

A New Model of R&D Collaboration: Networks of Centres of Excellence (NCE) of Canada

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1. Introduction

Since the end of the Cold War, science and technology (S&T)-related issues have been front and center in political decision-making. We have now learned that the real strength of a country lies in its industrial competitiveness and in a global knowledge-based economy. Science and technology are key elements in the creation of national wealth. This has been demonstrated by countries with little deficient natural resources, such as Korea, which have created their competitive advantages by innovative activities using knowledge-based resources, not natural one.

However, recent S&T is getting bigger, being complicating and being systematic. No organization or country can complete the development of S&T alone without combining efforts with others (Chung, 1999). Researchers exchange their knowledge with others through co-publishing of articles, coordinating on projects, exchanging graduate students, or forming consortia. For researchers, institutes or even competitors, now is the time to make partnerships and networks with others.

Collaborating with researchers or institutes outside their territory can not be continued effectively without the systemized support and initiative of governments. One of the critical roles of the government is to provide resources such as funding for projects and researchers to enable them to gain a leading edge on research and development (R&D). Acknowledging the advantage of collaboration, government have recently offered more opportunities to the R&D teams which is consist of researchers from various sectors such as academia, industry and government-institutes.

This paper introduces a new model of national R&D program which brings partners within and outside the country to create networks for innovation and integrate R&D with the good of application and commercialization. The Federal Government of Canada initiated an R&D program, the Networks of Centres of Excellence (NCE) in 1989 for establishing new models of partnership and collaboration, and it is now exploring ways of better integrating their capabilities into Canada's system of innovation through this new collaborative approach. The Federal is striving to address emerging S&T issues and economic opportunities that will be beneficial on a national level (Government of Canada, 2001).

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This article is an overview of the NCE program. This explores the mechanisms of management and R&D activities of the NCE. It also addresses its benefits and impacts, and concludes with some recommendations towards Korean R&D.

“The NCE Program is an integral component of the Government of Canada's Innovation Strategy and an important example of our commitment to university research.” - Allan Rock, Minister of Industry, 2001-2002 NCE Annual Report -

The NCE program could be useful for Korean S&T communities to recognize how the government could act to stimulate researchers to form collaborative R&D networks and what the impacts could be expected from such an R&D partnership.

2. Overview of the NCE Program

Administered by the three federal granting councils in collaboration with Industry Canada, the NCE program represents an innovative approach to R&D. The NCE program puts Canada at the leading edge of multidisciplinary targeted research which is based on nation-wide collaboration among universities, industries and the government (Government of Canada, 1996). This unique initiative of the NCE is expressed as the one more anchored on the university side and focusing on creating new receptor capacity (Atkinson-Grosjean, 2001a)¹.

2.1 Program Goal and Priority

Having clearly demonstrated the advantages of collaboration, the NCE was made permanent in 1997 and was renewed with a commitment of \$47 million² annually funded through existing sources and reallocations (Government of Canada, 1997). The NCE Program is an integral component of the Government of Canada's Innovation Strategy³, and now regarded as an investment in research and entrepreneurial talent that generates economic and social benefits for Canadians.

The goal of the NCE program is to mobilize Canada's research talent in the academic, private and public sectors and apply it to the task of developing the economy and improving the quality of life for Canadians. This goal is consistent with, and reinforces, the three pillars of the Federal S&T strategy of Canada: sustainable job creation and economic growth, improved quality of life, and advancement of knowledge (NCE Program Guide, 2002).

¹ In the other hand, she asserts that others such as IRAP (Industrial Research Assistance Program of Canada) is more anchored on the industry side enhancing the capacities of existing industries.

² In this article, the currency unit \$ means CA\$, the Canadian dollar.

³ Canada's Innovation Strategy was launched in 2002, with the release of two documents: Achieving Excellence and Knowledge Matters. Its goal is to move Canada to the front ranks of the world's most innovative countries.

As well as contributing to the Innovation Strategy of the Government of Canada, the NCE program also strives for the goals of:

- creating knowledge and bringing ideas to market more quickly;
- training highly qualified people for the knowledge economy;
- supporting innovation in communities everywhere; and
- attracting investment not only from Canadian companies and organizations but also from international partners (NCE Annual Report 2001-2002).

Networks of Centres Excellence

“Excellence defines the individual researchers who have distinguished themselves through a record of peer-reviewed research. The *Centres* are created from this pool of excellent researchers who work together on common research projects. The *Networks* are institutes without walls, formed by Centres coming together to assemble a critical mass of intellectual capacity and to address strategic research questions deemed vital to Canada's social and economic development. Together, the Centres are capable of achieving more than the sum of their individual efforts.” - <http://www.nce.gc.ca> -

In regards to strategic programming, to become one of the most innovative countries in the world, the NCE puts its strength on four areas: health, human development and biotechnology; information and communications technologies, natural resources and environment, and engineering and manufacturing (NCE Annual Report 2001-2002). NCE competitions, however, are open to all research areas. Just the NCE Steering Committee decides target areas for new networks prior to each competition considering fund-availability, ongoing networks area and national needs.

2.2 Mechanism of Management

The NCE program draws together universities from across the country with industrial partners to do research in areas of particular importance to Canada. As a "virtual research organization", the NCE requires leading-edge telecommunication technology, for creating research consortia with a critical mass of expertise across the country.

In the Federal S&T Report 1998, research consortia was highlighted as one of important concepts for Canadian R&D. Consortia represents an excellent mechanism to pool expertise and knowledge and to advance the knowledge frontier much faster than could be accomplished by any one consortium members individually. Research consortia are not just meetings of organizations with similar interests, rather they are meetings driven by shared needs and complementary capabilities (Government of Canada, 1998)

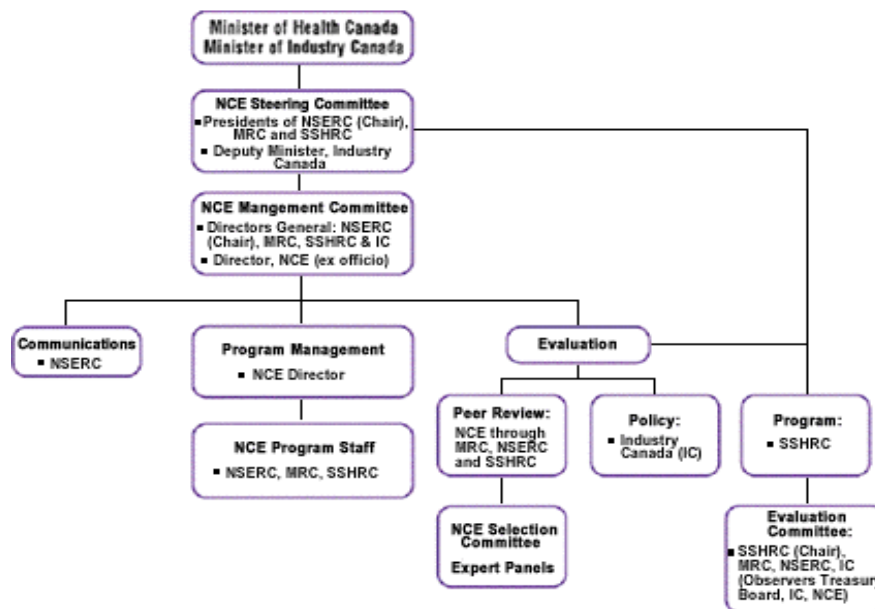
Under this framework, the federal departments which support the NCE are helping the researchers and various institutes manage the program at the federal level, and also at the level of individual Networks.

2.2.2 Federal-Level Management

Three Canadian federal granting agencies help to support the NCE initiatives: the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council of Canada (SSHRC). Industry Canada also supports the program.

The Minister of Industry Canada has the overall program responsibility. The NCE Steering Committee comprised of the presidents of the three granting agencies is responsible for overseeing all aspects of the program, including direct responsibility for the program evaluation function. Responsibility for specific Networks is assigned to the Granting Council most appropriate for the subject area in question. NCE program-related activities include individual Network competition and selection, program management and administration, evaluation, monitoring, and guidance.

<Figure 1> Administrative Structure of the NCE Program



Source: Adopted from NCE Annual Report 1998-1999.

The program evaluation is organized by SSHRC with guidance from the NCE program Evaluation Committee, as well as peer review of the individual Networks which is lead by the responsible Granting Councils and policy review organized by Industry (NCE Evaluation Report, 1997).

In 2002, an independent evaluation of the NCE Program was launched to comply with the Treasury Board⁴'s requirement to ensure that Canadians receive the best value for

⁴ Treasury Board, a member of Cabinet, was established in 1867 and manages the government's financial, personnel, and administrative responsibilities.

their investment in research and innovation. The evaluation assessed the success of the program as measured by the NCE results, asking questions about: international competitiveness, support for critical areas of research, development of education and training, creation of start-up companies, development of contracts and patents, and impacts on socio-economic policies, norms, standards, and regulations (NCE Evaluation Report, 2002)⁵.

2.2.3 Individual Network-Level Management

The management approach to the establishment and operation of the individual Networks is relatively flexible. Networks are given a fair degree of freedom to determine their individual management structures and styles of operation.

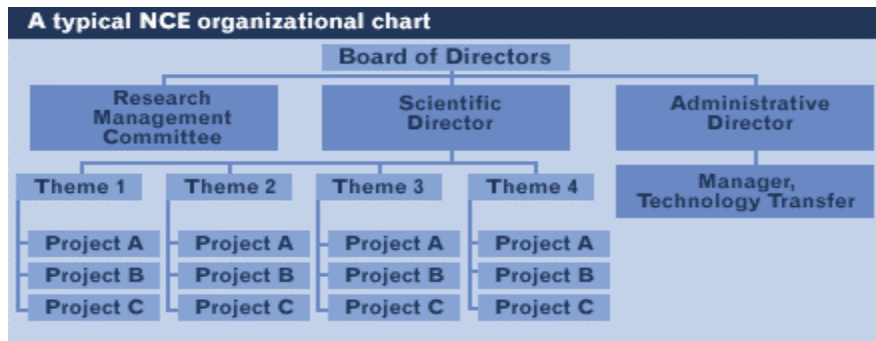
There are, however, some mandatory requirements for the Networks. Each Network is expected to have an administrative structure capable of managing a complex multidisciplinary, multi-institutional program. The particular structure will vary according to the needs of the individual Network, but the structure must be detailed by the proponents in their Internal Agreement⁶ and approved by the NCE Steering Committee. All networks have: a board of directors; a scientific committee to organize the research program; and, a network management team. Some Networks have: an executive committee of the board for speedy decision-making and various types of industrial committees to organize links with the private sector. Some Networks may also have committees, etc (NCE Evaluation Report, 1997).

The Scientific Director, among other functions, provides scientific leadership, promotes collaboration and often chairs the Research Management Committee. The Network Manager directs daily business, ensuring control and accountability, and is responsible for internal and external communications. The Host Institution, normally a university, hospital or other partner, provides suitable space for the Network's Administrative Centre.

⁵ The evaluation methodologies of the NCE, in the Evaluation Report 2002, were as follows: (1) international literature review; (2) review of NCE performance data and reports; (3) survey of all network partners through an e-mail based survey; (4) interviews with Network Scientific Leaders and Network Managers; (5) web-based survey of Network Researchers; (6) interviews with members of the Expert Panels and NCE Selection Committee; and (7) other interviews with NCE Program Administrators and officials within the granting agencies.

⁶ The organizations participating in a network must prepare and sign a separate agreement. This "Internal Agreement" covers such matters as: the responsibilities, obligations, commitments and privileges of each organization; the arrangement and structures governing the management of the network; the distribution of funds; the internal reporting requirements; the interactions between the participants including corporate partners; the ownership and disposition of intellectual property; the publication of research results; conflicts of interest; title to equipment, insurance etc. The Internal Agreement must be consistent with the NCE program objectives and is subject to formal approval by the NCE Steering Committee (Evaluation Report, 1997).

<Figure 2> Individual NCE Organization



Source: NCE 2001-2002 Annual Report

3. Networks and R&D Activities

At present there are 20 networks conducting leading-edge research in strategic areas. There are four research categories including 8 Health and Biotechnology NCEs, 5 Advanced Technologies NCEs, 2 Natural Resources and Environment NCEs, and 2 Engineering and Manufacturing NCEs. Each Network is at a different stage of maturity.

<p>Birth of NCEs</p> <p>1989: 8 1995: 4 1998: 3 1999: 3 2000: 4</p>	<p>A typical NCE</p> <ul style="list-style-type: none"> • Lead by Scientific Director / Research Management Committee • 15-25 Projects in 4-6 Themes • 50-60 Professors in 12-20 Universities • 100-150 Highly Qualified Personnel (HQP) • 20-50 Companies • \$CDN 3-6 Million from NCE per year <ul style="list-style-type: none"> - Doubled with Partner's Cash and In-kind - Quadrupled with Individual Research Grants <p>(Jean-Claude Gavrel, 2002)</p>
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Typically, one NCE is funded \$3-6 million per year by the program. The NCE organizes between 15 and 25 projects under 4-6 themes. The personnel of an NCE, usually includes 50-60 professors from 12-20 universities, 100-150 Highly Qualified Personnel (HQP) and 20-50 companies.

The federal government of Canada has illustrated that in an average year the NCE program involves approximately 5000 participants including over 3600 research associates and students, creates over 17 spin-off companies, and assists almost 1500 university graduates to obtain industry employment (Government of Canada, 2001). In 2001-2002, 778 companies, 221 provincial and federal government departments and agencies, 63 hospitals, 155 universities, and more than 327 other organizations from Canada and abroad were involved in the NCE program (NCE website).

In Phase I of the program, 1989/90 to 1993/94, the NCE supported 15 networks with a total funding package of roughly \$240 million. For Phase II, 1994/95 to 1997/98, 14 of the existing networks reapplied to the program and 10 were renewed. In addition, four new networks were supported from 1995/96 to 1998/99. The total funding package for Phase II was about \$197 million (NCE Evaluation Report, 1997). And from the 1998/1999, up to 2001/02, it was funded about \$269 million for the grants and program administration by cash.

In 1999/2000, the funding for NCE program was largely increased, as well as the sources from its partners. This increasing active involvement of Canadian industry provides stimulating training environments and employment opportunities for students. In 2001-2002, Network graduates had an 84% job placement success rate (NCE Annual Report 2001-2002). The networks stimulated outside investments over \$87 million which included more than \$44 million by participating private-sector companies (NCE program webpage). See the Table1.

<Table 1> R&D Expenditures

Year	NCE Grants	Administration	Partners	Total (CA\$)
1995-1996	44,856,502	1,435,000	41,852,874	88,144,376
1996-1997	41,386,749	1,394,000	48,367,000	91,147,749
1997-1998	39,084,000	1,209,000	60,299,699	100,592,699
1998-1999	46,624,000	1,476,000	75,944,479	124,044,479
1999-2000	63,845,076	1,896,000	70,595,330	136,336,406
2000-2001	74,745,933	2,653,476	84,548,581	161,947,990
2001-2002	74,763,891	2,635,476	87,743,822	165,143,189
Total	385,306,151	12,698,952	469,351,785	867,356,888

Source: NCE Annual Reports, 1995-1996 to 2001-2002

According to the NCE Annual Report 1999/2000, over one thousand organizations, were involved in this program. And in the program 2001/02, the rate of participating organizations increased. The NCE is a university-side program and over 5 hundreds companies work within the program. An industrial partnership which includes universities, hospitals and governments in R&D activities, stimulates technology transfer and market success. Also over 20% of the organizations are from non-Canadian sector help domestic organizations to access to international facilities and leading-edge knowledge. See the Table2.

<Table 2> Participating Organization

Year	Fed.	Hosp.	Indu.	Other	Prov.	Univ.	Total	(Ca)	(N.Ca)
1995-1996	36	37	405	63	40	48	629	565	64
1996-1997	43	43	466	105	62	61	780	677	103
1997-1998	40	44	463	219	85	61	912	789	123
1998-1999	31	18	462	99	73	58	741	634	107
1999-2000	52	46	563	266	86	98	1,111	903	208
2000-2001	65	44	596	269	78	149	1,201	926	275
2001-2002	100	63	778	327	121	155	1,544	1,260	284
Total	367	295	3,733	1,348	545	630	6,918	5,754	1,164

* Sectors of organization: Federal, Hospital, Industry, Other, Provincial, University, Canadian, Non-Canadian
 Source: NCE Annual Reports, 1995-1996 to 2001-2002

Over 7,000 personnel are involved in the NCE program in a year which mobilizes researchers, postdoctoral fellows, graduate students, and partners from the public and private sectors. During the period of the program 2001/2002, the program created nationwide multidisciplinary research partnerships, connecting 2,000 researchers and 5,000 other highly-qualified persons. See the Table 3.

<Table 3> R&D Personnel

Year	NCE Researcher*		HQP**		Total
	University	Non-Univ.	NCE Fund	Non-NCE F.	
1995-1996	835	196	1,714	1,376	4,121
1996-1997	808	120	1,851	1,419	4,198
1997-1998	742	139	1,615	1,478	3,974
1998-1999	992	184	1,208	1,349	3,733
1999-2000	1,140	359	1,820	1,756	5,075
2000-2001	1,396	304	2,179	2,088	5,967
2001-2002	1,662	436	2,718	2,349	7,165
Total	7,575	1,738	13,105	11,815	34,233

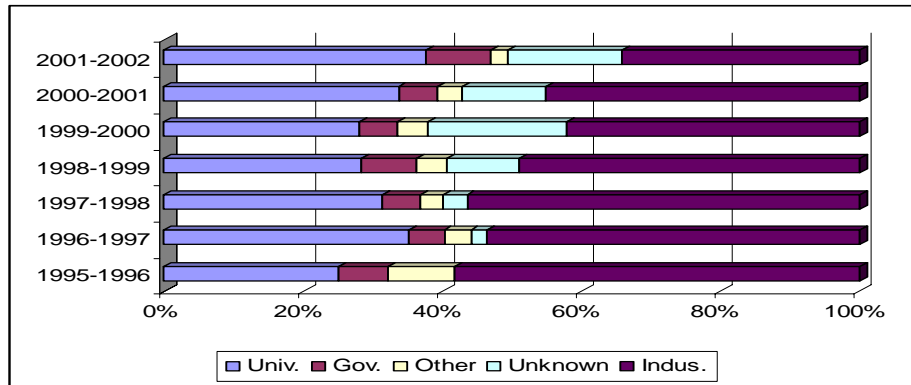
*NCE Researcher: A researcher from the academic, public or private sector responsible for certain aspects of Network-funded research projects.

**Highly Qualified Personnel: Research staff such as research associates and technicians, and research trainees such as postdoctoral fellows, graduate students and summer students.

Source: NCE Annual Reports, 1995-1996 to 2001-2002.

The NCE has a very high of post-Network employment rate for graduate students. This provides an opportunity for active involvement in the Canadian industry. Almost 80% are successful at finding jobs upon graduation annually and the figures are recognized as importance for the future of innovative R&D. In 2001-2002, the majority of grad students were hired by universities (37.6%). Others were employed in industry (34.2%) and government (9.4%). The employment rate of graduate is nearly 80% and recognized importance of innovative R&D. See the Figure3.

<Figure 3> Post-Network Employment by Sector



Source: NCE Annual Reports, 1995-1996 to 2001-2002

4. Impacts and Benefits

The NCE program's unique partnership between universities, industry, government and non-governmental organizations has been successful in nurturing Canadian research and entrepreneurial talent to have economic and social benefits for all Canadians. The NCE's impacts, have been beneficial for the development of program processes, the increase of knowledge, technology transfer, and the creation of intellectual property.

The networks provide employment and valuable training experience to thousands of highly qualified researchers (Government of Canada, 1998), which gives benefits to the Canadian industry by hiring these students who have direct with hands-on experience⁷.

An analysis on the relationship between the costs and benefits of

Program Impacts of NCE

1. Process Impacts

The NCE Program has transformed the way research is conducted. It included a variety of research methodologies developed from: collaboration, inter-disciplinarity, student training, partnerships with users, knowledge and technology transfer, intellectual property (IP) protection, and development of local and national critical mass.

2. Knowledge Transfer

Most of the HQP trained by networks, 88% in 2000-2001, have found employment after leaving the Network. A substantial number are employed by industry and government.

3. Technology Transfer

In 2001, 97 spin-off companies associated with the NCE had been created, and there was active patent activity—56 granted among 170 filed. Several networks rely on other mechanisms such as carrying out pre-competitive research or relying on application of research results.

4. Intellectual Property Protection

There are still problems within some networks with regards to IP protection and exploitation. These problems arise from the variety of IP ownership rules at various universities, and variable levels of trust and collaboration between individual Networks and their university Industry Liaison Offices (Evaluation Report, 2002).

⁷ According to the 1997 federal report, a six-month decrease in the learning curve of Network graduates in globally competitive areas such as microelectronics and telecommunications is estimated to produce annual savings of more than \$3 million for their employers (Government of Canada, 1997).

the NCE program was conducted by Dennis Rank and Douglas. In their research they explain that the NCE is very successful in the analysis of partial benefit/cost, although there are often difficulties in using economic analysis to review research programs (Dennis Rank, 1999).

5. Concluding Remarks

The successes of the NCE have established an international reputation for the program. The NCE Annual Report 2001-2002 states that the European Union and countries such as Japan, China, Sweden and France are studying this program and modeling their own R&D program on its network concept. It is excellent example of how government support can lead to the advancement of knowledge in a country.

Realizing the importance of the NCE's network-oriented research environment, researchers are developing their own research questions. Donald Fisher, professor of University of British Columbia (UBC), introduces concept of "Network Science" which offers the potential for a scale and scope of investigation for single researchers and small groups (Donald Fisher, 2001). Janet Atkinson-Grosjean, policy researcher at UBC, asserts that the NCE has extended the unique networked research model and it is becoming the preferred way to practice science (Atkinson-Grosjean, 2001).

The federal government's Speech from the Throne in January 2001 laid out the bold challenge of moving Canada from the 15th to among the top five internationally in R&D as a percentage of GDP. As a result, the government committed to doubling its investment in R&D in the coming decade and also admitted that effective and productive partnerships between all sectors of society will be critical to Canada's success in reaching this objective.

In the Federal S&T Report 2002, the government signed an agreement with the Association of Universities and Colleges of Canada (AUCC), whereby universities committed to doubling the R&D they invest by 2010 and tripling their commercialization performance (Government of Canada, 2002). The NCE program would play a critical role as a new R&D model.

In Korea, there is also a national R&D program for Center of Excellence. Korean Centers of Excellence (COE) program which involves Science Research Centers (SRC), Engineering Research Centers and Regional Research Centers (RRC). As its mandate, the COE program aims to encourage multidisciplinary collaboration rooted in universities between academia and industry. The goal is to raise Korean research capabilities to an international level.

There are a lot of similarities between the purposes of the NCE's and COE's: both are located in universities; support highly experienced research teams at Centers; and

enhance the cultivation of competent manpower, technology transfer, academic exchange, and international cooperation. COE's, however, are quite smaller than NCE's in aspects such as funding, participating personnel, and participating organizations and companies. The NCE shows a network-oriented R&D activities, not the center-oriented one that is generally found in the COE.

Korean R&D program is getting bigger and requiring partnership and collaboration between researchers in university, industry and government research institutes. To accomplish this task, the intention and role of the Korean government is central.

There are many methods with which the government could stimulate R&D collaborations. The government could initiate a new program forming national R&D network consisting of centers of excellence across Korea. To stimulate the on-going programs such as the COE, the government could enlarge the R&D funding and require more partnerships. The 21st Century Frontier R&D Program⁸ could be an alternative choice for the government to establish a national R&D innovation system. It is critical for the success of the program to involve industry in the R&D network. For active involvement of industry, the Korean government should review its R&D tax credit laws and develop them to stimulate industrial R&D.

Furthermore, the government of Canada is pursuing studies on the relationship between the NCE program and the regional innovation in Canada. This topic would also be quite interesting to the development and future expansion of the Korean S&T communities.

⁸ An ambitious program of Korea aims at complete technological competitiveness and leading edge in selective research fields such as IT, BT and NT. It currently operates 20 Research Centers which funded each maximum 17 million in a year and managed by Director of Center with its independent management policy.

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