

A Network Approach to R&D Activities: The Networks of Centres of Excellence (NCE) Program of Canada and Its Implications

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<Contents>

1. Introduction
2. Theoretical Review and Analytical Framework
3. Program Overview: What is the NCE program?
4. A Network Approach of the NCE in R&D Management
5. Concluding Remarks and Implications

1. Introduction

With the arrival of the knowledge-based society, technology became a key issue in terms of national competitiveness, innovation and even wealth. It is well recognized that science and technology (S&T) is a sort of capital goods and important factor in knowledge-flow such as knowledge generation, transfer, adoption, absorption and building a learning organization. This has been demonstrated by countries deficient in natural resources, such as Korea, which have created their competitive advantages through innovative activities using knowledge-based resources, not natural resources.

As S&T become more important and crucial in national development and growth, on the other hand, developing technology alone becomes more difficult. Nowadays, S&T is growing even bigger in both funding and R&D size, its complexity and more inter and multi-disciplinary in application to other technologies and fields. No organization or country can follow the developmental pathway of technology alone without collaborative efforts with others.

In the R&D sector of industries, global and collaborative R&D already has been issues in their business. Huge multi-national companies (MNCs), especially in the pharmaceutical area, are investigating in small biotechnology-based R&D ventures to gain state-of-the-art technology and its advantage or to break the technological bottleneck. At the national level also, R&D collaboration has been and is being emphasised

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between R&D actors for the same reason, and big countries form research consortia in the high-technology fields, such as 'Genome' and 'Nano'. Researchers exchange their knowledge through co-publishing articles, managing projects, exchanging graduate students, or forming consortia. Now, for institutes, researchers and even competitors, it is the time to make partnerships and networks with others.

For R&D collaboration, to be done effective and sustainable, it is necessary to systemize all related supports and processes whether it happens at the national level or not. As is well known with the theory of national innovation system (NIS) for technological development, the most critical role of government is in linking actors, forming networks and building infra-structure as a whole. Governments have recently been driving new R&D policies initiating programs and offering more opportunities to R&D teams, networking researchers from various sectors such as academia, industry and government-institutes. No matter what the sectors are, at present the network is the best-emphasized issue for their success. In national R&D policies, of course, it is no different, so that building a research network is mandated usually in R&D programs as a major objective.

The R&D program of Canada shows a network approach in R&D management that brings partners within and outside the country to create networks for innovation, and integrates 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 government is striving to address emerging S&T issues and economic opportunities that will be beneficial on a national level (Government of Canada, 2001).

The purpose of this paper is to analyze the approach of the NCE program in R&D collaboration through some perspectives, such as organizational structure, management system and institutions, and find some implications for Korean R&D programs. It would be useful for Korean S&T communities, including government, to adapt a new model of R&D management, new ways stimulate researchers to form collaborative R&D networks and the impacts that could be expected from such an R&D partnership.

2. Theoretical Review and Analytical Framework

Freeman (1987) defines that the NIS is a network between the public and private sector, which conducts related technological activities and transactions to attain, improve and diffuse new technology. In the process of technological innovation, he emphasizes the importance of the system, which has been overlooked by researchers. In his theoretical frame, a network is a kind of system for generation, diffusion and employment of technological knowledge (Freeman, 1991).

Lundvall (1992) comprises all organization and system related with searching and exploring so that the

NIS, for him, the meaning includes the economy at large and sub-systems of production, education and finance as well as R&D department, technology institutes and those in universities.

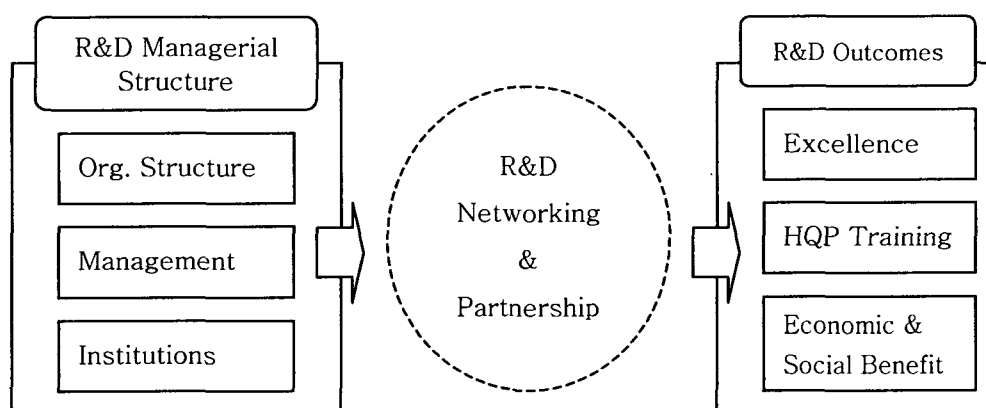
Defining simply NIS as an assembly of organizations that affect mainly the outcomes of technological innovation, Nelson and Rosenberg (1993) consider businesses, their research institutes and affiliated institutes in the university and public sector, and discuss more such as the relationship between science and technology, the limitation of science, and learning through practices.

In a study by Powell (1990), the network is a relation among organizations having unique intermediary character, not a market of free trade or hierarchy in a vertically unified organization. And, in industrial sector, the increasing aspect of technological collaboration through the network (Alcorta, 1998) and the deepening changes in its spec, depth and substance (Coombs et al., 1996)) has been discussed.

What about in the public sector? It's natural that, in the public sector, government holds an important role in NIS, in particular for the technological innovation system. There are several policy patterns for government to develop technology innovation system (TIS), which generally consists of policies for technology supply, technology demand and environment or liaison (Kim & Dahlman, 1992; Rothwell, 1982). Among those, technology supply policy forms NIS actors to enforce national technology level and supply resources in terms of human, finance and information to initiate all of the actors in the system (Lim, 1998).

As one of policy means of technology supply, the national R&D program has been put in a significant role in national R&D policy and strategy, and nowadays, it is emphasizes the ability to systemize the R&D network across country through participating in the program with a research project. From this point of view, it is important to design a program system, including organizational structure and managerial system in the process of knowledge flow and fusion (Nonaka & Takeuchi, 1995; Amabile, 1988; Damanpour, 1991).

Figure1. Analytical Framework



In order to explore the above, this study poses some research questions: what about the R&D activities of the NCE in terms of investment, researchers and organizations involved? How does the organizational structure of the NCE program function at each management-level? What are the key managerial strengths and institutional frameworks of the program in stimulating R&D networks? The analytical methodology of

this study area as follows: (1) literature review; (2) review of NCE performance data and reports; (3) interviews with Network researchers, Network Managers and officials in the university (UILO); and (5) information on the NCE website.

3. Program Overview: What is the NCE program?

The Networks of Centres of Excellence (NCE) program was established as a pilot project in 1989, as part of the Canadian government's science and technology strategy to better link research with wealth creation. Since its inception in 1989, the NCE program has been linking Canadian researchers from the university, public and private sectors to work collaboratively on the advancement of research on the development of new technologies. Networks provide opportunities to develop innovative research approaches that cross traditional disciplinary and sectoral boundaries, and promote collaborations among scientists and engineers from several domains. These collaborations have contributed significantly to speeding up the intake of new knowledge and technologies by the industry and other receptor communities, and have led to important socio-economic benefits.

Having clearly demonstrated the advantages of collaboration, the NCE was made permanent in 1997 and was renewed with a commitment of \$47 million¹ annually funded through existing sources and reallocations (Government of Canada, 1997). The NCE program is an integral component of the Canadian government's innovation strategy, and now regarded as an investment in research and entrepreneurial talent that generates economic and social benefits for Canadians.

3.1 Program Goal and Priority

The goal of the federal 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 of Canadians, which is consistent with, and reinforces, the three pillars of the federal S&T strategy: sustainable job creation and economic growth, improved quality of life, and advancement of knowledge. As well as contributing to the Canadian government's innovation strategy, the NCE program also strives for the purpose 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).

The NCE has five criteria of excellence: the excellence of the research program; the opportunity for developing highly qualified personnel; the networking and partnership possibilities; the opportunity for

¹ In this article, the currency unit \$ means CA\$, the Canadian dollar.

knowledge exchange and technology exploitation; and the quality of the management of the network. And the excellence above is accomplished by investing in research networks that meet the followings: Stimulate internationally competitive, promote leading-edge fundamental and applied research in areas critical to Canadian economic and social development; Develop and retain world-class researchers in areas essential to Canada's productivity and economic growth; Create nation-wide multidisciplinary and multi-sectoral research partnerships that integrate the research and development priorities of all participants; And accelerate the exchange of research results within the network and the use of this knowledge within Canada by organizations that can harness it for Canadian economic and social development.

3.2 R&D Activities of the NCE

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 (Jean-Claude Gavrel, 2002). These networks are at different stages of maturity; eleven networks have been created in 1989 and in 1995. Eleven other networks have been created during the last four. In accordance with the NCE program framework approved by the government in February 1997, networks can benefit for a maximum of two 7-year of funding cycles. There are four research categories including 9 Health and Biotechnology NCEs, 5 Advanced Technologies NCEs, 2 Natural Resources and Environment NCEs, and 2 Engineering and Manufacturing NCEs ². Each Network is at a different stage of maturity.

3.2.1 Funding

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.

² Advanced Technologies(5: Photonics/Geomatics/Robotics and Intelligent Systems/ Mathematics of IT/Microelectronics), Engineering and Manufacturing(2: Automobile/Intelligent Sensing/Health), Human Development and Biotechnology(9: Advanced Foods and Materials/ Arthritis/Bacterial Diseases/Genetic Diseases/Language and Literacy/Vaccines and Immuno therapeutics/Stroke/Protein Engineering/ Stem Cell), Natural Resources and Environment(5: Aquaculture/Arctic/Water issue/Mechanical Wood-Pulps/Forest Management)

Table1. Funding to the NCE

(Unit:CA\$)

Year	Federal	Partners	Total
1995-1996	46,291,502	41,852,874	88,144,376
1996-1997	42,780,749	48,367,000	91,147,749
1997-1998	40,293,000	60,299,699	100,592,699
1998-1999	48,100,000	75,944,479	124,044,479
1999-2000	65,741,076	70,595,330	136,336,406
2000-2001	77,399,409	84,548,581	161,947,990
2001-2002	77,399,367	87,743,822	165,143,189
Total	398,005,103	469,351,785	867,356,888

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

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.

Last year The NCE program stimulated outside investments of over \$69 million, including more than \$33 million from private-sector companies. With the addition of the Program's own investment, the total dedicated to research, training and commercialization in 2002-2003 reached more than \$147 million. The NCEs also nurtured the commercialization of research through 153 patents and licenses and the establishment of five spin-off companies in areas of high economic and social value. Equally important, the NCEs helped lay the foundations for Canada's future competence and prosperity by training 4,772 research staff such as postdoctoral fellows, students, research associates and technicians to carry our strategy into the new century.

3.2.2 R&D Actors

The main actors of the program include the three granting councils: the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research (CIHR) and the Social Sciences and Humanities Research Council (SSHRC) as well as Industry Canada. Canadian universities, as well as affiliated hospitals and research institutes, and some industry consortia, also are key players in delivering the NCE program.

Individuals and organizations mobilize to achieve the expected results. University faculty and students, as well as public and private sector partners, play a significant role in achieving these results. Industries and organizations within the areas covered by NCE networks are important stakeholders that benefit from the

research results generated by the networks. In many instances, they are closely involved in commercializing new products, services or processes or in adopting new practices and policies, linked to NCE research.

Globally, the NCE program also bears the potential for impact on the development of entirely new industrial sectors in Canada. Parliament is another stakeholder given the significant role played by the NCE program within the federal science and technology strategy as well as within the various activities of the Industry Canada portfolio. The Canadian public can also be considered as a stakeholder since the results are already known to have important impacts on the economy and on the quality of life of Canadians. Moreover, at the international level, many research results of the Program have impacted on the development of international standards, policies and regulations, thus affecting individuals and organizations outside Canada. Other network stakeholders include collaborators, consultants, clients, suppliers, various levels of government and the written and electronic media that closely monitor the NCE program.

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 nation-wide multidisciplinary research partnerships, connecting 2,000 researchers and 5,000 other highly-qualified persons. See the Table 3.

Table2. Participating Personnel and Organization

Year	Personnel			Total
	Org.	Resr.*	HQP**	
1995-1996	629	1,031	3,090	4,121
1996-1997	780	928	3,270	4,198
1997-1998	912	881	3,093	3,974
1998-1999	741	1,176	2,557	3,733
1999-2000	1,111	1,499	3,576	5,075
2000-2001	1,201	1,700	4,267	5,967
2001-2002	1,544	2,098	5,067	7,165
Total	6,918	9,313	24,920	34,233

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

*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.

3.2.3 Research Collaboration

Data from recent years in Table 4 shows that the NCE has been successful in garnering support from a wide variety of organizations both in Canada and, to a more limited extent, from abroad.

Table3. Types of Organization

	2000- 2001	1999- 2000	1998- 1999	1997- 1998
Number of participating organizations:				

- Canadian universities	54	55	49	45
- International universities	95	43	9	16
- Canadian companies	500	475	389	380
- International companies	96	88	73	83
- Canadian hospitals	34	39	17	42
- International hospitals	10	7	1	3
- Canadian federal departments & councils	59	45	28	37
- International federal depts. & councils	6	7	3	3
- Provincial departments & councils	78	86	73	85
- Other Canadian organizations	201	203	78	200
- Other international organizations	68	63	21	19
TOTAL	1,201	1,111	741	912

* Source: NCE Annual Reports 1997/98-2001/02

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. * Sectors of organization: Federal, Hospital, Industry, Other, Provincial, University, Canadian, Non-Canadian

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 2002-2003, the NCE program supported 1,613 researchers in 68 universities. The program's partners included 624 companies, 184 provincial and federal government departments and 232 councils from Canada, and 298 international partners, making it a truly national and international program and bringing together leaders in business, industry, research and government to create effective partnerships.

4. A Network Approach of the NCE in R&D Management

4.1 Organizational Structure

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 program-level, and also at the level of individual Networks.

4.1.1 Federal Program-Level

Industry Canada and the three federal granting councils, which are CIHR, NSERC and SSHRC, jointly manage the program and support its initiatives. The Minister of Industry Canada has the overall program responsibility. The presidents of the three granting councils comprising the NCE Steering Committee oversee all aspects of the program, including direct responsibility for the program evaluation function. They are partners in the program, providing the base of funding that complements NCE research activities.

Responsibility for specific Networks is assigned to the granting councils 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. The NCE Directorate is responsible for the day-to-day management of the NCE program. The NCE Directorate receives administrative support from NSERC. The Management Committee was established in 1991 to oversee operations and coordinate activities related to administration, communications, and evaluation.

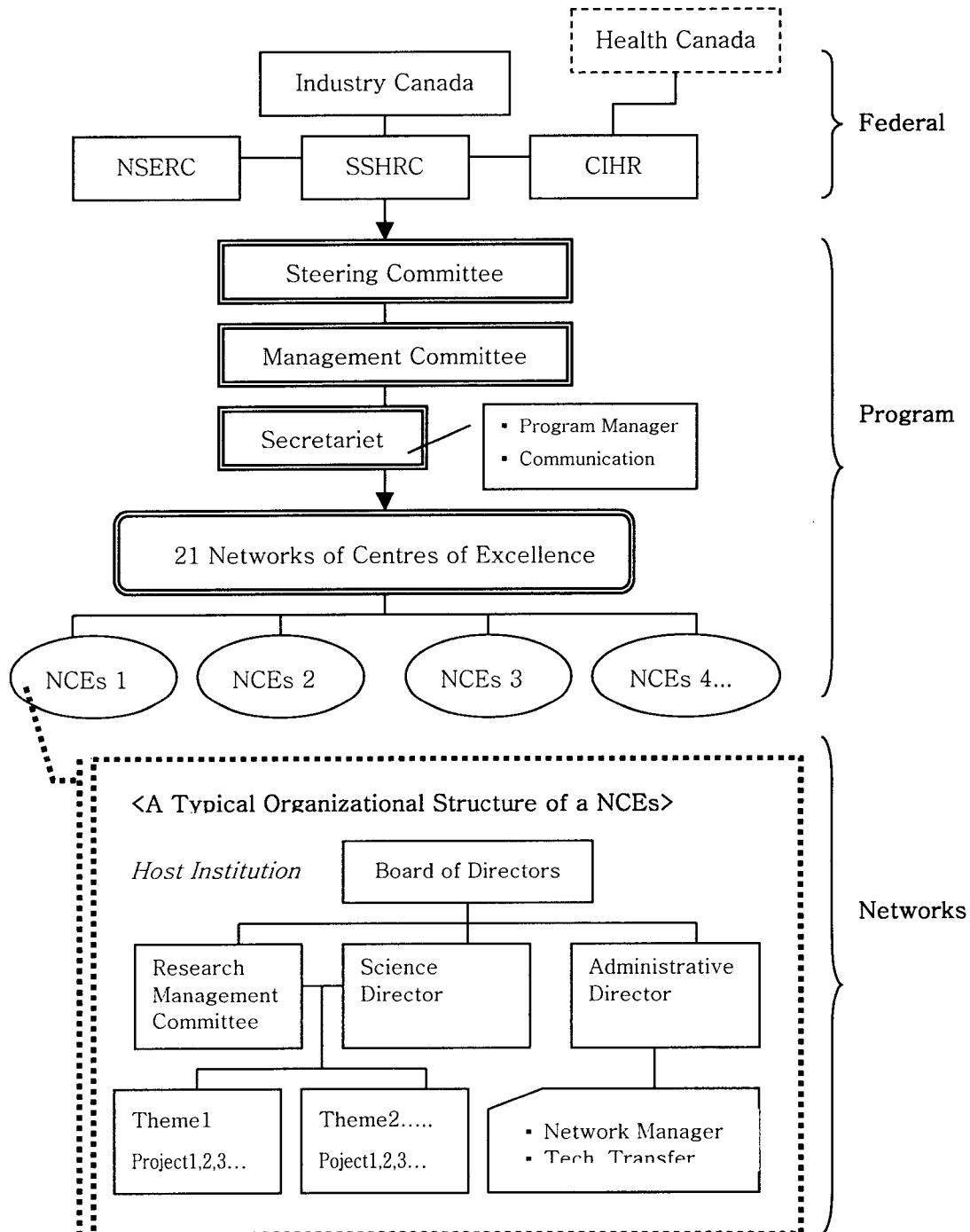
The management of communications is critical to the success of individual networks and the program as a whole. Effective internal network communications are vital to the network mode of conducting research. R&D activities, results from the Networks should also be delivered to external audiences, including potential participants from all sectors, public policy makers, the media and the general public.

The NCE Steering Committee is responsible for evaluating the effectiveness of the NCE program and reporting the results to the Minister of Industry. Program evaluation activities, carried out by an independent firm, may involve surveys and interviews of individuals and staff. Current and former networks are required to take part in the evaluation of the NCE program and make information and records available to the program evaluation team on request.

4.1.2 Individual Networks-Level

Each network must possess an organizational structure appropriate for the management of the research and business functions of a complex multidisciplinary, multi-institutional program. These elements must include: a board and committee structure to ensure that appropriate policy and financial decisions are made and implemented; the presence of effective leadership and expertise in the research and the business management functions; effective research planning and budgeting mechanisms; and effective internal and external communications strategies.

Figure2. Organizational Structure of the NCE program



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 may also have committees or subcommittees related to training, intellectual property, communications, and so on. Networks have been encouraged to consider incorporation, but the decision regarding incorporation is the responsibility of the individual network, and requires approval by their Board of Directors.

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 partners, provides suitable space for the Network's Administrative Centre.

Each network must develop a communications plan with a set of comprehensive objectives and activities designed to enhance interest in the network and its research activities and to promote the network and the NCE program to the broad spectrum of sectors that may benefit. Networks are encouraged to produce their public communication channel and publications in both official languages when possible.

The network's communications activities and messages must be consistent with and complementary to the NCE program communications plan. They must acknowledge the contribution of the federal government, and the fact that the networks are expected to collaborate closely with the NCE Directorate Communications Officer for their communications activities directed to an external audience. Network university partners are also expected to cooperate with the networks and the NCE Directorate Communications Officer in communicating the successes arising from network-funded research.

4.2 Management System

4.2.1 Peer-review

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, although there are some mandatory requirements.

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. The 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.

All funding decisions are based on an arm's length and peer-reviewed assessment of applications by expert panels and selection committees. The NCE program uses a peer-review system which is an assessment by impartial experts of research proposals in their specific fields.

For each competition, the NCE Steering Committee appoints a Selection Committee composed of international experts with broad expertise in the domains of the three granting councils. The Selection Committee reviews the reports of the expert panels that evaluate each application and sends a priority-ranked list of networks to the NCE Steering Committee. The Steering Committee then decides which networks will receive funding.

The Selection Committee will review the letters of intent based on the selection criteria, the application's relevance to the NCE program goal and objectives as well as, if applicable, the proposed network's relevance to the target area. The Selection Committee will make recommendations on which applicants should be invited to submit full applications to the NCE Steering Committee for decision.

The NCE Directorate will appoint an interdisciplinary expert panel to evaluate each full application. The review will be based on the NCE selection criteria. An expert panel will meet with representatives of each group of applicants and their partners.

The expert panel will provide a detailed evaluation of the strengths and weaknesses for each selection criterion and will make recommendations on the appropriateness of the requested budget. The review reports, which will be provided to the respective applicant groups after the competition, will be transmitted to the NCE Selection Committee.

Taking into account the reports of the expert panels, the Selection Committee will review and rate the applications based on the selection criteria. The Selection Committee will transmit a priority-ranked list of networks recommended for funding along with a list of recommended awards to the NCE Steering Committee for decision. The decisions reached by the NCE Steering Committee are final. There is no appeal process.

The progress of each funded network is monitored on an on-going basis with an in-depth peer review at the mid-point of the funding cycle. Each network prepares a detailed report on the first years of activity and a strategic plan for the remaining years. An in-depth evaluation of the network's performance is conducted by an expert panel that makes recommendations to the NCE Steering Committee. The mid-term review could result in continued funding, continued funding on a conditional basis, or the phasing out of a network before the end of the current award. Bilingual corporate reports, statistical tables, financial reports, statements of other sources of funding, and administrative reports such as, conflict of interest and environmental review reports are required annually as stipulated by the NCE Directorate.

4.2.2 Funding to Networks

NCE grants are administered through the NCE Directorate. In general, the rules and policies of the granting council into whose domain the network's research falls will apply to that network. Networks whose research falls under the mandate of more than one granting council must choose and adhere to the rules and

policies of a single granting council. In addition, networks must adhere to the regulations and administrative policies specific to the NCE program.

Organizations eligible to receive funds are universities, affiliated hospitals and research institutes, and post-secondary institutions that have a research mandate. Researchers and organizations that receive NCE funds must meet the general eligibility requirements of one of the three federal granting councils administering the program. An industry consortium may receive funds to administer a network.

Payment of grants is authorized by the NCE Steering Committee through one or more of the granting councils. Subsequent installments are approved annually, subject to the availability of funds, satisfactory progress, and the network's continuing compliance with the program's policies, terms and conditions.

Consistent with the cash management policy and to minimize the amount of time and administrative effort required for making installment payments, the standard function programmed into the award management information system is for the payment of each annual amount over twelve installments spread over the year.

For networks administered through a university, funds are released to the designated financial administrative unit of the host university, following normal payment schedules for the granting councils. The network advises the host university on the amounts to be disbursed to participating institutions. For networks not administered through a university, funds are released monthly in arrears to the financial administration unit of the network that is responsible for the distribution of funds to participating institutions.

The NCE Directorate reserves the right to terminate or suspend a grant should the recipient cease to meet the eligibility criteria. Amounts paid after the expiry of eligibility or on the basis of fraudulent or inaccurate application, or in error, are subject to recovery action. The NCE Directorate may withhold an appropriate amount of the total grant payable to the recipient until it is satisfied that the recipient meets the eligibility criteria of the program. Fraudulent use of NCE funds is referred to the appropriate legal authorities.

4.2.3 Management of Conflict of Interest

The Network Board of Directors or its conflict of interest sub-committee is charged with the responsibility of managing conflict of interest, and determining and implementing the appropriate course of action. This management system is based on disclosure. While it is recognized that it may be difficult to completely avoid situations of potential, apparent or actual conflict of interest, complete avoidance or divestment may be required in certain cases. Such divestment should not consist of a sale or transfer of assets to family members or other persons for the purpose of circumventing the conflict of interest compliance measures as directed by the Board.

An individual participating in the network who is involved with, or has an interest in, or deals in any manner with a third party which might cause a conflict of interest, will not be present and participate in any network decisions, including committee decisions, if the declared potential conflict of interest could

influence the decision or actions of the network. It is the obligation of the individual to declare such potential, apparent or actual conflict of interest before discussions take place so that the committee or Network Board of Directors is aware of the situation in order to ensure that the individual is out of the room when the discussion and decision process on the item in question are taking place. This course of action should be recorded in the minutes of the meeting.

Any question raised by an individual or company regarding the potential conflict of interest of an individual will be raised at the Network Board of Directors level and must be documented in writing. The Network Board of Directors will determine the extent to which the question should be pursued and in such cases will consult the individual in question. If necessary, the individual will be asked to respond in writing.

4.3 Institutional Framework: Agreements

4.3.1 Network Agreement: Intellectual property Right

Release of the first installment of the award is also conditional on the signing of a Network Agreement by participating institutions that receive NCE funds. This agreement sets out the operating rules of the network and outlines the rights and obligations of its investigators and participating institutions.

The networks are expected to disseminate the results of their research activities through public sources such as publications or otherwise in a timely manner. The contributions of industrial partners to the network must, however, be recognized by allowing them preferential access to the commercial exploitation of intellectual property under terms commensurate with the extent and level of their contributions. Consistent with the program criterion on knowledge exchange and technology exploitation, the networks should make every effort to have the results of the network research exploited in Canada, for benefit of Canadians. This "Canada First" clause has significant implications for technology transfer and is discussed further in subsequent sections.

The ownership and disposition of intellectual property arising from network-funded research must be governed by the arrangements described in the Network Agreement. Intellectual property resulting from network-funded research must be promptly and concurrently disclosed by researchers to the network and the industry liaison office of the employing or contracting institution. Networks are encouraged to maximize the use of resources such as the universities' industrial liaison offices, the Canadian Technology Network (CTN), and the Industrial Research Assistance program (IRAP) to expedite the exploitation of intellectual property.

Normally, the results of research funded through public sources must be published or otherwise disseminated to the community in a timely manner. Since the NCE program encourages the transfer of knowledge and technology to the user sector, it may be necessary to obtain protection for intellectual property resulting from network-funded research prior to disclosure in a public forum. Provision for

reasonable publication delays (usually not exceeding six months), or other arrangements, may be made to avoid jeopardizing the commercial potential by premature disclosure.

Agreements made regarding the ownership of the intellectual property resulting from network-funded research must take into account the NCE objective of creating partnerships. This implies a sharing of eventual benefits between the partners commensurate with their respective contributions, as well as the sharing of costs to protect the intellectual property. The industrial partners' contributions to the network must be recognized by allowing them access to the commercial exploitation of the intellectual property under terms commensurate with the nature and level of their contributions. The arrangements with each corporate partner must be addressed in a Network Affiliate Agreement.

A key NCE program objective is to advance Canadian economic and social development. Accordingly, every effort must be made to have the results of network-funded research exploited in Canada, for the benefit of Canadians. Benefit to Canada is defined as incremental Canadian economic activity and improved quality of life in Canada. Maximum benefits would be derived from the creation of high-quality jobs in Canada, which should be an important goal of any commercialization activity.

The owners of intellectual property resulting from network-funded research, or the agent acting on their behalf, will consult with relevant stakeholders (Network administrators, universities, and researchers) on issues of commercialization. When selecting a receptor company for the exclusive license of the commercial rights of intellectual property resulting from network-funded research, the agent or owners of intellectual property resulting from network-funded research will use reasonable and thorough efforts to maximize benefits to Canada in a national and international context, including the possible development of new Canadian receptor companies.

Due diligence in efforts to maximize benefits to Canada depends in part on the nature of the research results that are being exploited, and on the window of opportunity. If there is evidence of negligence on the part of the Network in performing the due diligence, the NCE Steering Committee reserves the right to impose sanctions as it deems appropriate.

4.3.2 Funding and Internal Agreement

Prior to the release of the first installment of the award to the network, a Funding Agreement that outlines the terms and conditions for funding under the NCE program, as well as the governance structure of the network must be signed by designated representatives.

Networks receive advice and direction from Program Management on various aspects related to the networks' development and ongoing activities. They also receive advice on requirements and procedures for negotiation of Internal Agreements.

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.

5. Summaries and Implications

As a "virtual research organization", the NCE program draws together universities from across the country with industrial partners to do research in the strategic areas of Canada, and which creates research consortia with a critical mass of expertise across the country. Due to the success stories, the program has established an international reputation and the European Union and countries such as Japan, China, Sweden and France have been studying this program and modeling their own R&D program on its network concept. It is an excellent example of how government support can lead to the advancement of knowledge in a country.

The NCE program accomplishes its goal by investing in national research networks that will stimulate leading-edge, internationally competitive research in areas critical to Canadian economic and social development; develop and retain world-class researchers in areas essential to Canada's productivity and economic growth; create nation-wide multidisciplinary and multi-sectoral research partnerships that integrate the research and development priorities of all participants; accelerate the exchange of research results within the networks; and accelerate the use of these results within Canada by organizations that can harness them for Canadian economic and social development.

It is also designed to achieve the goals by not only stimulating collaboration, but also removing the traditional barriers that separate university research, industrial exploitation and the public use of research results. For these reasons, the networks involve a high degree of networking and collaboration among participating researchers, organizations and even governments, including granting councils.

The federal government's Speech from the Throne in January 2001 laid out the challenge of moving Canada from the 15th to among the top five internationally in R&D as a percentage of GDP. 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. The NCE program would play a more critical role as a new R&D model in Canada.

In Canada, the NCE model, which is built on the concept of the R&D network has been already focused and has created new words, such as "NCE-like" and even "One-stop shopping" means the NCE has distinct advantages, including the nature of its support across a wide range of R&D activities through networks from fundamental research to commercialization through applied work. Researchers recognizing the network-

oriented research environment of the NCE, are also developing their own research questions like “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, a policy researcher at the University of British Columbia, re-emphasized that the NCE has extended the unique networked research model and it is becoming the preferred way to practice science in her interview (Atkinson-Grosjean, 2001).

Having a twenty trillion won-R&D capacity as a whole, Korea is ranked at the top ten in the aspect of national R&D investment. In 2003, the Korean government spent almost six trillion won, or 5% of the government’s annual budget on its national R&D program through nineteen ministries. The Korean national R&D program is growing bigger and also requires partnerships 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.

Among its major programs, in Korea, there is a representative R&D program, Korean Centers of Excellence (COE), which as famous as Science Research Centers (SRC) and Engineering Research Centers (ERC). The COE program initiated in 1989, aims to encourage multidisciplinary collaboration being rooted in universities between academia and industry. The goal is to raise Korean research capabilities to an international level too. At present, in 2004, there are 65 Centers, which will be up to 100 in 2005. Each Center, in average, having 20 researchers is funded annually maximum one billion won for 9 years.

There are similarities and differences between the NCE and COE. From the mandates, both are located in universities; support highly experienced research teams at centers of excellence; and enhance the cultivation of competent manpower, technology transfer, academic exchange, and international cooperation. The COE, however, are smaller than the NCE in the aspects of funding, researchers, institutions, and companies. Above all, the network approach of the NCE to R&D activities and management, which can be called network-oriented R&D activities, not center-oriented, is needed the COE to look at.

The two programs are different in their R&D circumstances with its S&T culture and capacity though, some recommendations could be suggested to the COE in the aspects of the network approach, especially organizational structure, management system and institutions.

First, to promote inter-relationships between researchers and partners, the COE needs to consider a position of communication within a Center. Especially in a certain Networks of the NCE appoints a Network Business Manager to deal with partners from industry, government and other sectors for research commercialization.

Second, to be selected in the NCE competition as new Networks, the proposal has to be well-established and organized with various research partners and organizations in its research field across the country. That means the COE program might to emphasize pre-organized team work in selection and peer-review process.

Third, institutional system is crucial in forming R&D network and partnership not only for stimulate research collaboration but also get rid of conflicts of research interests and any other barriers. It is important in the case of intellectual property right (IPR) in particular. Only when their right can be protected within a system such as rules and agreements, all participants can co-work and share the research information fully

each other, and which could cultivate inter-trust and R&D culture.

There are also many other ways with which the government could stimulate R&D collaboration. Korean government could initiate a new program to form national R&D network consisting of centers of excellence across Korea. Or 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 Program³ could be an alternative choice for the government to establish a national R&D network system. And 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.

³ 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 22 big research centers, each funded at a maximum 10 billion won in a year and managed by Director of Center with its independent management policy.

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