Innovations and Sustainability

Part 2

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This is the second of a six-part Discussion Paper Series of the SSHRC Research Project: *Environmental Governance for Sustainability and Resilience: Innovations in Canadian Biosphere Reserves and Model Forests*. This project involves researchers located at the University of Waterloo, Ontario and University of Saskatchewan, Saskatchewan, Canada.

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This Discussion Paper is intended to spark discussion and debate. Please use it but ensure that the ideas presented within are appropriately attributed to the author. Correspondence about the project as a whole can be directed to Dr. Robert Gibson at rbgibson@uwaterloo.ca or Dr. Maureen Reed at m.reed@usask.ca

Innovations and Sustainability

2. Synoptic overview of strategies and programs to develop a Canadian Innovation System for the new knowledge-based economy. Main issues being raised by official reviews, independent academic reviews and commentaries. Preliminary concluding observations.

Current Situation in Developing a Canadian Innovation System

Many organizations and individuals in Canada are aware, interested, and involved in technological and other innovations and their potential role and benefits for the national and regional economies. Given the structure of Canadian federalism, both the federal and provincial governments have roles in fostering innovations in different social and economic sectors. Major initiatives tend to cluster in urban regions across the country with the over-all result being that the Canadian Innovation System under construction is in fact a regional (within country) innovation system.

Canada has been a member of the Organization for Economic Cooperation and Development (OECD) since the latter was founded in 1961. As of 2012, Canada was well into negotiations with the European Union for some kind of “free trade” agreement. This means that many government officials, corporate executives, and people in Canadian non-governmental organizations are well aware of the work of these organizations, and many have participated in meetings related to innovations for social and economic development that have been convened by international bodies. There is also a general awareness of Canada’s rankings in OECD of performance among member countries in building effective national and/or regional innovation systems for the knowledge-based growth economies. The federal government takes these rankings seriously as it strives to improve the weaker components in the system it is promoting.

The over-all goal is to bring together results from research in the sciences and applied sciences into various business sectors in ways that management of the latter can readily take up and use such knowledge for developing new products and services, and eventually grow to become competitive in export markets throughout the world. There is a strong sense of urgency in doing this. It is widely believed that a new “knowledge-based economy” is the next major transformation underway in a post-industrial world

where the heavy industrial and manufacturing economies have now emerged strongly in Asia and are growing fast in South America and the Middle East.

Main Institutional Arrangements and Programs for The Canadian Innovation System.

Although there are certainly overlaps, it seems possible to discern at the federal government level the emerging structure of the Canadian Innovation System. These are briefly summarized in terms of: 1) facilitating policy frameworks; 2) major organizational and program components; 3) recent government-sponsored reviews of the system(s) being built; 4) some provincial complementary arrangements; and 5) independent research and critiques by academic scholars.

1. Policy Frameworks

1.1. *Policies for Science and Technology:*

There are a number of precedents for promoting science for use in social-economic development in Canada. For example, the National Research Council was established in Ottawa in 1916 and has grown considerably in stature since then. In the 1960s, ideas about a science policy were discussed with a view to establishing some direction for developing science and technology that would inform social and economic policies. In 1971, the Ministry of State for Science and Technology (MOSST) was created. The Ministry of State (MoS) concept was an innovation in governance at the federal level in Canada during the 1970s. Each MoS was organized as a horizontal body over a number of operational federal departments and agencies in a major sector where it was to develop policy coordination arrangements for the sector while leaving the program administration responsibilities to each department. There was much debate about the effectiveness of this arrangement because of the lack of authority inherent in a MoS compared to that of old line and well-established departments. A number of the original MoS have been disbanded along the way, but the MOSST still exists.

MOSST negotiated the first National Science and Technology Policy (NSTP) in March 1987. Both the federal and provincial governments approved NSTP. The policy noted

that national research should be related to national needs, it emphasized the importance of Research and Development (R&D) for social, economic and regional development, and it recognized a need to address impediments to research, development, and innovations. The consultation necessary to obtain provincial support for the policy was itself an innovation, one not repeated for S&T since then.

Following wide consultations and extensive reviews by different organizations beginning in 1994, a new science and technology strategy was announced in 2007 (Government of Canada 2007). The strategy is linked more directly to the needs for a Canadian Innovation System. Under the terms of this strategy a Science, Technology and Innovation Council (STIC) was created to be an external advisory committee to governments. Industry Canada (2007) then based its own policy statement on this science and technology strategy statement. A major supplemental policy commitment was reached in 2002 between the Association of Universities and Colleges of Canada and the federal government (AUCC and Government of Canada, 2002). Academic institutions agreed to double their research efforts and triple their commercial outputs within the subsequent decade in return for continuing federal support for academic R&D and for university infrastructure.

1.2. *Policies for Financial Incentives:*

The *Department of Finance* sets the policy for the *Scientific Research and Experimental Development (SR&ED) Tax Credit Program* and the *Canada Revenue Agency (CRA*) administers it. The program was first initiated in 1944, and the current basic structure of it was developed between 1983 and 1985 with some administrative modifications since then. Its purpose is to encourage businesses in all sectors to conduct R&D in Canada and thereby enhance Canada's economic growth, competitiveness and technological base. The general definition of SR&ED is similar to OECD's, i.e. "work that achieves a technological advance, through a process of systematic investigation, overcoming a technological uncertainty, and conducted by qualified people". (Technology Initiatives Group Ltd, website accessed February 2012). The federal government gives eligible claimants cash refunds and/or tax credits that are among the most generous of their kind in OECD rankings. In 2011, there were reportedly more than 20,000 claimants who received over $4.7 billion (Globe and Mail newspaper, March 11, 2011). An impressively

large number of consulting firms are involved in the process. There is constant debate about the degree of supervision provided to weed out false claims.

Following several program reviews, and especially the “Jenkins Report” in 2011 that attracted much attention from the business press (see 3.5 below), the federal “Economic Action Plan 2012” (hereafter ‘Budget 2012’) noted that the government has generally accepted the Jenkins recommendations and is moving to reallocate some of the tax credits to direct business led R&D rebates and to setting aside $400 million for venture capital support as well as another $100 million to the Business Development Bank of Canada for their funding programs.

1.3. *Policies for Direct Assistance:*

The *Industrial Research Assistance Program (IRAP)* draws upon the National Research Council to assist CRA. This program focuses more directly on small and medium size enterprises (SMA). Definitions of SMA seem to vary rather widely in Canada. Industry Canada defines the SMA group itself as enterprises with no more than 500 employees with annual sales of less than $500 million. Small enterprises are generally considered to be ones with fewer than 100 employees if in the manufacturing sector, or 50 in the service sector, and both will have less than $10 million in annual sales. Budget 2012 will provide an additional $110 million annually to double support to companies through the IRAP.

The Canadian Innovation and Commercialization Program (CICP) was initiated in 2010 to help fill a “pre-commercialization gap” that exists between a stage where an innovation is sufficiently far along it can be tested in an operational context, but it has not been brought to scale. CICP is to supplement the SR&ED and IRAP, and it is also directed primarily for the SME sectors. CICP is administered by Public Works and Government Services Canada through the Office of Small and Medium (OSEM) Regional Offices. Successful applicants in effect sell their innovation to the federal government under a contractual agreement (that does not include intellectual property components) and the government then applies it to various programs it sponsors that provide the testing and modifications that might be made to it. The priority areas of interest to the federal government are environment, safety & security, health, and

enabling technologies. Budget 2010 initially committed $40 million over 2 years to CICP and Budget 2011 added $80 million over three years. At the first rounds of applications in 2010, 27 were eventually approved, and in 2011, 36 were approved. Budget 2012 provides $95 million over three years starting in 2012-14 and $40 million /year thereafter to make CICP permanent and add a military procurement component.

2. Major Organizational and Program Components

The federal government has some 200 research institutions and facilities that are managed by a number of departments. Most are "in-house" research operations that support the mandate of the home department. The Departments of Agriculture and Agri-food, Natural Resources Canada, Fisheries and Oceans, and Environment are examples. The others include regional development agencies. A number of these have been formed over the years and revised a number of times. The current set is: Department of Western Economic Diversification (WD) for the four western provinces, Canadian Northern Economic Development Agency (CanNor) for the Northwest Territories, Nunavut and Yukon, Federal Economic Development Initiative in Northern Ontario (FedNor), Federal Development Agency for Southern Ontario (FedDev Ontario), Federal Development Agency for the Regions of Quebec (CED-Q), and the Atlantic Canada Opportunities Agency (ACOA) for the four eastern provinces. These agencies are also responsible for some transfer payments, some expenditures on infrastructure, and the Community Futures Development Corporations (Dupuis 2011). Budget 2012 will support an enhanced "Western Innovation Program" to be administered by WD.

2.1. *Industry Canada Portfolio*: Industry Canada has been given the lead role for developing the Canadian Innovation System. It does this through its "portfolio partners", a variety of different programs that report to the Minister of Industry. The portfolio changes as budgets change through a familiar process of "meta-governance", i.e. a continual review of existing agencies and programs, adding new layers to address new problems while consolidating, transferring, or terminating older administrative units that no longer seem to be politically salient. Industry Canada's 2010-2011 "Program Activity Architecture" has stated that the Strategic Outcomes being sought are:

- "The Canadian marketplace is efficient and competitive,

- Science and technology, knowledge, and innovation are effective drivers of a strong Canadian economy, and
- Competitive businesses are drivers of sustainable wealth creation".

Research institutes operated by the National Research Council (NRC) are the organizations that are relied upon the most to serve these functions. They have been located in a number of urban centres, and are often close by, or on university campuses. Some have been identified as key draws for creating "vibrant technology clusters". NRC began devising the cluster strategy in the 1990s with examples such as Silicon Valley (Palo Alto, California) in mind. In 2000, funding was received to initiate four clusters in Atlantic Canada, and these were deemed to be sufficiently successful that others were initiated across Canada. As of 2012, there were 11 clusters, all directed to different priority areas in Canada's national S&T strategy. Currently, the NRC institutes and associated clusters in different urban areas across Canada are:

In BC:

Penticton: NRC Herzberg Institute of Astrophysics (one of two locations); Dominion Radio Astrophysical Observatory. Conducts astronomical observations, and research on advanced scientific instrumentation and data technologies.

Victoria: Other location for the Herzberg Institute of Astrophysics. Canada-France-Hawaii Telescope. Gemini Observatory.

Vancouver: NRC Institute for Fuel Cell Innovation: *Fuel Cell & Hydrogen Technology Cluster.*

In AB:

Edmonton: National Institute for Nanotechnology: *Nanotechnology Cluster*.

Calgary: NRC Institute for Biodiagnostics, research on diagnostics and imaging.

In SK:

Regina: NRC Institute for Research in Construction; *Sustainable Infrastructure Cluster.*

Saskatoon: NRC Plant Biotechnology Institute; *Plant for Health and Wellness Cluster.*

In MB:

Winnipeg: NRC Institute for Biodiagnostics; *Biomedical Technology Cluster*.

In ON:

London: NRC Industrial Materials Institute, and NRC Institute for Research in Construction.

Ottawa: National Bioproducts Program; NRC Canada Institute for Scientific and Technical Information; NRC Canadian Hydraulics Centre; NRC Canadian Photonics Fabrication Centre; NRC Centre for Surface Transportation Technology; NRC Genomics and Health Initiative; NRC Imaging Network Portal; NRC Industrial Research Assistance Program; NRC Institute for Aerospace Research; NRC Institute for Biological Sciences; NRC Institute for Chemical Process and Environmental Technology; NRC Institute for Microstructural Sciences; NRC Institute for National Measurement Standards; NRC Institute for Research in Construction; NRC Steacie Institute for Molecular Sciences. *Photonics Cluster*.

Chalk River: NRC Canadian Neutron Beam Centre.

Mississippi Mills: Carleton/NRC Fire Research Facility

In QC:

Boucherville: NRC Biotechnology Research Institute; NRC Industrial Materials Institute; NRC Institute for Information Technologies.

Montreal: Aerospace Manufacturing Technology Centre; NRC Biotechnology Research Institute.

Saguenay: Aluminium Technology Centre: *Aluminium Transformation Cluster.*

In NB:

Fredericton and Moncton: NRC Institute for Information Technology (Fredericton); Bioinformatics Lab (Moncton); *Information Technology and e-Business Cluster (both cities).*

In NS:

Halifax: NRC Institute for Biodiagnostics; NRC Institute for Marine Biosciences: *Life Sciences Cluster.*

Ketch Harbour: NRC Institute for Marine Biosciences; Marine Research Station.

In PEI:

Charlottetown: NRC Institute for Nutrisciences and Health: *Nutrisciences and Health Cluster.*

In NL:

Saint John's: NRC Institute for Ocean Technology: *Ocean Science Cluster.*

This distribution of funding takes into account other clusters that were already quite far along in other sectors, such as transportation (rail and aerospace) in Montreal, *in situ* energy (oil and gas) in Calgary, software design and informatics in the Waterloo Region.

NRC is well aware that it may take decades to create a “vibrant technology cluster”, but NRC institutes and industry support programs are intended to expedite the process. Nevertheless, “each cluster needs visionary and strategic leadership, community-based champions, and risk capital providers. They also need specialized suppliers, a shared R&D infrastructure and networking opportunities, along with expertise in managing intellectual property and the challenges of commercialization”. (NRC website, accessed February 2012). Budget 2012 added $67 million for NRC to support business-led and industry-relevant research.

Private sector R&D is also important to the overall process of creating technology clusters because they can lead to the final stages of commercialized innovations. They are usually proprietary ventures protected by various legal provisions to protect intellectual property rights. There are other contributions to clusters. Some provinces have supplemental programs to promote innovations, Ontario and Quebec (see below) and the western provinces seem to do this more than the eastern provinces.

2.2 *Funding the Basic and Applied Research*

The Tri-Council funding agencies: Because the post-secondary education sectors are in provincial jurisdictions, federal funding goes into basic and applied research. This comes from the tri-council granting councils, i.e. Natural Sciences and Engineering Research Council of Canada (NSERC), the Canadian Institutes of Health Research (CIHR) and the Social Sciences and Humanities Research Council of Canada (SSHRC). As of about 2010, the Tri-council had received $2.7 billion to dispense under their different rules for applicants. NSERC and CIHR had received much more than SSHRC given government priorities, and this was reflected in budget 2011 when $37 million was added, $15 million each to the first two Councils and $7 million to the social sciences. Budget 2012 continued this level and allocation of funding for applied research.

This has also led the first two Councils to spend more on developing their own partnership arrangements with other organizations. The CIHR operates 13 “virtual institutes” for Aboriginal Peoples’ Health; Aging; Cancer Research; Circulatory and Respiratory Health; Gender and Health; Genetics; Health Services and Policy Research; Human Development, Child and Youth Health; Infection and Immunity; Musculoskeletal

Health and Arthritis; Neurosciences, Mental Health and Addiction; Nutrition, Metabolism and Diabetes; and Population and Public Health.

Under the Innovative Challenge Award Program (2004) for example, NSERC and the Canadian Science and Technology Growth Fund administered by the Business Development Bank of Canada were able to make a number of grants or awards to encourage graduate students in engineering and science to relate their topics to potential new products or services (NSERC 2009).

The Canada Foundation for Innovation (CFI) was created as a separate Crown corporation in 1997 to fund up to 40% of infrastructure facilities on or near university campuses; the remainder comes from provincial or private sources. Universities must have a strategic plan pre-approved by the CFI in order to apply. This shared-cost funding provides state-of-the-art equipment and facilities for applied work and/or "incubators" for research personnel with an entrepreneurial interest to develop prototypes and business plans for possible start-up high technology companies. These incubator facilities might also help gain access to 'angel investors' to help fund and mentor the start-ups, and then to venture capital for further commercialization of innovations. Budget 2012 will add $500 million over five years to CFI, starting in 2014-15.

Canada Research Chairs program: Under the terms of the CFI approved strategic plans, universities can also apply to the Canada Research Chairs (CRC) program. It was initiated in the early 2000s, with a federal government commitment of $258.6 million to fund 1,902 CRC appointments across Canada. The purpose is to strengthen excellence in research capabilities for a wide range of subjects. The funding is allocated by the Tri-council granting agencies with a pre-allocation of 45% of the Chairs to natural sciences and engineering, 35% to health research, and 20% to social science and the humanities. Each degree-granting institution in Canada is pre-assigned the number of Chairs it can apply for at any given time, based on the CFI approved strategic plans. The approved allocations are issued annually.

A Steering Committee comprising the Chairs of each of the granting councils, a Deputy Minister of Industry Canada and an *ex officio* CFI official guide this process. Tier 1

Chairs are for outstanding people in their field whose appointment is for 7 years and renewable. The home university receives $200,000 annually for the term of their appointment to support their work. Tier 2 Chairs are for promising "emergent researchers" who may be appointed for 5 years renewable once. Universities receive $100,000 annually to support their work. CFI can augment this with grants to bring research facilities up to the highest standards. As of March 2012, there were 812 Tier 1 Chairs and 1,007 Tier 2 Chairs for a total of 1,819 appointments in 72 participating universities; 1,086 of these had been renewed for a 2nd term. About 24.5% of the appointments (446) were people from other countries and Canadian expatriates attracted back to Canada.

The *Networks of Centres of Excellent (NCE) program* has created "virtual institutes". The program was established in 1989 by the federal government. It was considered to be an innovative way to mobilize the best talent from the academic sector and various socio-economic sectors to make knowledge exchange and technology transfer happen. It was modeled in part on the Canadian Institute for Advanced Research (see below). The program is managed by the Tri-council in partnership with Industry Canada. It became permanent in 1997 and was administratively modified in 2002. It now receives letters of intent annually to decide on renewals or approval of new NCEs. Every network is eligible for funding for two 7-year cycles, subject to progress reports and peer-reviews of on-going work. More recently a Research Management Fund has been established to help ease networks that successfully completed their two 7-year cycles to other sources of support.

As of its 20th anniversary in 2009, the NCE program had created 39 different networks including 17 on-going ones. More recently it had also created 17 Centres for Commercialization and Research, and, since 2007, four Business-led NCEs. Over 1,700 partners were involved in these arrangements each year, at least 150 spin-off companies had been created, and thousands of patents and hundreds of licenses were received to use commercial technologies. In addition, on behalf of the College and Community Innovation (CCI) Program, NSERC has helped 35 partnerships, each for five-year periods, between technical colleges and local small business organizations. Budget 2012 will add $12 million/year to make business-led Networks of Centres of Excellence a permanent program.

Industrial R&D Internships (IRDI): This program was created in 2007 to provide 1,000 internships per year for graduate students and postdoctoral fellows from all disciplines to relate their specialized skills to "real-world research challenges". Stipends are up to $10k for a period of 4-6 months and the federal contribution is limited to no more than 50% of this amount. IRDI is formally under the Tri-Council Centres of Excellence, but it is being administered by Mitacs, a national not-for-profit research organization with a number of partners across Canada. Budget 2012 provides $14 million over two years to double the number of internships.

2.4. *"Stand Alone" Components of Innovation Systems:*

The following are some examples of organizations that seem independent from the main clusters and networks noted above. Federal funding seems to be granted to them as initiatives within annual budgets rather than as part of larger programs.

Genome Canada: This was created as an independent non-profit corporation in 2000 and given the mandate to develop and implement a systematic approach to genomics and proteomics research. These underlay what will become transformative technologies in support of a Canadian bio-economy that can become internationally competitive. A distinctive feature of Genome Canada is that it is required to include genomics-related ethical, environmental, economic, legal and social research (GE^3LS) into their programs. During its first decade, Genome Canada has received $915 million of federal funding that enabled it to create five regional centres all viewed as an inter-active emergent Canadian Genomics Enterprise. Budget 2012 provides $60 million for new applied research programs.

The collaborative work of this enterprise has, with matching grants, received $1.9 billion for research on topics such as cancer, infectious and rare diseases, adverse drug reactions, and crop science. The enterprise has also created 20 new companies in the first 10 years. Its strategic plan for 2012-2017 envisions "a seamless portfolio of programs that optimizes the entire innovation continuum from research and discovery, to applied research, to development and demonstration, and to translation and commercialization" (Genome Canada 2012, p.14). This means a more "purpose-driven"

approach from the demand side of industry interests than the push side from researchers with ideas for someone to explore further.

Sustainable Development Technology Canada (SDTC) is a non-profit foundation created in 2001. It reports to Natural Resources Canada. It administers two funds. The SD Tech Fund ($590 million) supports the development and demonstration of clean technologies, especially in areas that can be related to pollution prevention (air, water and soil) and/or to climate change. STDC issues a call for proposals and for those approved, takes an active role in developing industry-led consortia to take the innovations through to the venture capital financing stage. The 19 funding rounds to date have approved 228 projects that were allocated $560 million in total. This has leveraged an additional $1.4 billion from other sources. In addition, SDTC has a $500 million fund, the "NextGen Biofuels Fund" to support large demonstration scale facilities for biofuel production. (Source: SDT websites, accessed, February, 2012).

Canadian Institute for Advanced Research (CIFAR): The idea for this kind of private non-profit institute arose at the University of Toronto in the 1970s and was subsequently realized in 1982 with the founding of CIFAR as a unique approach to developing international, interdisciplinary collaboration among groups of scientists and scholars to address high priority issues. CIFAR is based in Toronto with a Secretariat. It also has a Board of Directors with a Council of Advisors on matters relating to the operation of the Institute, and a Research Council to identify high priority research topics, help establish appropriate research groups for each, and phase them out should they no longer be judged "advanced".

As of 2011, CIFAR had an annual budget of $16 million drawn from the federal government, three provincial governments (BC, AB, ON), foundations, corporations, and philanthropists. The 12 interdisciplinary research programs underway were: Cosmology and Gravity; Earth System Evolution; Experience-based Brain and Biological Development; Genetic Networks; Institutions, Organizations and Growth; Integrated Microbial Biodiversity; Nanoelectronics: Neural Computation and Adaptive Perception; Quantum Information Processing; Quantum Materials; Social Interactions, Identity and Well-being; and Successful Societies. (Source: CIFAR website, accessed February, 2012). Budget 2012 provides another $10 million over two years.

Canada Advanced Research and Innovation Network (CANARIE): This was established in 1993 to develop the use of a high speed and high capacity fibre-optic network to enable scientists and others to access and use tools that are the foundation for data-intensive, multidisciplinary, collaborative digital science, while also supporting the development of a competitive digital economy. The network has grown to use 19,000 km of fibre optic cable that links Canadian advanced networks to over 100 other advanced networks in 80 countries, with some 1,100 institutional connections altogether.

- CANARIE sees this entity as a single world class research, education, and innovation network. It services it with a staff of 21 who manage its operation and also develop technological improvements in its structure. It has an annual budget in the order of $60 million about 40% of which comes from the federal government and the rest from the provinces and user fees. The volume of traffic through it has increased five-fold between 2007-2012. This has been driven mainly by the use of digital data in health care (e.g. medical imaging), natural resources (e.g. global sensor networks, climate models), physics (data from the Large Hadron Collider, European Organization for Nuclear Research, CERN), and social sciences (downloading databases from Statistics Canada and other official sources). (CANARIE 2012). Budget 2012 provides $40 million over two years to continue this work.

Forest Innovation and Market Development Support: Please see "Repositioning the Forest Sector in Canada for the 21st Century" in *Innovation and Sustainability – 5*. Budget 2012 provides $105 million over two years for support to the Expanding Market Opportunities Program and to the Forest Innovation Program.

3. Program Reviews of the State of the Canadian Innovation System

3.1 *National Research Council Renewal Project, 2005*: The renewal project was to re-position the NRC for the future (NRC 2005). It consisted of several consultant studies (e.g. Murgatroyd 2005) and consultations with other organizations that addressed key trends in the global economy, critical developments in science and technology, and

major challenges and opportunities for Canadian industry. The global trends were sketched out in terms of:

- Changing demographics (population growth, migration, ageing and opportunities for youth);
- Geopolitical and social challenges including the growing obsolescence of the western worldviews and assumptions on which they are based;
- Increasing lack of confidence in institutions and leadership;
- Demands for enhanced security from various threats and vulnerabilities including the privatization of conflict;
- Global challenges such as energy environment/climate change, health and wellness &
- Major restructuring of the global marketplace as new industrialization centres arise in Asia and elsewhere.

While “waves of innovation” have been experienced from the time of early industrialization, they are now becoming more rapid and disruptive. “Transformative technologies” already underway include ICT followed soon by biotechnologies and energy/environmental technologies. The major new “driving or enabling technologies” are considered to be nanotechnology, materials science, photonics, microfluidics, and quantum information. Not only that, but these are expected to converge in ways that might enable each other such that some “nano-bio-info-cogno-technologies” could open up all manner of new (but unpredictable) possibilities.

The main concluding observations of this review were:

- The Canadian R&D community is busy, complex but unfocused. There is no clear explicit strategy for science and technology;
- There is good evidence that Canada’s, science and technology expertise is world-class and productive. Canada also has one of the most effective and generous tax-credit regimes that support innovation;
- Canada does not have innovation practices that enable increased private sector R&D investment and for support of the flow of venture capital. It has poor coordination among the players in innovation policy both provincially and federally;

- NRC is in a good position to help bring this altogether. It needs to become more responsive, agile, and integrated in its delivery of services and programs to the key sectors of industry.

3.2*. Council of Canadian Academies:* The CCA was formed in 2005 and is comprised of the Royal Society of Canada, the Canadian Academy of Engineering, and the Canadian Academy of Health Sciences. Its role is to conduct independent science-based assessments. It has a $30 million endowment from the federal government that entitles the government to refer up to five questions per year seeking Council's advice.

The Council's first assessment, completed in 2006, was of the state of science and technology in Canada. It identified four broad areas of strength, i.e. in natural resources, information and communications technologies, health and related life sciences and technologies, and environmental technologies. The federal government adopted these for its 2007 Science and Technology Strategy.

Also in 2007, the Council was requested to assess innovation and business strategies in Canada. It created an Expert Panel on Business Innovation and decided to focus on long-run phenomena that unfold over decades and through several business cycles, including the much larger and sudden downturn triggered in 2008 while the Panel was doing its work. The Panel saw its role as diagnosing the symptoms of lagging business innovations that had been long evident, and presenting them in policy relevant but not policy prescriptive ways. Thus it viewed innovation primarily to be an economic process rather than a science and technological process.

In its report (CCA 2009), the Panel first took note of the much larger contexts in which these phenomena occurred, i.e. the history and structure of the Canadian economy, noting especially that it is "upstream" in most sectors as a commodity supplier and technology adopter with relatively small and fragmented domestic markets having a large degree of foreign ownership and control over the long supply chains in which Canadian firms are embedded. The "issues of pervasive influence" identified by the Panel "suggest the need for proactive public policies" that:

- Encourage investment in advanced machinery & equipment in general and in ICT in particular. Incentives need more understanding of why ICT has been so slowly adopted so far;
- "Sharpen the incentive" for innovation-oriented business by increasing their exposure to competition and promoting a strong export-oriented provision of goods and services that are "downstream" in the value chains hence closer to end-users;
- "Improve the climate for new ventures" that will translate research into viable businesses especially during their early-stage needs for financing with experienced mentorship;
- Support areas of Canadian strength and opportunity "through focused, consistent sector-oriented strategies" (direct quotes from p.26).

In addition, the CCA has carried out, or as of 2011 was in the process of undertaking ten assessments with more narrowly defined topics (CCA. 2011.)

3.3. *Government of Canada, Mobilizing Science and Technology to Canada's Advantage. 2009*:

This is the title of a Progress Report prepared on behalf of the Department of Industry, Department of Finance, and Ministry of State (Science and Technology). Its intent is "to demonstrate more clearly the impact of federal S&T investments and to advise Canadians of the progress being made in implementing the Strategy. The examples "…are not meant to be comprehensive: rather they show the scope and depth of the Government of Canada's activities, its commitments to getting initiatives up and running and to advancing the principles of the S&T strategy" (p. 11) The report summarizes some policy, financial, and administrative details that "modernize" competition and investment laws and strengthen public-private research and commercialization partnerships especially in the four priority S&T sectors.

The report also up-dates the funding commitments for the different components of the Canadian Innovation System, such as renewed funding for the federal government's Foundations as well as new individual programs or other initiatives that were launched in recent annual budgets. Examples of the latter (including Budget 2012, and in no presumed order of importance) are:

Institute of Neurosciences, Mental Health & Addiction (addition to the Canadian Institutes of Health Research);

Perimeter Institute for Theoretical Physics and Institute for Quantum Computing, Waterloo ON, 2007 & 2009;

Strategic Aerospace and Defense Initiative (SADI), Industry Canada Industrial Technologies office, 2008;

Bioindustrial Innovation Centre, Sarnia, ON;

Automotive Partnership Canada (APC) for 5 years (2009-2014), and for the North American Centre for Diesel and Advanced Power-train Research, Windsor, ON;

Ivey Centre for Health Innovation and Leadership, Richard Ivey School of Business, London, ON;

Materials Technology Lab at McMaster Innovation Park, Hamilton ON, 2008;

NEPTUNE Canada (with CANAIRE and CFI), $ 300 million for a regional cabled ocean network of continuous data recording devices and remotely operated vehicles positioned at multiple sites on the ocean floor and linked electronically with interactive labs on shore, in order to expand scientific knowledge of the ocean and ocean floor off BC and the Pacific Northwest;

Canadian Space Agency, $100 million over 3 years (from 2009) for development of space robotics related to earth observations and communication satellites;

Feasibility study for a High Arctic Research Station at Cambridge Bay, NU;

Montreal Centre of Excellence in Brownfield Rehabilitation;

International Network of Protein Engineering Centres;

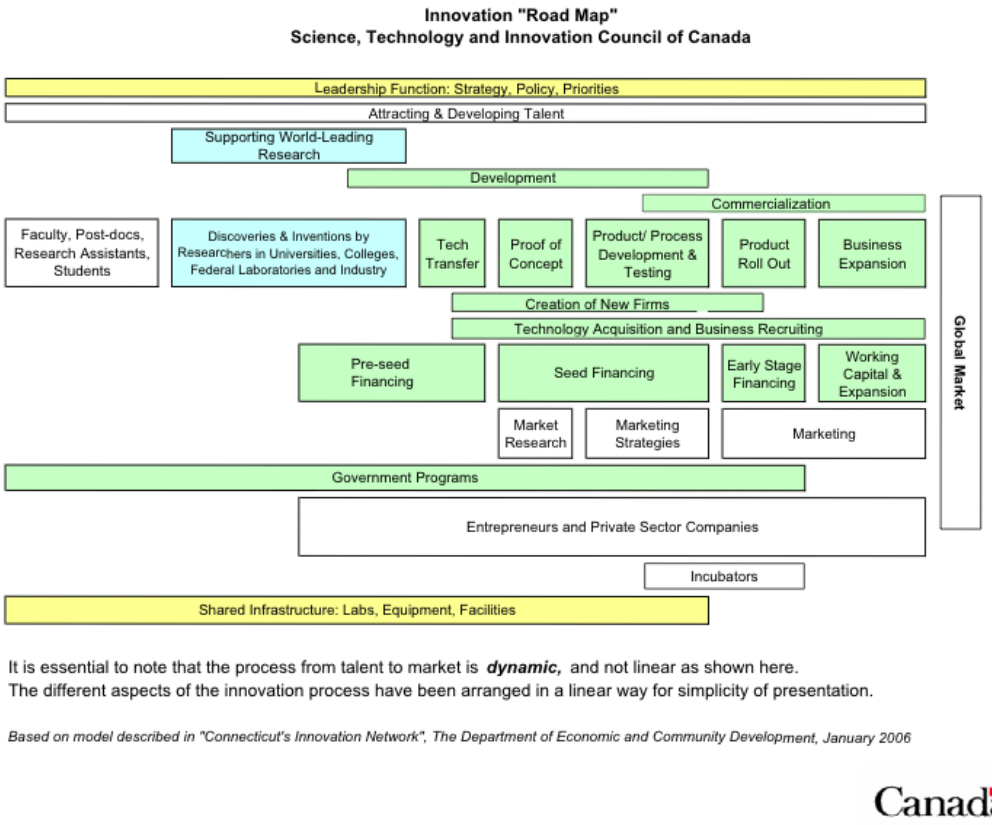
Evaluation of team-based approaches to health care delivery, McMaster University 2012;

Enhanced satellite data reception, RADARSAT, NR Canada, 2012;

New technologies for the production of medical isotopes, NR Canada, 2012.

3.4. *The Science, Technology and Innovation Council (STIC)* was created in 2007 as a 16 member external advisory council. It has created a “road map” image of the systems it advises (see below), and undertaken two State of the Nation reviews in 2008 and 2010. Based somewhat on the OECD definitions, STIC in 2008 defined innovation as “the process by which individuals, companies, and organizations develop, master and use new products, designs, processes and business methods. These can be new to them, if not to their sector, their nation, or to the world. The components of innovation

include research and development, invention, capital investment and training and development (STIC 2008). Through consultations with other groups and a review of benchmark indictors used by OECD and other international bodies STIC adopted a set of 20 indicators to measure innovation performance in 2010, with some comparisons to what it discovered in 2008.



STIC (2010) again reviewed Canada's science, technology and innovation system. Their perspectives are summarized as follows:

> "Canada aims to be among the world's innovation leaders. To do so we must understand the components and connections in the science, technology and innovation (STI) system. A well-functioning STI system is built on the foundation of a strong talent pool, excellent research, public and private sector institutions that create value from research and development, strong systemic mechanisms for knowledge transfer and application, and successful commercialization of innovation within the private sector. It takes a well-functioning integrated system to move ideas from imagination to innovation to markets." (p. 1).

Commentary was mainly addressed to the four priorities identified by the federal government, i.e. environmental sciences & technologies, natural resources & energy, health & related life sciences and technologies, and information & communications technologies.

In general, the "talent pool" is holding its own in terms of the number of university graduates, especially in science and, engineering, and in the performance of 15 year olds in reading, math and science. Business has increased the R&D funds in universities but the total is still small, less than 10% of the overall R&D spending by business. Transferring knowledge from research institutions (government and universities) to the market and building a culture of innovation in business "remain paths requiring attention". R&D performed by business in Canada is low by international standards, and declined further from 2007-2009. Collaboration should be considered in a clusters context as a way of building critical mass in both short and long-term research in areas of joint interest to companies and research organizations.

The STIC report reviewed in much more detail on-going work in several countries towards develop criteria and indicators for the different components of a well-integrated innovation system and applied them to compare the situation report in 2008 with the current report for 2010. It also suggested some new indicators, such as tracking business expenditures on IT services rather than just purchases of equipment.

3.5. *Review of Federal Support to Research and Development*: This review was carried out by an Expert Panel convened by the Minister of State for Science and Technology to review the $5 billion of support provided by the federal government annually for R&D in Canada. (Innovation Canada 2011 – the "Jenkins report"). The Panel met with more than 160 stakeholders across Canada, surveyed over 1,000 businesses, received 228 written submissions, and consulted with experts in other countries. The Panel was not to debate over-all funding levels, regulatory work done by federal laboratories, or basic research. However, it did find the funding system to be unnecessarily complicated and confusing to navigate while at the same time it had significant gaps.

The main recommendations were:

- Create an Industrial Research and innovation Council (IRIC) to deliver the federal government's business innovation programs. This would replace more than 60 programs and 17 different departments that now do this;
- Simplify the SR&ED tax credit system so that SME enterprises don't have to rely so heavily on consultants to decipher the details;
- Make business innovation one of the core objectives of government procurement policies;
- Transform the NRC Institutes into a series of large-scale collaborative centres involving business, universities and provinces;
- Have the Business Development Bank work with angel investor groups and develop late-stage risk capital/growth equity funding;
- Assign responsibility for innovation to a single Minister, evolve the current Science Technology and Innovation Council (STIC) as the Innovation Advisory Council, and work closely with the provincial and territorial governments for collaborative dialogues necessary to improve coordination and impact.

Given the scope of these suggestions, there was much commentary and criticisms in the media soon after the Jenkins report was tabled. As noted earlier, in 2012 the federal government had informally accepted the general purpose of these recommendations.

3.6. *Coalition for Action on Innovation for Canada*: This group was formed in 2010 "to forge a consensus across a broad range of stakeholders…for a focused and achievable agenda to position Canada as a world leader in innovation. Leaders from across business sectors and from the academic community are working together to remove barriers holding Canada back from taking its rightful place on the world stage" (lead-in statement on the Coalition's website declaration, accessed February 2012). It further declares that our future prosperity is threatened by global competition, demographics, and productivity issues, hence "we must become a nation of innovators". Innovation is creating value through ideas; it is an attitude that puts ideas to work and it matters everywhere.

The Coalition has a team of 50 leaders from various organizations and has identified ten themes to address: Reform the tax support for R&D; Expand the pool of risk capital;

Adopt the world's strongest intellectual property regime; Strengthen business-academic links; Tap private sector expertise when spending public money; Speed adoption of innovative products and services; Launch a National Learning and Innovation Initiative; Seek out the best and the brightest; Nurture and strengthen innovation clusters; and Ensure on-going advocacy for innovation.

3.6. *Centre for Business Innovation, The Conference Board of Canada*: The Conference Board is a long-established not for profit applied research organization that also organizes conferences, runs courses, and provides other services to business on a fee for service basis. It disseminates information widely to major business associations and organizations. It is affiliated with the Conference Board Inc. New York and its connections in a number of countries. It is also a Canadian partner of the World Economic Forum. These relationships give the CBOC access to related research done elsewhere, including rankings of Canada in various benchmark data comparisons.

The Conference Board has long recognized that Canada's national productivity performance has year-after-year ranked in the middle of the pack or worse. Thus, it established The Centre for Business Innovation in 2012 for a five-year period (initially). The Centre recognizes four kinds of business innovations, i.e. radical changes to products and services and radical changes in the processes of producing them, and incremental improvements to products and services and/or processes. Learning opportunities to be offered are based on continuing applied research and will focus on five areas: Business strategies for firms; Capital markets; Management and/or employees education, training and skills; Public policy; and Performance measurement and macro-analyses (CBOC 2012).

4.0 Provincial Innovation Systems.

Detailed reviews of provincial innovation programs and projects would go much further than the main purpose of this paper. Instead, a brief synopsis of the main features of Ontario and Quebec are given below to indicate both complementarities and overlaps with the federal innovation system, both of which are changing in their details almost all the time. A brief commentary on other provinces is noted in conclusion.

4.1. *Ontario*.

The lead agencies in Ontario are the Ministry of Economic Development and Innovation (MEDI) and the Ministry of Training, Colleges, and Universities (MTCU), supplemented by sector ministries such as the Ministry of Agriculture, Food and Rural Affairs, and the Ministry of Northern Development and Mines. In April 2008, the provincial government launched a $3.2 billion Ontario Innovation Agenda. The general strategy as reported by MEDI is to focus on four general priorities, i.e. building prosperity through increased productivity and innovation, promoting Ontario as the place in Canada to do this, supporting regional growth through the province's strategic sectors, and promoting modernization of government. MEDI has created or administers a number of special funds such as an Innovation Demonstration Fund, the Investment Accelerator Fund, an Ontario Emerging Technologies Fund, an Ontario Venture Capital Fund, and a Business Ecosystem Support Fund. It also provides client-focused advisory services and a brokering of contacts role for prospective entrepreneurs through a number of centres that together constitute an Ontario Network of Excellence (ONE), as well as a number of regional development organizations, and the MaRS Discovery District complex in Toronto. (MaRS originally meant "Medical and Related Sciences" but has since considerably expanded its scope such that MaRS is now just a name, and no longer an acronym).

The Ontario Centres of Excellence (OCE) is a non-profit corporation that focuses on commercialization of innovations in selected sectors such as Information and Communications Technologies, Materials and Manufacturing Technologies, Earth and Environmental Technologies, Photonics, and Energy. OCE also supports the federal Centre for Commercialization of Research (CCR) in Ontario. The MTCU funds the post-secondary educational institutions, and a number of programs that supplement this. The latter include the Ontario Research Fund Research Excellence program to support "transformative, internationally significant research of strategy value to the province", and various small grants to individual industry-academic collaboration initiatives to help expedite them.

The general result has been a variety of commitments to cluster initiatives funded by the federal government (with each party "leveraging" funding from the other, subsequently

reported as an indicator of success by each), along with some stand alone other clusters of smaller scale in smaller urban or near urban rural areas. There appears to be no convenient total list of these, possibly because the picture changes from year-to-year. Some of the provincial support goes into large and well-established clusters such as the ICT and bio-technological clusters in Ottawa and Toronto. Others supplement these larger clusters such as the Greater Peterborough Bioscience Innovation Cluster, the Niagara Ontario's Wine Cluster, the Guelph Agro-Innovation Cluster. and the Ontario Mining Cluster in Sudbury.

Funding has also gone to particular institutions such as the Perimeter Institute for Theoretical Physics and the Institute for Quantum Computing in Waterloo, the Ontario Entertainment and Creative Cluster Partnership Fund in Toronto, and the Ontario Institute for Cancer Research, located in the MaRS complex in Toronto. There are also initiatives underway to determine the feasibility of working towards larger scale sub-regional networks involving a number of communities. An Ontario Biotechnology Cluster Innovation Program (BCIP) has conducted inventories of the core communities in four regions in Ontario with a view to exploring how different clusters might be nurtured in each region, and possibly inter-linked through ICT networking. Informal discussions have been started about a possible Ontario Technology Corridor for Digital Media that would link 11 universities and 11 colleges in the London, Niagara Region, Waterloo, Greater Toronto Area and Ottawa and their various associations with ICT complexes.

4.2. *Quebec*.

The lead agency is the Ministry of Economic Development, Innovation, and Export Trade (MDEIE). It has a very diverse portfolio including responsibilities for administering various statutes and their regulations, tax credits, research funds including a recent consolidation of three university granting agencies (into Fonds Recherche Quèbec), investment funds overseen by government corporations or other agencies and steering committees for major technology-based clusters. Investment Quebec is the largest fund administered by MDEIE. It provides for the full range of advisory services and funding options including loans, loan guarantees and purchasing of share capital of businesses, as well as arranging for tax credits. The main sectors it focuses on are agri-food; mines, materials, energy & environment; forest products; life sciences; and information and communications technologies. MDEIE has a strategic science and innovation advisory

committee and an ethics in S&T advisory committee. The Ministry has developed strategies and action plans for major technology-based sectors such as the aeronautical industry development strategy, biopharmaceutical strategy, and a strategy for the Quebec fashion and clothing industry. In addition, the Quebec Research and Innovation Strategy (QRIS) has been up-dated for 2010-2013 and is viewed as an integral component of Quebec's Economic Development Strategy. MDEIE 2006; c 2007).

The role of the provincial (national) government in Quebec is to provide top-down direction and priorities for management of different socio-economic sectors and for the 17 different administrative regions of the province. The State acts as a facilitator, providing advisory services and targeted funding to help achieve goals, targets and outcomes identified in the various strategies and action plans.

The main challenges identified by MDEIE are the current weaknesses in the international competitiveness of businesses in Quebec, the need to convert compartmentalized thinking of organizations into partnerships among businesses, universities, and government, and the need to focus on the development of new knowledge and transfer technologies to broaden the spin-offs from research. The government already funds S&T in genomics, nanotechnologies, optics & photonics that can also be applied to a number of other sectors including the traditional resource extraction industries as well as fields such as aeronautics, ICT, and pharmaceuticals. Agencies such as the National Optics Institute, Genome Quebec and Nano Quebec have already been established. Enhanced tax incentives along with direct funding is on offer for R&D conducted by medium size firms, establishing research internships in businesses, and to foreign investors for locating R&D operations in Quebec.

The research transfer process is still a weak link in the innovation processes, especially from the proof-of-concept, through pre-start up and start up phases of product development. Public research development corporations have already been created to address these weaknesses in close cooperation with major universities and teaching hospitals based in four different constellations in the Greater Montreal and Quebec City urban regions. These public corporations deal with advisory services, intellectual property issues, and start up funding options, and they have a good record in terms of creating spin-off companies, obtaining patents and licenses, and creating employment.

Quebec also supports 11 “technology incubators” in these and other regions. It intends to strengthen further the 31 CÉGEP Technology Transfer Centres (CCTT), each specializing in different socio-economic sectors. Funding is also being made available from a Regional Economic Intervention Fund (FIER) to help start ups in other sectors, and via tax measures create additional “pre-competitive research consortia” (to the 11 existing ones) in different sectors and regions.

The federal government also contributes funding for some of the main cluster developments in Quebec (as part of its Canadian Innovation System). Through the Economic Development Agency of Canada for the Regions of Quebec (CED-Q) that works with the Ministry of Municipal Affairs, the Regions and Territorial Settlements (MAMROT) it supports 56 Community Futures Development Corporations and 10 Business Development Corporations (as the Réseau des SADC du Quèbec). Offices in 14 regions provide advisory help and services, start up funds for the small business sector, recognition awards for valuable initiatives in small communities, and special programs for youth to enhance problem-solving team work and business useful skills development (SADC 2010; CED-Q 2011). At the international scale, the federal government has supported and helped economic development agencies from the 11 largest cities to coordinate the promotion of trade and investment through a ‘unified brand’ of marketing called “Consider Canada”. Montreal International and Quebec (City) International are both associated with this endeavour.

Other sectoral ministries in Quebec such as the Ministry of Education, Leisure and Sport (MELS), have supporting roles in the programs of the MDEIE, and annual provincial budgets provide specific funding of particular projects and programs related to the technological innovation agenda.

4.3 *Other Provinces*: Cursory readings of websites for innovation systems in other provinces indicated that the main themes and issues being addressed to develop these systems are quite similar to those described for the federal and two provincial systems noted above, but with differences in the organizational arrangements arising from their regional economic histories and sector priorities. There can be one or sometimes several lead agencies that set general policies and directions for supporting S&T in universities, technical colleges, and provincial government institutions, and for R&D

support to the private sector. Linking these components to different business sectors remains a key challenge. “Productivity” in a number of sectors, especially for SMEs is weaker than it should be. The need for effective bridging and facilitation arrangements such as “incubators” with a broad range of advisory services and start-up funding is recognized. Initiatives that can take interesting scientific discoveries and potentially worthwhile inventions through the early stages of proof-of-concept, pre-start up business planning through to funding and mentorship for actual start-up or spin-off companies are being provided in various ways. But that is still a long way from growing companies to the point that some might eventually become a competitive multinational corporation in its chosen sector(s). The western provinces are every bit as entrepreneurial as the central Canadian ones, while the history of the eastern provinces seems to pre-dispose them to smaller social economies in relatively smaller communities that rely more on different mixes of an informal economy, transfer payments, cooperatives and credit unions, and some quite original individual local innovations.

5.0. Independent Academic Reviews and Commentary.

The works noted below are mainly by Canadian academics and/or others who have included Canadian experience as case examples in whatever observations they are making. Although there are a number of overlaps in subject matter, some broad themes can be identified.

5.1. *Critiques of the conceptual framework and underlying assumptions of a Canadian Innovation System*:

The concept of national or regional innovation systems (NIS/RIN) are best thought of as social constructs whereby people who created intellectual or other frameworks use them to provide meanings, normative values, and guidelines for actions in situations of interest to them. These must be constantly re-affirmed to persist. The origins of NIS/RIS have been well documented from this perspective by Godin (2009a;b) who also documents the major roles played by the Organization for Economic Cooperation and Development (OECD) as a facilitating institution since its founding in 1961. Godin (2011) has also traced the history of “innovation” as a contested concept since the time of the early Greeks and Romans.

The creation of this social construct pitted two factions of economists (the dominant "epistemic community" in OECD, Europe and North America) over several decades. One faction, originally the dominant one, was strongly committed to neo-classical economic market models re-enforced by use of econometric input-output models to provide policy advice to governments and corporate lobbyists that was based on rigorous "mathematical science". The other faction was predominantly a school of development economists who were informed by history and recognized a number of drivers of changes such as science and technology, population changes, and institutional regimes. Theirs were the dynamic systems perspectives rather than some theoretical optimum dynamic equilibrium goal to be maintained forever. The OECD as a policy advisory body for its Member States was constantly alert to senior government officials' pre-occupations about national economies and global trade.

Over several decades the competitiveness of European and other "developed countries" was seriously undermined when major industrial and manufacturing industries relocated to Asia, parts of Latin America, an elsewhere. Thrust into a new and different "post-industrial" world, the already "developed" countries had to scramble to take advantage of some new "knowledge-based economy" using new technologies not yet fully developed.

A second divide appeared that cut across the first two. One included people from both camps whose priorities were to develop their disciplines into strong theories combined with empirical testing of them. The other, including OECD policy advisors, much preferred more focused studies on topics relevant to policy makers, and results presented in simple language with catchy phrases and graphics so politicians can understand issues quickly and use it for whatever political debates they get into at home. Within the OECD these differences were reflected in work carried out in different departments that dealt with S&T and industry policy issues, and other administrative units that dealt with economic issues including trade, labour, entrepreneurship and local development. The two people most credited with originating the innovation systems concept were both economists who had worked for OECD and served as long-time consultants. (They were the late Christopher Freeman, a development economist who created the Science Policy Research Unit at the University of Sussex, England, and the home now for the Social, Technological, and Environmental Pathways to Sustainability

(STEPS) Centre, and Bengt-Ake Lundvalle, in the Department of Business Studies at Aalberg University, Denmark).

The rapid adoption of MIS/RIS by OECD Member States (and by the European Union) is thought to have been due to the consistency of the concept with the neo-liberal and market-driven doctrines that dominated both the OECD and EU at the time. So the question was only how to "operationalize" the innovation systems to exploit opportunities in the new knowledge-based economies for the new post-industrialism and also have statisticians create the metrics to judge the effectiveness of whatever is being done. Again, OECD obligingly develops the metrics, limited only by new funding it could obtain from Member States.

The summaries of the current situation in Canada (see above) suggest that the concept of innovation systems resonated well with governments, the business world, and increasingly with universities and colleges. Albert and Laberge (2007) investigated the social processes associated with the adoption of the RIS framework from OECD by the federal and Quebec governments, and by middle level civil servants in Quebec's administrative regions who are the final link in the top-down dissemination chain. From a number of interviews with the latter, they concluded that the main factors were the perceived prestige and symbolic power of the OECD and its associated epistemic community, the cultural authority of Science, and the resulting acceptance of an economistic worldview. This worldview confirms the idea that the primary goal of S&T is to be a tool for business and economic competitiveness. The absence of critical thinking among these officials, aided them in gaining a consensus about what is needed for policy implementation and collecting whatever data were needed for reporting out. Senior civil servants were the bureaucratic carriers of RIS ideas while regional staff acted as cultural intermediaries to mobilize local popular support (*op. cit*. p. 240).

5.2 *Empirical observations about the strategies used and issues encountered in creating the Canadian Innovation System*:

While there are a number of independent studies that would take much more time to review properly, special mention is merited for a major collaborative research program that involved a large number of Canadian academics as *The Innovation Systems Research Network (ISRN)* associated with the Program on Globalization and Regional

Innovation Systems (PROGRIS) at the Munk School of Global Affairs, University of Toronto. This network arose from a 1997 workshop in Ottawa on innovation management and the economy, and a 1998 call for proposals from the SSHRC for research on the nature of innovations for the knowledge-based economy and the on-the-ground functioning of regional clusters in Canada. The ISRN was then funded by SSHRC and it attracted other sources of support as well. Members of the ISRN were loosely organized into five regional nodes across Canada each of which had an interest in understanding how the innovation process functions in their own regional economy as well as regional economies elsewhere in Canada. For the first three years (September 1998 to August 2001) they each undertook studies from various multidisciplinary perspectives, and the group met annually to exchange findings and share ideas. In 2001, with new funding from SSHRC and several other sources, the group undertook coordinated case studies of 26 regional and local industrial clusters across Canada. The results have been published in several books and a large number of articles from members of the different groups (Holbrook and Wolfe (2005).

The researchers worked with both statistical surveys (Statistics Canada and their own local surveys) as well as their own case studies. They found that firms are more likely to be innovative if they are involved in cooperative or collaborative agreements, and more successful if they are adopting or adapting innovations themselves. In British Columbia, innovative firms shared similar characteristics in both high tech and resource-based industries. Innovation was a distinctly two-stage process. The first was to decide whether to innovate or not, and the second was on how radical or incremental an innovation would be. The ISRN noted two conflicting views about globalization, i.e. does this reduce the significance of local innovations or does the local embedded nature of innovation take on an accentuated role? Evidence from Ontario showed that indigenous firms innovated locally and remain embedded in the Ontario economy while multinational firms continued to rely upon their parent companies and the latter's in-house R&D, often in the US or elsewhere.

The case studies examined a common set of factors that are known generally to influence the formation and functioning of innovation clusters, but depending upon the sectors involved and how detailed the analyses were, each situation seemed to be somewhat unique. Five recurring themes did emerge:

- Learning was the key economic process with both local and non-local learning relationships apparent;
- Skilled labour was the single most important asset; success in attracting talented workers becomes an endowment that attracts other highly educated and potentially mobile workers to the point it may be a self-reinforcing critical mass who are “drawn to thick, deep, opportunity-rich local labour markets”(p. 116) and the local amenities associated with these;
- Leadership within firms is crucial, but so is leadership at the community level exercised by “civic entrepreneurs” from local governments and business associations;
- Institutional contexts such as policy frameworks, up-to-date laboratories and other facilities, and public-private relationships are somewhat more subtle and pervasive influences that help support the functioning of clusters in effective ways; and
- Location matters in terms of subtle influences over the tension between local and non-local relationships and knowledge flows; this has been expressed as the dynamic tensions between “local buzz” (the excitement of new possibilities continually opening up) and “global pipelines” (access to technologies, financial capital and new knowledge from elsewhere).

Wolfe (2008) discussed this work in more detail and related it to recurring themes in the wider literature on technological innovations. Although the IRSN has officially wound done, a number of individuals continue with major studies, for example Wolfe and Bramwell (c2011) detailed review of the Canadian ICT industry.

5.3 *Clusters and clustering, cores and peripheries:*

The sheer complexity of fully-functioning regional innovation systems has been documented by Niois and Bas (2003) in reference to the “Biotechnology Megacentres” in Montreal and Toronto. In both cases there are two distinct sub-systems. The oldest are centred on the large laboratories of pharmaceutical multi-national corporations most of which are foreign-owned and controlled. Contract service organizations service most of these corporations as well as a host of specialized biotechnology firms (SBFs) that have been spun-off from these over the years. The other sub-system is composed of many SBFs, university and affiliated hospitals research programs, and access to venture capital to commercialize innovations in products and/or processes. Both sub-systems

contribute to a number of economic sectors and sub-sectors. The Montreal complex hosted over 100 SFEs of which some 70-80 have been active in products and processes for human health. These firms employ over 2,000 researchers and their market capitalization was over $1.5 billion (in 2002). The Toronto complex hosted about 170 SFEs of which about 90 were active in human health. There were 12 venture capital firms in the mix. The major biotechnology firms employed about 3,300 people and had a market capitalization of about $8 billion (in 2002). In both urban regions, the origins of these industries can be traced back to the early 20th century, with a few pre-cursors in the late 19th century.

Doloreux (2004a) reviewed the regional networks of SMEs in the Metropolitan Ottawa Region in terms of their development as part of a cluster specializing in telecommunication technologies. Ottawa does not have much of a tradition in the manufacturing sector since it specialized in federal government and related services. Yet the development of the National Research Council there over the years led to advanced work in telecommunications and a related cluster of firms in the west end of the region (Kanata). The main finding was the SME firms in Ottawa rely as much on external networks of customers and suppliers as they do on firms based in their own region. It pointed to a need to shift away from assumptions about the need to focus only on a particular geographic scale to understand innovations.

5.4. *Urban vis-a-vis Peripheral Regions*:

Doloreux (2004b) compared two regional innovation systems, both involving SMEs in the high tech sector in Ottawa and the low-tech industries in the region of Beauce, about 60 km south of Quebec City. Although there were substantial differences in the types of SME found in each region, firms in both region were highly engaged in innovation activities. In both cases, firms relied as much on external networks of customers and suppliers to make improvements in their products and services. It was concluded that although the Beauce appeared to be a peripheral region, especially contrasted with Ottawa, it was nevertheless embedded in the wider Quebec City metropolitan innovation system. Doloreux and Dionne (2008) conducted a similar enquiry for a peripheral region in La Pocatière about 100 km north-east of Quebec City on the south shore of the St Lawrence River. The institutional system there had evolved over four distinct periods from 1827-2005. This resulted in a distinctive developmental trajectory that created a

competitive advantage and differentiated them from other peripheral regions. It also gave rise to local perceptions of a quality of life and lower costs of living that retained skilled labour.

Petrov (2008) noted the widespread belief that remote communities in frontier regions are assumed to be well beyond any possibilities of meeting criteria for economic transformation and revitalization because they don't have the features of creativity associated with urban metropolitan areas. Yet ICT provide the space-time compression that can question earlier geographical definitions of remoteness and should be considered as opportunities to escape the lock-ins and path dependencies associated with the one industry resource extraction operations around which many of them formed. Petrov modified the metrics used to assess metropolitan potentials for technological innovations and applied them to 34 towns and cities in the near and far north in Canada. While most had severe lack of entrepreneurial capital, some do have elements of creative people and creative economies that are sometimes associated with their aboriginal populations. While more work is required to understand this better, the traditional top-down development policies based mainly on transfer payments need to consider potentials for small scale bottom-up initiatives. Six of the communities scored relatively high on his rankings, and another seven seemed also to show promise.

Côté and Miller (2008; 2012) have undertaken large ranging surveys about "Managing Innovation in the New Economy (MINE)" that were directed to understanding how business firms actually innovate and assess the results of their efforts. MINE now has survey results from 1,000 firms from around the world with qualitative case studies of 200 well-known innovative firms. Statistical analyses of these data revealed six clusters defined by the maturity of the markets they were in (new emerging, or mature with many firms in it) and the "product architecture" they used (stand alone system breakthrough product, platform-based open system, or a closed system of mature technologies dominated by a few large firms). At any given time, a firm, if it is interested in innovation at all, will be situated in one of these six "games that innovators play". Each 'game' has its particular set of competitive conditions and involve both collaboration and rivalry with other firms. The authors define innovation as "a product, service, or a way of doing something which is superior to what existed, and which is adopted" (*ibid* 2012:5). Most firms by far are situated in mature markets where new and improved products,

manufacturing processes and marketing, or “mass customization” of complex products serve to attract and retain customers.

The results of these surveys and analyses of them raised questions about public policies intended to promote innovation in the business world, such as those constituting the Canadian Innovation System. For example, the authors query the emphasis placed on tax credits for R&D expenditures compared to the importance of management committed to at least incremental improvements and has created a corporate culture that values this such that together they can manage growth and change. Also, targeting new emerging markets and small start-up firms is really only a very small and highly vulnerable component in national innovation strategies, and providing support instead to emulators in a fast emerging market (*vs* the original ‘break through’ “Eureka!” innovator) will generate much more innovation in that sector. While funding research in universities and intra-mural National Research Council facilities adds to advances in knowledge, this is (or should be) made widely available. It generally has little to do with innovation policy that matters to most firms.

Preliminary Concluding Observations

It is very clear that the innovation systems narrative has been embraced enthusiastically by the government and business establishments who are spending $ billions to realize it. There are two somewhat contrasting assumptions underlying the strategies being followed. One reflects a rather mechanistic view of the world that keeps adding new organizational units either nested among the existing ones or layered across them so that the ensemble will begin to work more effectively and efficiently. The other, a complex systems perspective, views innovation systems as vast learning enterprises that have to bring together codified knowledge from sciences and applied sciences with the more contextual and experiential tacit knowledge of practitioners and others as a mutual set of individual and social learning processes. Trust among the players has to be established, and given their diversity this can be facilitated by various kinds of organizational arrangements, but it can take a long time. One reason is they have also to resolve debilitating internal contradictions. A conspicuous example is the wide open sharing of knowledge and ideas necessary for the initial creative phases that lead up to “proof of concept” completion and thereby ready for the initial commercialization phase

versus the secrecy of the subsequent phases carried out by industrial R&D wrapped tightly in legal intellectual property rights armor, with lawsuits at the ready.

Generally, it seems that the answer to any perceived shortcomings in the innovations agenda means that more innovations are needed. This could mean incremental modifications of those underway for the new high tech knowledge-based economies, or major supplements to them such as eco-innovations and social innovations. The last especially is deemed as the way to deal with human casualties, created for example, by the incessant call for improved "productivity" in the private sector. "Productivity" of a business might appear relatively easily by firing workers and other staff and/or reducing their wages and benefits. This generates the desired numerical ratios (e.g. annual earnings of the business per employee) that can then be confused with competent business management.

The impacts from innovations can show up in changing power relationships among various business and social groups along with increasing inequalities of incomes and entitlements. Innovations can be seen either as the cause or consequence of "transitions" (incremental changes intended for a desirable but largely recognizable goal) or "transformations" (from the familiar to the completely unknown and unpredictable). This could place a heavy burden of expectations on the innovation narrative and the institutions that have taken the commanding leads at any given time. While it would be easy to find people and organizations that dismiss the whole innovations narrative because of dissonance with their disciplinary or other beliefs, there appears to be very little efforts underway in Canada at this time to de-construct or re-construct the innovation construct. There are some attempts, noted above, to refine it to accommodate particular disciplinary players in it.

One can be struck by the almost complete absence of ethics in the innovations discourse with the exception Genome Canada (noted above). Otherwise the assumption appears to be that the mainstream new knowledge-based high tech agenda is so urgent and critical for future economic prosperity that its ethical goodness should be self-evident to all. Some newer innovations have contributed to advances in drone-based warfare, continuous surveillance systems over entire populations and targeted individuals, cyber attacks on major ICT installations or on other critical infrastructures,

and cultivation of pandemic microbes for “research”, This is not seen to be a fault of the technologies. It comes from the nefarious sources using technologies.

There are other consequences to anticipate in terms of “governance” other than surveillance. Close to home (for university grant holders) there are issues arising from the corporatization of universities and colleges. Besides cooptation of academic administrators into agendas set by government and corporate business interests, the new slogan of “knowledge management” along with private sector calls for control or removal of faculty associations (similar to attacks on organized labour) could easily be applied to removal of any dissenting or inconvenient views as the new curricula requirements that serve the needs of the mainstream innovation agendas take over. Reflexivity related to these putative urgent innovation necessities seems in short supply.

Complex systems however, can still be expected to yield interesting surprises. There seems little doubt that all of these changes underway will affect landscape regions, especially ones that are relatively close to major clusters. Before taking up these questions, the development associated with eco-innovations and social innovations need first to be considered.

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