region. The organization structure of the network, in effect, mirrors the innovation systems being studied, so that each node proceeds in a fashion most appropriate to its social, cultural and political considerations.

This provides a firm foundation for comparative studies and ensures that our conclusions about innovation in Canada are not unduly influenced by the large mass of economic activity concentrated in the larger provinces of Central Canada. It also allows for studying specific policy issues and providing policy advice appropriate to each region, which, in turn, facilitates dissemination of that advice. This approach has greatly facilitated the buy-in to what is primarily a federally-funded project by provincial administrations and regional and local economic development agencies.

Through the ISRN's first three years (from September 1998 to August 2001), the individual members maintained their extensive array of research on a wide range of subjects related to regional and local innovation systems. Members of the regional nodes met locally, comparing and synthesizing research findings. They also organized workshops along with officials of federal regional development agencies, provincial ministries, local economic development agencies, and several international collaborators.

The success of these workshops served as an invaluable means of strengthening links between the network and its stakeholders.³ Regional meetings provide 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. This two-way flow of knowledge and information has dual benefits: on the one hand, it affords federal, 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 research in a more applied policy context and setting.

These meetings reinforced the proposition that in order to study the Canadian system of innovation, further studies were needed at the regional level. Furthermore, to understand how each regional system of innovation worked (recalling that they might be found to operate in different ways) a number of case studies needed to be conducted of specific industrial clusters. By operating at the cluster level, we could build up an understanding of the region and its specific features, and researchers could also compare

individual clusters across Canada, thus gaining further information about the diversity of innovation across Canada. In 2001, with new research funding from SSHRC and several other federal and provincial agencies, ISRN commenced this coordinated set of case studies of industrial clusters across the country.

Insights from ISRN research

It is difficult to summarize the research results since 1998 from a broad and diverse group of individual researchers. The national network has collected the research outputs from many of its members and published them in a series of books (Holbrook and Wolfe, 2000; 2002; Wolfe, 2003; Wolfe and Lucas, 2004). In addition, individual members of the network have maintained their own extensive research and publishing programs (de la Mothe and Niosi, 2000; de la Mothe and Foray, 2001).

ISRN researchers have worked with both statistical surveys and case study methods to examine the nature of Canada's innovation system. The following sections discuss selected results from these studies, which illustrate the breadth and interdisciplinarity of the research effort.

Innovation surveys: regional variation

A key question preoccupying ISRN researchers is: does innovation proceed in the same way across Canada's diverse regions? Are there regional variations? One study used the 1999 Survey of Innovation by Statistics Canada to analyze differences between innovators and non-innovators and between successful innovators and unsuccessful ones. It found that the odds of being innovative increase substantially when firms are involved in cooperative or collaborative agreements and undertake R&D themselves, reinforcing the argument about absorptive capacity mentioned above (Therrien, 2002).

Furthermore, actively adopting a range of innovative activities strongly increases the likelihood of being a successful innovator. On a regional basis, firms based in Ontario and Quebec are more likely to innovate than those in other regions of the country. Related studies based on the Survey of Innovation have also examined the effects of sources of information on the novelty of innovation and the impact of local collaboration on firms' innovative performance (Landry and Amara, 2003; Therrien and Chang, 2003).

However, other ISRN members have argued that Statistics Canada data are not robust enough outside Ontario and Quebec to answer this question directly. ISRN researchers in British Columbia have carried out a number of individual surveys examining this issue and 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

interrelationship 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 understanding the difference is necessary for understanding the Canadian innovation system as a whole (Holbrook and Hughes, 1998).

Innovation and social capital

ISRN researchers have conducted surveys of innovation at the sub-provincial level, generating new insights into the nature of innovative behaviour at the local and regional levels. 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, researchers devised indicators for five distinct 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). Assuming that innovation is not a discrete event but a complex process, they modeled the decision to innovate as a two-stage process: in the first stage, firms deal with the decision to innovate or not, while in the second, those choosing to innovate make decisions about the radical nature of the innovation.

The study concluded that diverse forms of social capital influence the innovation decision and, more importantly, that marginal increases in social capital, especially in the form of participation assets and relational assets, contribute more than any other explanatory variable to increasing the likelihood of innovation by firms. As for the decision made at the second stage, the evidence indicates that social capital in the form of research network assets contributes more than any other variable to stimulating more radical innovations, while the variable exerting the second strongest influence is the number of different advanced technologies employed by firms for production (Landry *et al.*, 2002).

Impact of globalization

ISRN researchers have 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 this debate: 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 scale; 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 examining the innovative practices of 242 indigenous and multinational establishments in

A study in Ontario found that indigenous firms are more likely to perform innovative activities locally: multinational establishments show lower R&D intensity, are more reliant on in-house marketing units, and continue relying on parent companies for innovative ideas

Ontario with respect to in-house technological capabilities, innovative processes, external sources of innovative ideas, and the nature and the extent of innovative inter-firm practices, found that indigenous firms are more likely to perform innovative activities locally and are more embedded in the Ontario economy than their multinational counterparts. Indigenous firms exhibit higher R&D intensity, have a larger proportion of scientific, technical and managerial employees, adopt innovative inter-firm practices more extensively, and are more likely to source innovative ideas from local customers.

The multinational establishments, in contrast, exhibit lower R&D intensity, are more reliant on in-house marketing units, and continue relying on parent companies as a primary source for innovative ideas. These results suggest local context still exerts a significant influence on the nature and extent of innovative activities in the knowledge-based economy (Gertler *et al.*, 2000; compare also with Gertler *et al.*, 1998).

NAFTA and innovation

The impact of expanding North American trade ties on the innovative strategies and behaviour of firms in four high-technology industries is important in Canada, particularly in the Toronto region. The study's central conclusion 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 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 remain predominantly 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 small and medium-sized enterprises (SMEs) are less capable of adjusting, even in one of Canada's most industrially developed regions.

The most favourable inference from this research 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 joined the group that invested in the US market and global sourcing systems at a much earlier stage and whose actions preempted any significant response to the Free Trade Agreement (FTA) or the North American Free Trade Agreement (NAFTA). The foreign affiliates that responded have product mandates and resemble the foreign firms that earlier decided that the Toronto region 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 (Britton, 2002).

Knowledge flows and transfers in the system

Role of public sector laboratories

Studies by ISRN researchers of the clustering aspects of specific industries found that knowledge-intensive industries tend to be geographically concentrated, as a result of the spillovers they generate. Competencies in these industries are strongly clustered around a few large and mid-sized urban agglomerations, such as Toronto, Montreal, Vancouver, Edmonton, Ottawa and Calgary, with smaller clusters around Quebec City and Saskatoon.

One study using biotechnology, information technology and industrial materials as cases confirmed the theory of the competencies of regions. In these three cases, Government laboratories (as well as universities and a few large firms) act as entry attractors. The study examined the relative competencies of the regions in these three areas of technology using quantitative data based on an empirical analysis of patents granted in the United States to Canadian corporations in the three areas.

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 12 firms, with six located in Toronto, two in Montreal, and one each in Vancouver, Edmonton, Ottawa, and Saskatoon. 'Star' researchers in biotechnology are equally concentrated, with 80 in Vancouver, 70 in Montreal and 40 in Toronto.

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 (Niosi and Bas, 2000; Niosi, 2000; Queenton and Niosi, 2004).

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 World War II and the post-war period. However, Government laboratories remained located far from the industrial cluster, eventually reducing the innovative synergies in industry. The strategy was successful in terms of employment, production and exports, but generated little innovation in Montreal.

In the field of human health biotechnology, the Government supported university research and venture capital across Canada. However, it located only one (out of three) of its main laboratories in one of the three poles (Montreal) where firms, venture capital and university research are concentrated. This may suggest some kind of policy inertia, sometimes acting against the market, instead of reinforcing market trends and avoiding the dispersion of research effort. Canadian Governments have implemented horizontal policies to help science-based companies in all regions and all industries grow. However, the research findings suggest they may have ignored the dynamics of the clusters in the two science-based industries investigated (Niosi, 2002).

University-industry linkages

Research undertaken by ISRN members has probed various dimensions of the evolving relationship between universities and industry. Their research has highlighted the significant increase in industry funding of university research (Doutriaux, 2000), the impact of university-industry relations on the development of knowledge-intensive clusters in Canada (Doutriaux, 2003), and proposed an analytical framework to assess the broader impact of university-based research on the innovation system (Langford, 2002).

Another study examined the different dimensions of knowledge transfer between universities and industry, drawing attention to the significant measurement problems encountered in documenting the extent of these flows. It examined the factors contributing to effective knowledge transfer in university-industry collaborations. Understanding and appropriating the tacit dimension means firms need to establish a common ground with university researchers. While this most often consists of personal communication between the partners, it also occurs through shared

expertise, equipment and material embodying a certain amount of the firm's existing stock of knowledge. This helps link university-created knowledge to a firm's existing knowledge base — an important factor in a firm's ability to absorb new knowledge (Wolfe and Lucas, 2001).

Results from the current cluster research

In the current research initiative, launched in 2001, ISRN researchers are studying 26 regional and local clusters across the country. Table 1 shows the distribution of case studies underway.

Each case study addresses a common set of features including: the size and composition of the actual or potential cluster; the history of the cluster's evolution, including key events (intentional and accidental); the nature of relationships between firms, and between firms and the research infrastructure; the geographical structure of these relationships; the role of finance capital (especially angel investors and venture capitalists); the role of local associative behaviour; and other forces contributing to (or inhibiting) 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 as a result of regional influences and histories.

The study commenced with Michael Porter's concept of regional clusters as the analytical framework for its study. He argues that the prosperity of a region, which is closely linked to the strength and dynamism of its traded clusters, is grounded in the microeconomic foundations of competitiveness, which in turn depend heavily on the quality of the regional business environment in which they operate.

Clusters take varying forms depending on the particular mix of industries involved, but most include service companies, suppliers of specialized inputs,

sources of financing and firms in related industries. They may also include producers of complementary products, providers of necessary infrastructure and education and research institutions and relevant government agencies (Porter *et al*, 2001, page 7).

Drawing on his previous work on firm-based strategy and national competitiveness, Porter bases the microeconomic foundations of regional competitiveness on four broad areas: factor input conditions; demand conditions; the context for firm strategy and rivalry; and the presence of related and supporting industries that include locally based suppliers and firms in related industries (Porter *et al*, 2001, pages 35–37).

The interim findings of our case studies to date reveal a significant degree of consensus and common experience concerning the forces shaping each region and the development of their individual clusters over time. However, they also exhibit a surprising lack of consistency with key elements of Porter's model. Relatively few of the Canadian case studies suggest that all four parts of the diamond need to be present for local clusters to emerge and contribute to the innovative capacity of a regional economy. In contrast, five key themes emerge from the research.⁴

Learning

Learning has been found to be the key economic process unfolding in each of our cases. It is instrumental in enabling old and new industries 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.

Table 1. Distribution of ISRN case studies

Clusters	West	Ontario	National capital region	Quebec	Atlantic Canada
Biotech	Saskatoon Vancouver	Toronto London	Ottawa	Montreal	Halifax
Multimedia	Vancouver	Toronto		Montreal	
Photonics/wireless	Calgary Vancouver		Ottawa	Quebec City	
Wood products	Interior BC				
Food/wine	Okanagan (BC)	Niagara region			
Information technologies		Kitchener-Waterloo	Ottawa		New Brunswick Cape Breton
Auto/steel/aerospace		Windsor (auto) Kitchener-Waterloo(auto)		Montreal (aerospace)	
Mining supply and services		Hamilton (steel) Sudbury (mining services)			

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 both in more traditional industries and newer, knowledge-intensive ones. 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 among 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, and their ultimate competitive success.

Leadership is also expressed at a social scale, at the level of the community. Here, our findings point to the key role of 'civic entrepreneurs' in catalyzing the development of industries such as telecom equipment in Ottawa, wireless equipment in Calgary or the efforts to create an ICT (information and communication technologies) 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

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innovative capabilities of local firms, and represent the common, collective interest of firms in the industry when required

Legislation, law and laboratories

Our cases also reveal the subtle but pervasive influence of institutional forces, exerted in a number of ways and on 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 channelling 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, as noted above, the National Research Council 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 the study began with the premise that 'geography matters', it recognized the perils of presupposing the importance of place, rather than revealing it through systematic study. What is emerging from the individual 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 (Bathelt *et al.*, 2004).

A particular example is the development of the concept of an innovation entrepôt (Phillips, 2002). This type of industrial cluster is not characteristic of clusters in an industrialized economy, but suggests a model that might apply to developing economies. Moreover, these findings lead us to appreciate the specificity of particular case study circumstances, in which regional, national, sectoral and historical variation is significant.

Conclusion and policy implications

The OECD concluded that the study of national innovation systems offers new criteria for evaluating the effectiveness of government science and

technology policies. Applying the innovation systems approach means policy makers can identify sources of success and failure within the broader mix of institutions that facilitate or inhibit the innovation process, and specific structural gaps in the innovation system. Policies for enhancing the national innovation system must be designed with an eye to their impact at the local level within clusters in a regional innovation system. Attempts to develop policy exclusively at the national level in a country such as Canada may flounder on the diversity of the Canadian innovation system. A regional focus grounds our understanding of the innovation process within a meaningful complex reality.

A framework designed to accomplish this requires a broad mix of policies, including those providing support for upgrading the innovative capabilities of firms across a range of sectors; infrastructure (both physical and technological) policies promoting the rapid diffusion of new technologies across a range of firms; policies building the market for new technologies; and policies supporting the growth of SMEs 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.

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 on the intangible assets of social capital and trust as part of the glue that holds the networks together. As the ISRN case studies confirm, a key factor that underlies the competitive advantage of these regionally based networks is the strength of the talent pool located in the region.

The new 'geography of talent' is important in two respects. It is talent, rather than more traditional economic incentives, that serves as a magnet for attracting existing firms to a region. Secondly, the presence of talent and a critical mass of firms attract other knowledge-based workers. The presence of talent is partially a product of the quality of education and training institutions in the region, and more intangible lifestyle factors that make a specific region attractive (Gertler *et al.*, 2002).

Many of the essential elements for enhancing Canada's innovative capacity are currently in place. In Canada, public research infrastructure, such as post-secondary institutions and Government labs, are a critical component of local and regional innovation systems. They are strongly responsive to the industrial structure of their economies and they operate in the context of other elements of the innovation system. While continued investment in strengthening research capacity is 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 may not produce the desired outcome.

A comprehensive framework of policies to support the innovation system must recognize the interactive and interdependent nature of all the elements of the system. Investments in expanding the knowledge base of a local or regional economy without due attention to either its existing industrial structure or the 'absorptive capacity' of the firms operating in it may risk being squandered. What is essential for effectively upgrading an innovation system is to 'embed' the business sector in a broader system involving greater complexity of interaction and stronger links between the actors.

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 for promoting regional growth. Greater attention must be paid to fostering the growth of dynamic, locally-based clusters of innovative firms embedded in regional innovation systems. These strategies must be designed with an eye to the industrial structure and innovative potential of the regions in question.

A well functioning innovation system requires that the federal Government work with, and through, regional and local partners, stimulating the development of dynamic clusters at the local and community levels. Critical for the success of such a strategy 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 effective innovation strategies within the framework of existing national and regional policies.

Building trust among actors in a local or regional economy is a difficult process requiring 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.

Notes

1. For a discussion of innovation in federations see Holbrook and Salazar (2004).
2. The workshop led to the commissioning of a series of papers that were subsequently published in de la Mothe and Paquet (1998).
3. The network also maintains its own web site <<http://www.utoronto.ca/isrn>> and several of the nodes publish electronic newsletters that have proved to be an invaluable mechanism for disseminating the research findings of network members, updating network members and their stakeholders on the latest research results from around the world and expanding the network's broader audience.
4. The following discussion draws from a more extensive treatment of these themes in Wolfe and Gertler (2004). The longer paper includes a full set of references to the individual case studies. The most recent set of case study results can also be found on the ISRN web site at: <http://www.utoronto.ca/isrn/working_papers.htm>.

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