Innovation Policy for the Knowledge-Based Economy: From the Red Book to the White Paper

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The need to accelerate Canada's transition to a knowledge-based economy and society and increase our investment in research and development has been a prominent theme of the Liberal government since the election of 1993. Commencing with the original Red Book, *Creating Opportunity: The Liberal Plan for Canada*, the government has highlighted the importance of federal support for research and development as a key policy priority to promote Canada's transition to a knowledge-based economy and society. It reaffirmed this commitment in the speech from the throne on January 30, 2001, "To secure our continued success in the 21st century, Canadians must be among the first to generate new knowledge and put it to use."[2] The throne speech committed the government to double current federal investment in R&D by 2010.

However, the progress towards realizing this commitment has been successively undermined – originally by the priority on achieving a balanced budget during the first mandate, and more recently, by the priority attached to the new security agenda in the current budget (outlined in the Introduction to this volume). The early priority on fiscal probity was symbolized by the major expenditure cuts in the 1995 budget, including many to key programs that support research and development. The return to a stronger fiscal position that coincided with the second mandate in 1997 was followed by the introduction of new spending programs on research and development. Among the initiatives introduced in the past five years are the Canada Foundation for Innovation,

increased funding for the research granting councils and the National Research Council, the formation of the Canadian Institutes for Health Research, increased support for the Networks of Centres of Excellence, Technology Partnerships Canada, stable funding for the Canadian Space Agency, the creation of the Canada Research Chairs, and the formation of Genome Canada.

Whether these individual measures add up to an effective 'innovation policy' and whether they can deliver on the government's promise to make Canada one of the top nations to generate and use new knowledge is open to question. Despite the new initiatives, and the increases in federal funding (part of which merely compensated for the budget cuts imposed in 1995), the government's own spokesmen have indicated that Canada continues to lag significantly in its performance in the area of research and development. In a widely quoted speech to the Toronto Board of Trade in September, 2000, the Minister of Finance, Paul Martin, pointed out that Canada ranks 15th among OECD countries in the ratio of its R&D spending to Gross Domestic Product and said quite simply "That is not good enough." Our goal should be to rank in the top five.[3] The commitment to move Canada from 15th to 5th emerged as a central plank in the Liberal platform, *Opportunity for All*, in the federal election of 2000. The Red Book asserted "A new Liberal government will help Canada move by 2010 to the top five countries for research and development performance by at least doubling federal expenditures on R&D." The cost of this promise was projected at a minimum of an additional $1 billion in federal funding by fiscal year 2004-05.

The widely anticipated Innovation White Paper is expected to outline the government's approach to implementing this policy priority, but preliminary versions leaked in the press suggest that it

too may fall short of what is expected.[4] Both the significant new investments in R&D over the past five years, as well as numerous policy reports and documents released since 1993, raise questions about whether the overall framework governing the allocation of new funding is suitable to chart a course for innovation policy in the 21st century. This chapter reviews the government's analyses of Canada's innovation performance and its prescriptions to remedy its shortcomings against the innovation systems approach developed by a number of international scholars. It evaluates the effectiveness of the current policy mix and questions whether the deployment of new funds without a better understanding of the nature of the innovation system in this country will suffice to achieve the government's stated goal.

POLICY REVIEW AND BACKGROUND

The federal government's role in research and development has been subject to considerable strains since the election of the Liberal government in 1993. That election generated high expectations for science and technology policy based on the Liberal platform. The Red Book recognized that Canada was undergoing the transition to a global and knowledge-based economy. It argued that this new economy requires a greater capacity for adjustments and innovation, which in turn must build on the capacity of private and public institutions to become learning organizations. It stressed the dynamic role of small and medium-sized enterprises in a growing economy, the need to revitalize the manufacturing, resource and service industries, and to enhance the idea-based sectors of the economy, and the importance of supporting the communities in which these businesses are grounded. It identified the need to move research from the laboratory to the marketplace more effectively and to help Canadian business adopt and use new technology more effectively.

The Red Book called for new initiatives by the government to facilitate the adoption and diffusion of ideas in the innovation process and for measures to create a national system of innovation in Canada. It advanced the objective of doubling Canada's contribution to R&D spending. Among the explicit measures spelled out were the provision of an additional $1 billion in federal funding for R&D over the next four years, as well as the creation of a new Canadian Technology Network linking universities, industry associations and governments to improve the dissemination of information to SME's on new technology developments, to be run by the NRC's Industrial Research Assistance Program. The Red Book also called for measures to improve technology partnerships between universities and/or government research institutions and private firms, as well as stable funding for the three federal granting councils and the federal Networks of Centres of Excellence.[5]

A related theme of the strategy was the need to build clusters of economic activity within different regions of the country in order to create value-added jobs. As Paquet and Roy argued in an earlier version of *How Ottawa Spends*, this approach focused on a bottom up strategy of creating prosperity through the formation of clusters at the local and regional level.[6] It maintained that strong regional economies were the building blocks of Canada and the federal government had a responsibility to encourage local and regional governments to cooperate with a range of private sector actors in charting their own economic direction. Communities themselves are responsible for promoting the growth of clusters and related industries within their regions to create jobs and greater economic prosperity. The principle means for realizing this goal was fostering an entrepreneurial spirit and developing fora for economic cooperation and networking at the local and regional level. However, Paquet and Roy saw little commitment from the federal government over the next few years demonstrated to implement this approach. As we shall see

below, this dilemma continues to bedevil the federal government in the latest round of program initiatives and policy reviews.

Agenda: Jobs and Growth

In the fall of 1994, the government released a series of policy documents as part of the Agenda: Jobs and Growth. The overview document, *A New Framework for Economic Policy,* saw innovation policy as one of the four pillars of its economic agenda. "Since productivity growth depends on working smarter – for example, mastering the economics of 'ideas' – Canada must position itself to be at the forefront of *innovation* in the products and services we create; in the ways we organize economic and social activity; and in the ways we govern ourselves".[7] A companion document, *Building a More Innovative Economy*, placed the government's proposed S&T initiatives within the context of its broader economic agenda. Policy initiatives were to be pursued in four key areas: trade, infrastructure, technology and the climate of the marketplace. In the area of infrastructure spending, the government intended to support the information highway through its commitment to regulatory reform in the area of telecommunications policy, its efforts to extend the CANARIE network with capital spending and its support for linking all schools and libraries in the country to the Internet through the SchoolNET program. With respect to technology, it outlined the key issues to be addressed in the formal S&T Review (launched as part of a more comprehensive process of program review), including a more systematic approach to the commercialization of R&D, a strong scientific culture in Canada, the need to establish which scientific and technological developments Canada should pursue, to ensure that federal labs play an effective role in the commercialization of technology and measures to promote the rapid diffusion of technology to industry.[8] It translated the campaign commitment to create partnerships from a process of fostering community-based networking and cooperation into one

designed to help small business by cutting red tape, increase loan guarantees to small business and provide better support for exports.[9]

The Science and Technology Review

The high expectations raised by the Red Book and sustained through the Agenda: Jobs and Growth were shattered by the federal budget of February 1995. It signaled a major change in policy away from the themes of the election and towards a priority on deficit reduction. Not awaiting the outcome of the S&T Review, it leveled major cuts at program spending that were especially severe in the area of science and technology. The S&T Review was left to carry on to a painful conclusion, despite the lack of fiscal room for any of the anticipated new initiatives. The results of the review were widely anticipated in the science and technology research community, given the very inclusive nature of the consultation process that was conducted. In addition, four interdepartmental committees each produced an internal report, as well as another prepared by the National Advisory Board on Science and Technology. The inclusiveness of the process sustained the belief that the government still intended to pursue the policy goals articulated in the campaign platform of 1993.[10]

After two years of work, the S&T Strategy, released in March 1996, articulated the goal,

> ". . . to create in Canada world centres of excellence in scientific discovery; to build a broad base of scientific enquiry; to foster Canadian participation in all major fields of science and technology; and to ensure that new knowledge can be acquired and disseminated widely, from Canadian sources and from around the world." [11]

The strategy identified the need for the government to establish clear priorities for spending in light of the continuing pressure to reduce its fiscal deficit. As result of the reductions already underway, the report underlined the need for public spending to focus on core activities in the

S&T policy area. The principal means for improving the efficiency of delivery mechanisms was the use of partnership arrangements between government departments and agencies and other key components of the innovation system. The core S&T activities of the federal government were identified as: 1) funding that research which supports the mandates of federal agencies, 2) providing research support to universities, the Centres of Excellence, and other non-governmental research institutes, 3) supporting private sector research and development, and 4) disseminating knowledge, building information networks and acting as an information analyst. Despite the rhetoric of the strategy document, the action plans announced were widely perceived as a disappointment. In the eyes of one commentator, ". . . it took too long to deliver and resulted in a feeling that the policy leadership developed by the government was lost." [12]

The Knowledge-Based Economy/Society

Although the S&T Review landed with something of a thud, efforts by the federal policy apparatus to formulate new ideas on how to facilitate Canada's transition to a knowledge-based economy continued. The underlying ideas of the knowledge-based economy and society drew heavily on work done by the OECD. According to the OECD, most industrial economies are rapidly becoming knowledge-based economies. These are economies in which the production, use, and distribution of knowledge and information are becoming more critical for economic growth and development – "more science-intensive via the better use of existing stocks of scientific knowledge, more technology-intensive via the diffusion of advanced equipment, as well as more skills-intensive in terms of managing the increasingly complex knowledge base related to productive activities". [13] The knowledge-based economy highlights the production of knowledge in new, networked institutional settings, and the ability to distribute that knowledge to the relevant components of society.

The locus of thinking on this question shifted to the Policy Research Committee, an initiative launched by the Clerk of the Privy Council in the aftermath of the 1995 budget cuts to focus the government's policy-making capacity on key issues that cut across a wide range of government departments. Chaired by two Assistant Deputy Ministers from HRDC and Health Canada, the PRC undertook a number of initiatives, not least of which was the research pilot project on the Knowledge-Based Economy/Society (KBE/S). The feasibility study submitted to the PRC Steering Group in 1997 outlined a thematic approach to the issues to be addressed in a study of the KBE/S, as well as a proposal for implementation of the project. The Report by the KBE/S Working Group argued,

> Powerful forces are transforming fundamentally the nature of the economy and the whole of society. Ideas, invention and innovation are the lifeblood of a new 'knowledge-based economy and society'. . . . To survive and prosper in this environment requires continuous innovation and adaptation by all actors. . . . it introduces a new set of transitions and adjustment challenges for governments, firms and individuals.

The report identified a number of key challenges that must be met for successful adjustment to occur: the acquisition by individuals of the appropriate skills for a KBE/S; the effective creation and management of knowledge on the part of firms; the ability to adopt new technology in order to enhance firm performance; the implementation of organizational structures and human resource practices appropriate to the KBE/S; the capacity of firms to innovate; and the ability of institutional structures for the society as a whole, such as the financial system, legal and regulatory framework, industrial relations system and the educational sector to make the adjustments needed to facilitate the overall transition to a KBE/S.

PROGRAMS AND POLICY INITIATIVES

Despite the wide range of ideas presented in the various policy reviews between 1993 and 1997, the actual initiatives introduced over the period have largely been of an incremental nature – supporting or expanding existing programs – or have concentrated on funding research. While the government has paid lip service to the concept of the national innovation system, their actual initiatives reveal little understanding of its implications for the policy framework. The federal budget for 1994 announced funding for the Canadian Technology Network (promised in the Red Book), additional funds for the National Research Council, and stabilized funding for the Networks of Centres of Excellence and the Research Granting Councils. The Canadian Technology Network, run by the NRC's IRAP, was to provide firms with access to a suite of different services, including access to relevant government and private sector services and programs, benchmarking, managing technology, training, financing, standards and regulations and assessment and evaluation of technologies. Each CTN member has specialties in certain sectors, technologies or business expertise; they also act as a networking agent, bringing together parties with the appropriate skills and expertise to address their concerns.

This positive start suffered a severe setback with the expenditure reductions imposed in the budget of 1995 as noted above. The Industry Portfolio, including most of the relevant S&T programs was particularly hard hit, suffering a 42 per cent reduction in its program spending, over a two-year period, including most of its industrial subsidy programs, such as the highly regarded Defence Industry Productivity Program. The situation began to turn the following year after the release of the S&T Strategy, when the government introduced the Technology Partnerships Canada program to provide support to private sector partners, such as those in aerospace, in their efforts to commercialize high technology products and processes. The

aerospace industry was hardest hit by the cancellation of the Defence Industry Productivity Program in 1995, and its firms had protested strongly to the federal government. Although Technology Partnership Canada differs in important ways from its predecessor, it went a long way towards satisfying the concerns of the industry. Originally funded at $150 million a year, it was to increase to $250 million a year by 1998/99. Its unique feature is that successful projects are repayable to the federal government and it hopes to make the program 50 per cent self-financing.

In the years since, the steady improvement in the government's fiscal position, combined with a growing concern over the importance of innovation and the transition to the KBE/S has led to a number of new program and spending initiatives in the science and technology policy portfolio. First among these was the Canada Foundation for Innovation established in 1997 with an initial allocation of $800 million over a period of five years. The CFI provides funds on a matching basis to the provinces and universities for the modernization of research facilities in the natural sciences, engineering and health sciences at universities, colleges, research hospitals and non-profit research institutions. Contributions by the CFI cover up to 40 per cent of the total cost of infrastructure projects, leveraging a total of $2 billion in new infrastructure funding. CFI funding includes expenditures for the acquisition of state-of-the-art equipment, establishing computer networks and communication linkages and creating significant research databases and information-processing capabilities.[14] In addition, the 1997 budget made permanent the Networks of Centres of Excellence program with stabilized annual funding of $47.4 million – achieved largely by reallocating money from the budgets of Industry Canada and the granting councils. Finally, funding for the popular and successful Industrial Research Assistance Program run by the National Research Council was stabilized.

These measures to boost Canada's R&D capacity were further enhanced in the 1998 Budget. A Budget Document, *The Canadian Opportunities Strategy*, spelled out several new commitments, including the restoration of funding levels for the three federal granting councils – NSERC, MRC and SSHRC – to their 1994-95 funding levels. The councils were promised that in future years, their budgets would grow once again, receiving an additional $400 million by 2000-01.[15]

The budget of February 1999 further boosted Canada's S&T capability. The budget allocated an additional $200 million to the Canada Foundation for Innovation to help it meet the growing demand for research infrastructure in the areas of health, the environment, science and engineering. It allocated a further increase of $75 million over three years to the Natural Sciences and Engineering Research Council, as well as $15 million to the Social Sciences and Humanities Research Council. It promised $90 million of new funding over three years to the Networks of Centres of Excellence to create up to eight new networks. It also allocated $16 million over three years to the National Research Council to invest in advanced equipment, as well as $15 million to support national and regional research goals. The budget added $55 million in spending over three years to current federal investments in biotechnology research and development by science-based departments and agencies. The Canadian Space Agency was provided with additional resources of $430 million over three years and promised that its budget would be stabilized at $300 million annually. An additional $150 million was provided to Technology Partnerships Canada over the period from 1999 to 2002.[16]

The budget also included a major restructuring of federal support for medical research with the replacement of the existing Medical Research Council by the Canadian Institutes of Health

Research. The objective of the CIHR is to accelerate the discovery of cures and the prevention of disease; foster collaboration across a wide range of health research disciplines; and help bring new health products and services to the market. The budget set aside $65 million for the first year of operation, 2000-2001, with an increase to $175 million in its second year.[17] In total, the 1999 budget added $1.8 million for the current and next three years to federal government spending on the creation, dissemination and commercialization of knowledge.

The last budget before the 2000 election saw a further increase in spending on the S&T portfolio. It promised $900 million of federal funding over five years to create 2,000 new Canada Research Chairs, as well as a further $900 million to the Canada Foundation for Innovation, raising the federal government's total commitment to the CFI to $1.9 billion. Following on the creation of the CIHR in the previous budget, the government announced the establishment of the Genome Canada project – with a commitment of $160 million to five centres across the country providing laboratory facilities to researchers from universities, government and the private sector. The budget also included the announcement of a Sustainable Development Technology Fund to foster innovation by helping companies develop new technologies and bring them to market in areas such as clean burning coal and new fuel cell developments.[18]

The combined impact of the four budgets from 1997 through 2000 represented one of the most significant federal investments in science and technology spending in many decades. In light of this increase in federal spending, it is puzzling to hear key government leaders, such as the Minister of Finance and Prime Minister, refer to Canada's performance in research and development as inadequate and lagging our major competitors. Yet a closer examination of the current situation reveals the basis for their concern.

The latest figures from Statistics Canada indicate that Canada's total spending on research and development rose significantly during the decade, from $12.992 billion in 1993 to $18.288 billion in 2000 in constant 1997 dollars. Expenditures on R&D as a percentage of Gross Domestic Product rose from 1.67 per cent in 1993 to 1.81 per cent in 2000, largely as a result of the enormous boom in the high tech sector. The proportion of R&D expenditure funded by business enterprises rose slightly from 41.3 per cent to 42.6 per cent, while the proportion funded by government declined from 25.9 per cent in 1993 to 18.2 per cent in 2000, despite the substantial increases contained in the federal budgets between 1997 and 2000.[19] One explanation for this discrepancy is that many of the announcements made by the government, especially for the CFI and the Canada Research Chairs, involve multi-year commitments stretching out over the course of the current decade, while other spending initiatives, such as those for the granting councils and the Networks of Centres of Excellence, largely compensate for the stagnation of federal funding and serious cutbacks suffered in the 1990s. The reality is that well into its third mandate, after three successive Red Books and three consecutive electoral victories, the Liberal government is still struggling to deliver on the promises of the first electoral platform. The current commitment to increase federal spending by $1 billion by 2004-05 sounds remarkably similar to the one contained in the original Red Book!

THE THRONE SPEECH COMMITMENT

With a sense of deja vu, the Throne Speech takes us back to the situation of 1993. Even the rhetoric used in the Speech and the Prime Minister's Response to the Speech sound similar to the original Red Book. In his speech, the Prime Minister maintained that:

> Canada must have one of the most innovative economies in the world. A key element in

> getting there is to ensure that our research and development effort per capita is amongst the top five countries in the world.
>
> To achieve this objective, the government has a five-part plan.
>
> First, to at least double the current federal investment in research and development by the year 2010. The government over the course of its mandate will increase its investment in the Granting Councils. It will do more for Genome Canada and the Canadian Institutes of Health Research. And for research within government. . . .
>
> Second, to build on what we have already done to make Canadian universities the place to be for research excellence. And a place where the best and the brightest want to come. The government will work with the university community to assist our universities so that they have the resources necessary to fully benefit from federally sponsored research activities.
>
> Third, to accelerate Canada's ability to commercialize research discoveries, and to turn them into new products and services.
>
> Fourth, to pursue a global strategy for Canadian science and technology. Canada must be at the forefront of collaborative international research which expands the frontiers of knowledge.
>
> Fifth, to work with the private sector to determine the best ways to make broadband internet access available to all communities in Canada by the year 2004.[20]

The Prime Minister's commitment to make Canada 5th in the world in *per capita* spending on R&D represents a subtle shift from the electoral promise, as we currently rank higher on this measure than on the ratio of R&D expenditures to GDP. Regardless of which indicator is used, moving to 5th by the end of the decade will represent a massive challenge for the government. The challenge is made more difficult by the fact that Canada's international standing in R&D intensity has been leapfrogged by several of the smaller industrial countries in the past decade, including most of the Nordic countries. According to the Conference Board of Canada's *Second Annual Innovation Report* released in 2000, just improving our R&D intensity ratio to that of the OECD average would require an investment of about $6 billion in current dollars, with about

half the increase coming from business and half from government. This represents a substantially greater increase than the government has promised and would still not move Canada to 5th ranked position among the OECD countries.[21]

The budget brought down on December 10, 2001 provided an opportunity for the government to deliver on its Throne Speech commitment. Yet, just as the original Red Book promise was sidetracked by the 1995 fiscal crisis, the recent commitment suffered a similar fate at the hands of the security agenda (outlined in Chapter 1). While the government announced a number of new measures to support R&D, they fall far short of meeting the challenge outlined above. Among the innovation related measures included in the budget were a one-time expenditure of $200 million for the universities and research hospitals to offset the indirect costs associated with federal funding of research activities. The government made a further commitment to provide ongoing support for the indirect costs of research in a way that is predictable, affordable and incremental to existing support for direct costs. This responded to a long-standing complaint of the universities, but fell short of the more permanent solution they were looking for. The government also allocated additional funds to the base budgets of the granting councils – $36.5 million to NSERC, $7.5 million to SSHRC and $75 million to CIHR.

The budget expanded on a set of new initiatives by the National Research Council that had been provided support following the 2000 budget. In year-end 2000-2001, the government granted NRC $110 million over the next five years to support cluster-based research centres in Atlantic Canada. The 2001 Budget provided an additional $110 million over three years to support similar initiatives in other parts of the country – including a National Institute for Nanotechnology in Alberta, the Advanced Aluminum Technology Centre in Quebec, a new

research program in Plant Biotechnology Institute in Saskatoon, fuel cell research in British Columbia and the Canadian Photonics Fabrication Facility in Ottawa. The budget accelerated several internet-related issues by allocating $600 million to implement the Government On-Line Strategy by 2005, $110 million to build CA*net 4, the next generation of Internet broadband architecture linking all research-intensive institutions in the country, and an additional $35 million a year to support the existing SchoolNET and Community Access Programs in place of the far more ambitious broadband strategy sought by the Minister of Industry.[22] The largely incremental nature of the spending initiatives, with the exception of the NRC's new cluster approach, and the limited amount of funding, fell far short of realizing the ambitious agenda laid out in the Throne Speech.

A final opportunity for the government to deliver on its Throne Speech Commitment rests with the Innovation White Paper, expected in January, 2002. However, a preliminary leak of its contents, and the limited funding announcements included in the budget, suggest that the innovation agenda has been deferred in favour of other priorities. The leaked copy of the White Paper contained a number of recommendations already announced in the December 10 Budget, including payment to the universities for the indirect costs of research, increased funding to the granting councils, development of CA*net 4, and expansion of the National Research Council's Atlantic Innovation Strategy. However, the draft White Paper also contained additional recommendations that did not receive mention in the budget. These included measures to leverage the commercialization potential of publicly funded academic research, a new program modeled on the NCE's to promote collaboration between government research institutions, universities and the private sector, additional funding for IRAP to expand into international joint ventures and allow firms to access global technology, measures to increase the supply of venture

capital through the Business Development Bank, doubling the number of Master's and Doctoral Fellowships and scholarships, the establishment of a National Academy of Sciences to advise government on the formation of science-based frameworks and priorities for new investments, embarking on a sustained investment branding strategy to attract foreign and domestic investment, and providing smaller communities with funding to develop innovation strategies with the participation of local leaders from private, public and academic sectors.[23]

The question still remains whether these measures, taken as a package are sufficient to realize the Throne Speech commitment. Realizing it depends on the answers to two critical questions: is it feasible to move Canada to 5th in the world in per capita R&D spending, and even if this objective were achieved, would it automatically make Canada "one of the most innovative economies in the world"? Focusing exclusively on one indicator, such as R&D intensity, may prove to be more misleading than helpful in improving Canada's innovative capacity in the knowledge-based economy. An established body of research casts doubt on the value of 'benchmarking' industrial countries against each other on the basis of broad and indiscriminate indicators such as per capital R&D spending. The principal reason for caution in the use of such benchmarks is that countries differ significantly in terms of their size and their industrial structures. Such differences affect their propensity to invest in R&D. Differences in terms of areas of industrial specialization, inputs to the innovation process, trade patterns, technological specialization and the institutional infrastructures that support innovation are all constitutive features of their national systems of innovation and by extension, the capacity to perform R&D. In fact R&D performance varies enormously across both the size of firms and industrial sectors. A more accurate benchmark is a measure of R&D intensity that controls for both firm size and the industrial structure of the individual economy.[24]

This factor has long been recognized as relevant to any attempt to measure or evaluate Canada's R&D performance. A background paper prepared for the consultations on the S&T Review argued that size rather than foreign ownership was a major determinant of the propensity to perform R&D among Canadian firms,[25] while an earlier report to the Science Council of Canada concluded that roughly 40 per cent of Canada's underperformance of R&D in the business sector was accounted for by the industrial structure of the economy.[26] More recently, Jorge Niosi's analysis of Canada's national system of innovation depicted its distinctive industrial and sectoral patterns. It is stronger in 'upstream' areas of fundamental research as evidenced by the relative larger proportion of R&D performed in the higher education sector and the comparatively high level of publication by Canadian scientific researchers. Furthermore, Canada's business sector performs less R&D than many of its industrial competitors, including the US, the Netherlands, Sweden and Switzerland, and the R&D performed is strongly concentrated both in a relatively small number of firms and in specific industrial sectors. Telecommunications, aerospace, engineering and scientific services, finance, insurance and real estate, electronic equipment and pharmaceuticals together account for more than half of all business expenditures on R&D in Canada. Canada's R&D system also displays strong regional patterns of variation.[27] Attempts to boost our R&D performance, or even develop a more adequate measure of our relative performance, must take account of these distinctive features of the 'national system of innovation', yet there is little recognition of these aspects of it in the leaked version of the Innovation White Paper.

THE INNOVATION SYSTEMS APPROACH

As was suggested above, the government's innovation policy would benefit from making fewer

commitments to broad objectives of dubious value to our innovation performance and by paying more attention to the policy relevant insights derived from the innovation systems approach. Innovation and technical progress are generated by the complex interaction among the institutions that produce, distribute and apply various kinds of knowledge. Countries vary in the extent to which, and the sectors in which, they display a strong capacity to perform research and development and introduce new products and processes due to the underlying structure of their innovation systems. Firms are the main actors in the innovation system; but their capacity to innovate is the product of their complex interactions with other elements of the system, particularly their ability to adopt and use knowledge generated elsewhere in the system. The innovative performance of individual countries is influenced by the effectiveness with which the elements of the innovation system interact in the creation and application of knowledge.

The innovation systems approach grows out of work by Christopher Freeman and Bengt-Åke Lundvall. In his original study of the Japanese innovation system, Freeman defined a national system of innovation as "the network of institutions in the public and private sectors whose interactions initiate, import, modify and diffuse new technologies" and underlined the role of social and political institutions in supporting the adoption and dissemination of scientific and technical knowledge.[28] Bengt-Åke Lundvall adopted a somewhat different approach, starting from the premise that the most fundamental resource in the modern economy is knowledge and consequently, the most important process is learning. The learning process is an interactive one that must be understood in its institutional and cultural context. A significant aspect of his approach is the importance attached to the patterns of interaction between firms as part of a collective learning process in the acquisition and use of new technical knowledge. This flows from the belief that innovation is increasingly tied to a process of interactive learning and

collective entrepreneurship, especially in terms of the relationships between producers and users of new technology. For him "a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and . . . a national system encompasses elements and relationships, either located within or rooted in side the borders of the nation state".[29]

The key elements that comprise the national innovation system include: the internal organization of firms; the network of inter firm relationships; the role of the public sector; the institutional set-up of the financial sector; and the degree of R&D intensity and the nature of R&D organization. The interactions among these elements of the innovation system are influenced by a variety of broader factors that include the macroeconomic and regulatory environment, the system of corporate governance, the nature of the education and training system, the state of the communications infrastructure, and prevailing conditions in individual factor and product markets. Interactions among the various institutions and actors that comprise the national innovation system take a variety of different forms. The OECD representation of the pattern of interaction among these actors is shown in Figure 1.

Figure 1 about here

The innovation system in a knowledge-based economy encompasses the key functions of:

- Knowledge production – developing and providing new knowledge;
- Knowledge transmission – educating and developing human resources;
- Knowledge transfer – disseminating knowledge and problem solving.

Performing the functions of knowledge production, transmission and transfer has become more challenging for most national innovation systems. The role of the public sector in stimulating and

sustaining innovative behaviour is critical. In most of the industrial countries, governments directly or indirectly fund between 40 and 50 per cent of the costs of research and development. Moreover, the public sector provides a vast array of infrastructure critical for the innovation process in the form of the post-secondary educational system, public R&D facilities, and a wide range of institutions that support the process of technology transfer. The impact of public policies and the way in which the public funding of R&D impacts the private sector's capacity for innovation are central aspects of the national system of innovation.[30]

The OECD has concluded that the study of national innovation systems offers new criteria for evaluating the effectiveness of government science and technology policies. In the past, government policies have been oriented towards overcoming or compensating for *market failures*; however, the insights afforded by studies of the national innovation system also make it possible to study the nature of *systemic* failures. Applying the innovation systems approach enables policymakers to identify sources of success and failure within the broader mix of institutions that facilitate or inhibit the process of innovation, as well as specific structural gaps in the innovation system. The results of this analysis may also prescribe a broader range of policies, which place greater emphasis on the role of social factors and institution building than traditional approaches.[31]

Recently, the focus of work on innovation systems has shifted from the national to the regional and local levels. This shift grows out of the recognition that innovative capabilities are sustained through local and regional communities of firms and supporting networks of institutions that share a common knowledge base and benefit from their shared access to a unique set of skills and resources. The regional level is critical for this process because the factors of space and

proximity contribute to the kind of tacit knowledge and the capacity for learning that support innovation. The regional innovation system, like the national, can be conceived in terms of both the demand and supply side for innovation. On the supply side are located the institutional sources of knowledge creation in the regional economy. Closely linked to these are the institutions responsible for training and the preparation of highly qualified labour power. The demand side of the system subsumes the productive sector – firms that develop and apply the scientific and technological output of the supply side in the creation and marketing of innovative products and processes. Bridging the gap between the two is a wide range of organizations, which play a role in the acquisition and diffusion of technological ideas and know how. These may include technology centres, technology brokers, business innovation centres, organizations in the higher education sector that facilitate the interface with the private sector and mechanisms of financing innovation, such as venture capital firms.[32]

This emphasis on the region as a locus of innovation and the value of geographic proximity for the learning process also reflects the attention paid to the emergence of a number of dynamic, clusters in key locales around the globe. Michael Porter defines a cluster as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities".[33] Clusters include concentrations of interconnected companies, service providers, suppliers of specialized inputs to the production process, customers, manufacturers of related products and finally governmental and other institutions, such as national laboratories, universities, vocational training institutions, trade associations and collaborative research institutes.

Clusters operate within the distinctive features of the national and regional innovation systems

and the process of cluster development is embedded within a complex set of economic, social and institutional relationships at both the regional and national levels. Nowhere is this more apparent than in the cases of the most successful US clusters, such as Silicon Valley, Austin or San Diego. They have benefited from the highly decentralized nature of the post-secondary education system with complementary and interlocking roles for both the federal and state governments. Changes introduced in the 1970s and 1980s in capital gains rates and the tax treatment of stock options, as well as the rules governing investments in venture capital by pensions funds, stimulated the growth of the venture capital industry, a factor critical for the development of many clusters. The federal government also played a central role as the initial customer for many of the early products of the high tech clusters. And finally, it was the most important source of funding for much of the critical research and development that underpinned the growth of the clusters.[34]

CONCLUSION: IMPLICATIONS FOR CANADA'S INNOVATION POLICY

The lesson to be drawn from the preceding analysis is that national policy can play a significant role in foster local and regional economic development. The question is: what is the most judicious mix of policies to enhance this aspect of the national innovation system? There is little doubt that strong support for the system of higher education and the funding of basic research, which has enjoyed a prominent position in recent federal initiatives, is critical to the overall performance of the innovation system. Keith Pavitt argues that one of the key features of the US innovation system has been the massive and pluralistic funding by government of institutions of high academic quality and a willingness to make long-term investments in basic research leading to the development of new, often multidisciplinary fields, such as biomedical- and ICT-related

areas of teaching and research. However, he also warns against relying exclusively on the linear, or informational, conception of the benefits that flow from this investment.[35] The measures introduced since 1997 to increase support for the performance of basic research in universities, research hospitals and government labs have gone a certain way towards enhancing the capacity of Canada's research infrastructure, but as the Conference Board numbers indicate, we still have a long way to go to reach a level comparable with the most research intensive economies.

Research institutions are a critical component of regional and local innovation systems, but they operate in the context of a broad array of other actors. A more comprehensive framework of policies to support the innovation system must recognize the interactive and interdependent nature of the roles played by this array of actors. As was noted above, the development of new innovative capabilities is often location-based – it occurs in a specific geographic locale and displays a strong regional component. What is essential for the effective upgrading of a system of innovation is the 'embedding' of the business sector into a broader subsystem that involves a greater complexity of interaction and stronger linkages between the actors that comprise the subsystem.[36]

Policies to enhance the national innovation system must be designed with an eye to the fact that their impact will occur at the local level within the context of industrial clusters and be mediated through the intervening effects of the regional innovation system. Attempts to develop policy at the national level exclusively, may founder on the diversity that characterizes the Canadian innovation system. A regional focus helps ground our understanding of the innovation process within these diverse realities.[37] A framework designed to accomplish this requires a broad mix of policies, including those that provide support for upgrading the innovative capabilities of firms

across a range of sectors; infrastructure (both physical and technological) policies targeted at promoting the rapid diffusion of new technologies across a range of firms; policies to build the market for new technologies; and policies to support the growth of small- and medium-sized enterprises through increased networking and interaction. This framework must aim to stimulate both the supply of new knowledge, the technology base, and the demand for the technology – the capacity of firms to absorb and utilize the knowledge. Improving the innovation system involves the coordinated upgrading of both demand and supply for new inputs provided by the technological infrastructure.[38]

Many of the essential elements to enhance Canada's innovative capacity are currently in place. The research capacity of public sector research institutions, including universities, research hospitals and government labs has been greatly strengthened in recent budgets. Yet federal policy towards research in the higher education sector continues to pretend that it operates in a vacuum, ignoring the fact that much of the rest of the operating funds for these institutions flows through the provincial governments and is strongly affected by other federal policies, such as the Canada Health and Social Transfer. A truly effective policy to support the research and technological infrastructure of the innovation system must adopt a more wholistic approach to their funding and operation. Upgrading the communications infrastructure is also critical to promoting the more rapid uptake and diffusion of new technologies, especially in the area of ICT's. Recent initiatives to support Government Online, CA*net4, SchoolNET and the Community Access Program can contribute to this process, but they must also be coupled with a stronger role for government as a consumer of related products and services to stimulate their rapid diffusion through the private sector.

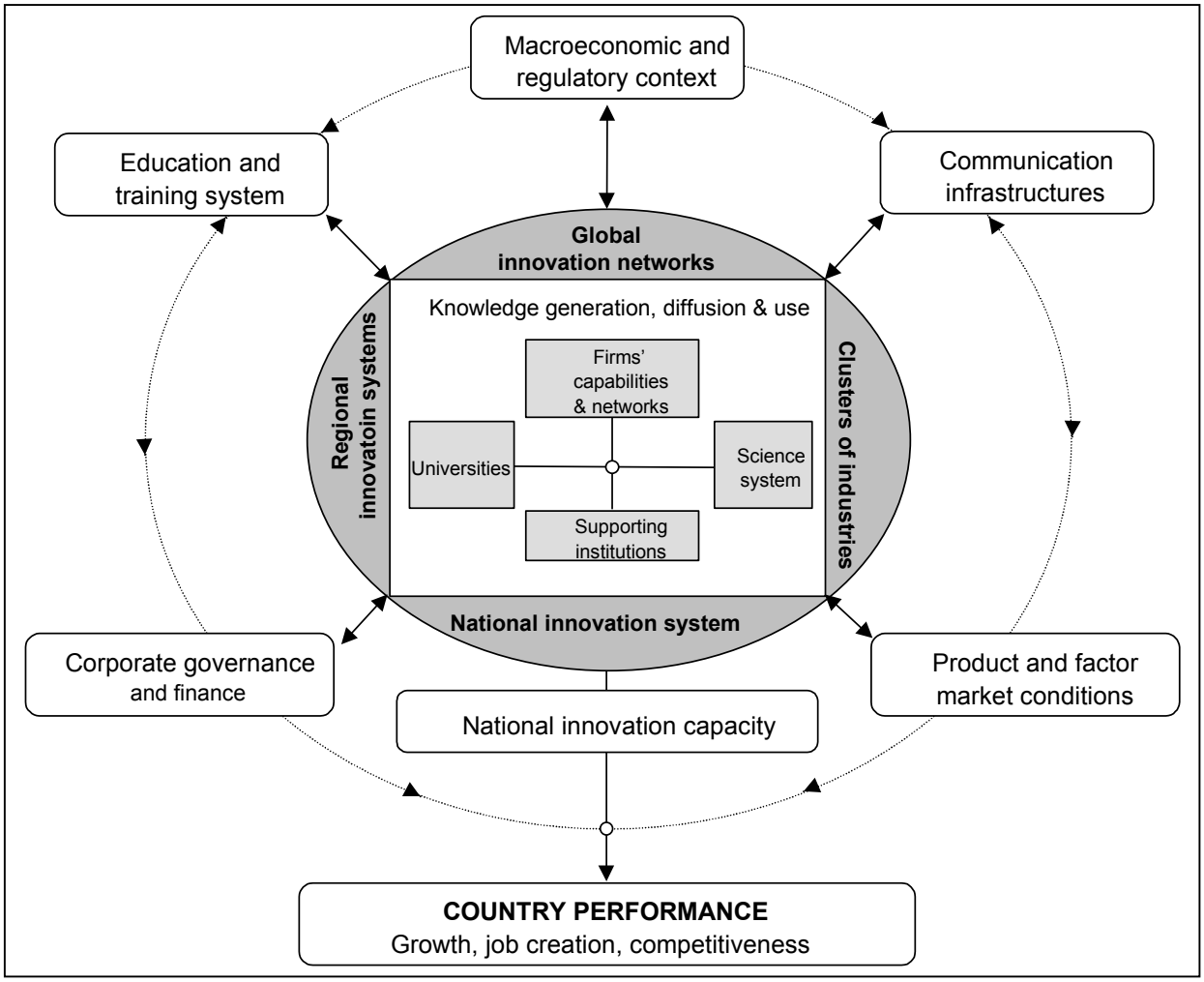
However, greater attention must also be paid to fostering the growth of dynamic, locally-based clusters of innovative firms embedded in regional innovation systems. Recent support for the NRC's cluster strategy represents a valuable step in this direction, but again tends to focus primarily on the supply side of the cluster development process. The success of these new initiatives in stimulating the growth of clusters in various locales across the country depends, in part, on the capacity of local networks of firms to take up and utilize the knowledge outputs of the these facilities. The availability of innovative financing is critical, especially in more disadvantaged regions, such as Atlantic Canada. In this respect, proposed measures to expand the venture capital activities of the Business Development Bank will prove helpful, but the effective operation of the venture capital market also requires that it be integrated with the broader capital markets to ensure that the venture capital can be recycled into new investments. Another federal program that has recently garnered praise from those in the investment field is the Canadian Community Investment Program, which links angel investors with entrepreneurs.[39] Federal policy should ensure that these various elements of the policy environment are well aligned.

In addition, a well functioning innovation system requires that the federal government work with and through regional and local partners to stimulate the development of dynamic clusters at the local and community levels. In this respect, the recommendation in the leaked White Paper to provide smaller communities with funding to develop innovation strategies with the participation of local leaders from private, public and academic sectors is most intriguing. A key virtue of this approach is the involvement of local actors in thinking about how to design effective innovation strategies within the framework of existing national and regional policies. Building trust among economic actors in a local or regional economy is a difficult process that requires a constant dialogue between the relevant parties so that interests and perceptions can be better brought into

alignment. The need for social learning, at the local and regional level is critical to the success of such efforts.[40] Recent experiments in both the US and Europe may offer some useful lessons for regions and communities interested in stimulating innovation and cluster development. An invaluable asset in this process could be the Industrial Research Assistance Program's network of 260 Industrial Technology Advisors across the country that enjoys strong linkages with existing networks of firms, research-intensive institutions and community associations in their local and regional economies. IRAP is widely regarded as one of the most successful federal programs in diffusing technologies and adapting them to firm-specific uses.[41] Further expanding its role could build on this strong foundation.

The challenge for the future of industrial and innovation policy in Canada is to learn from the best of alternative approaches at both the regional and the local levels in devising a means to overcome the traditional weaknesses of Canadian innovation policy. This will require an approach that builds from the bottom up and integrates the perspectives of all three levels of government in a coordinated fashion to both increase national capabilities and reflect regional and local realities.

Figure 1: National System of Innovation



Source: Adapted from OECD, *Managing National Innovation Systems* (Paris, 1999), 23.

[1] The author is indebted to David Arthurs, Adam Holbrook and Ezra Miller as well as the editor of this volume for helpful comments on an earlier draft. Responsibility for any remaining errors or omissions is mine alone.

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