Evaluation of the Networks of Centres of Excellence (NCE) Program

Final Summary Report

Prepared for:

NSERC-SSHRC Evaluation Division

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List of Acronyms

BL-NCE	Business Led Networks of Centres of Excellence
CIHR	Canadian Institutes of Health Research
HQP	Highly Qualified Personnel
IP	Intellectual Property
KTEE	Knowledge Transfer, Exploitation and Exchange
NCE	Networks of Centres of Excellence
NSERC	Natural Sciences and Engineering Research Council of Canada
R&D	Research and Development
SNG	Strategic Network Grants Program
SSHRC	Social Sciences and Humanities Research Council of Canada
S&T	Science and Technology
ST&I	Science, Technology and Innovation
KT	Knowledge Transfer
LOI	Letter of Interest

Executive Summary

Objectives, Scope and Methodology

The Networks of Centres of Excellence (NCE) program, established in 1989, is one of a suite of four programs managed by the NCE Secretariat to create virtual multidisciplinary and multisectoral networks designed to fund large-scale collaborative research networks and support private sector innovation. The program directly impacts researchers and organizations in universities, affiliated hospitals, affiliated institutes and industry consortia. Funded networks must comprise a Board of Directors, a research management committee, academic partners and researchers, and public and private sector partners that have provided a letter of support and/or contribution to the network. In total, 45 networks have received funding during the life of the program. There are 13 NCEs that received funding during the period under study and are included within the scope of the evaluation. The NCE program budget currently stands at $62.1 million annually.

The NCE evaluation was conducted jointly with the BL-NCE evaluation to allow for comparisons between the two programs. The evaluation of the NCE program was undertaken to meet the information needs of program management and delivery personnel (i.e., the NCE Secretariat) and to comply with the Treasury Board *Policy on Evaluation (2009)* and *Financial Administration Act* regarding evaluation coverage. The period under study is 2008-09 to 2012-13, although some of the networks that were included in the study were funded in 1999. The evaluation adhered to the Policy on Evaluation and its associated Directive and Standards relating to the core evaluation issues of relevance and performance and builds on a previous evaluation of the NCE program undertaken in 2013.

Six methods were employed for the evaluation of the NCE program by a hybrid evaluation team composed of the Natural Sciences and Engineering Research Council of Canada –Social Sciences Humanities Research Council of Canada Evaluation Division and an external firm: a document review; administrative data analysis; 12 key informant interviews and one group interview; web-based surveys with NCE (and comparator networks) researchers, partner organizations and highly qualified personnel (HQP); case studies of seven NCE-funded networks, and an analysis of allocative efficiency through five case illustrations of the actual and potential monetary benefits of NCE-funded innovation.

Summary of Findings

Relevance

The evaluation confirms the continued need for the NCE program. Demand for the program has remained strong with an increased number of applications for funding in the most recent competitions, and the network approach to research funding was found to have many advantages, fostering synergies and unique solutions to complex research problems that could not be achieved by individual researchers working in isolation. The NCE program is contributing to Canadian research and development (R&D) and innovation by providing a necessary catalyst and financial means and incentive for research collaborations to occur across sectors and disciplines. There was no evidence of duplication with other funding programs; the program is distinguished by geographic reach, scale and length of funding, and program design features. The research networks and projects funded by the networks are unlikely to have occurred in the absence of the NCE program.

The NCE program was found to be consistent with government priorities that highlight the ongoing federal commitment to R&D and innovation as key drivers of prosperity. The 2014 Science Technology and Innovation (ST&I) Strategy signals the continued federal role and priority for these investments, and underscores the NCE program's specific role in supporting the government's ST&I Strategy core principles as well as its research priorities. The program also aligns well with the strategic outcomes of the tri-agencies.

Effectiveness

The evaluation evidence indicates that the NCE program is achieving its intended outcomes.

Research, development and innovation. NCE networks have engaged many researchers and partners from various sectors. The leveraged contributions from partners (at a ratio of 1:1.2 for the NCE) demonstrate partner interest in the networks and have enhanced the overall investment of the networks in research projects.[1] The program and the networks themselves have put in place rigorous project selection and monitoring mechanisms to ensure the excellence of research which is judged by external expert panels to be of high quality. According to researchers and partners, projects funded by the NCE networks are leading to the creation or extension of knowledge.

Multidisciplinary, multisectoral and international collaborations. Multidisciplinary collaborations are actively fostered by NCE networks; NCE researchers are apt to be drawn from disciplines across the tri-agency domains. Many NCEs engage social scientists and have created discrete research areas devoted to addressing social science issues. The evaluation indicates that

[1] The ratio is based on both cash and in-kind contributions.

multisectoral collaborations, often with organizations that researchers had never worked with before, were established and included collaborations with other universities and other sectors including government, health, and non-profit and from the private sector. The collaborations are generally seen to be successful. According to the survey of NCE partners, involvement in the network seeded interest in future further collaborations with universities on research projects. NCE networks are more likely than comparator networks to feature international collaborations; NCE researchers are apt to indicate an impact on the international visibility and reputation of their research teams.

Meeting the needs of partner organizations. The NCE networks have put in place mechanisms to engage and identify the needs of partners through their governance, planning and networking activities. When they are involved in network research projects, partners are typically involved in the research definition phase and in dissemination and mobilization. A minority of network partners (about 1 in 4) do not feel their needs are being met by the network, often due to the network's finite funding/defined scope or targeting of funding, or because the longer-term horizon for network research endeavours is not compatible with industry partners' shorter-term focus. Key informant and expert panel members, while acknowledging the high quality of network-funded research, also observed that some projects may lack a strong and demonstrated linkage or benefit to policy or partner innovations.

Impacts on the attraction, training, retention and employment of HQP. For the NCE, the impact of HQP is significant and a key focus for the networks. Researchers and HQP agree that participation in the network provides benefits in terms of opportunities to conduct multidisciplinary/multisectoral research, knowledge creation and translation and to network and interact with other researchers. There is a slight underrepresentation of women among NCE HQP, though students do not indicate any participation barriers inherent to the program; during the study period, between 59% and 66% of NCE HQP each year were men. Impacts of employment could not be rigorously assessed given the sampling approach and small sample size, however, case studies indicate that opportunities provided by the networks have helped many students launch careers, both in academia and industry, suggesting more rigorous data collection on HQP employment is warranted.

Knowledge and/or technology mobilization by partner organizations. The NCE networks demonstrate broad dissemination of network research through traditional means (publications, conferences) and other means (specialized publications, social media), and researchers and partners agree that the networks accelerate the exchange of these results. Commercialization activities are also taking place mostly through patenting and licensing; almost 30 start-up companies can be traced to NCE research and development carried out during the study period[2].

[2] All reported outputs and outcomes (patents, spin-offs, publication etc.) must be produced with "network" funds.

Impacts on partner organizations and the user sector. Increasing the knowledge base of network organizations is by far the most common impact of network research and some researchers and partners (approximately 4 in 10) did not indicate any additional impacts on partners beyond increasing the knowledge base of network organizations. Approximately one-half of NCE network partners indicated that network research had a positive impact on R&D capacity and investment, on network organizations' products and services and on processes or practices (slightly fewer researchers indicated these impacts from their network-funded research project.). Qualitative evidence from the case studies captured numerous examples of impacts on partner organizations and end users, including providing highly sought-after new information, tools and processes, which advanced research and practice.

Long-term economic, social, health and environmental benefits to Canada. While a minority of partners and researchers (fewer than one in three partners and one in five researchers) were aware of impacts of network research of a longer-term nature that had already happened, there were a number of illustrations offered of economic, social, health and environmental benefits. These included, for example, economic impacts from start-up companies and new products or services, innovative solutions applied to natural hazards, public health, transportation, and patient treatment, and better informed policy discussions or development. The networks have also themselves produced offspring in the form of other research entities, networks and in the case of MITACS, a highly successful organization providing researcher internships and collaborations across academic, industry and government partners.

Efficiency and Economy

The administrative efficiency of the program is high and has been stable since the previous evaluation, suggesting that significant efficiency improvements are not required (although some concerns were expressed about insufficient capacity of the Secretariat to support the networks which was perceived to be due to turnover and understaffing during the period under study).

There is overall positive feedback on the success of the networks, particularly when there is strong and engaged leadership in place, a compelling niche that attracts breadth and balance of partners and researchers, and robust engagement of industry/partners. Key informants viewed the long-standing NCE program to be working well, although among network researcher and partner communities, knowledge of program delivery is limited and there are only moderate levels of satisfaction (particularly among partners). Management of intellectual property and reporting burden were often raised as challenges. Suggestions for improvement often focused on greater efforts for knowledge and technology exploitation and exchange and enhanced communications (e.g., sharing of success stories more broadly with external audiences, sharing of best practices among the NCE networks, and enhanced communications within networks).

The impact of the recent transition of the NCE program from a seven-year to a five-year funding cycle could not be definitively assessed. The change in the duration of the funding cycle is

relatively new and while some observers feel the timing is too short for NCEs to demonstrate their impacts, the networks currently operating under this new regime are only now submitting their applications for renewal.

Recommendations

1. **The NCE program is relevant and achieving its objectives and should therefore be considered for continued support at the federal level.** The NCE program is addressing a continued need using a network approach that has been shown to have many advantages. Demand for the program is strong.
2. **The impact of the recent (i.e., 2009) program change from a seven-year funding to a five-year funding cycle should continue to be monitored.** While there are mixed views about this adjustment to the program implementation, there is still a lack of evidence to assess the impact and to recommend any change to the current five-year funding cycle.
3. **The sharing of best practices among networks is recommended in two areas: the management of IP; and knowledge and technology exploitation and exchange (KTEE).** There are lower levels of less satisfaction with the management of IP and as it was identified as an area that is challenging for networks, it could be better supported through the sharing of best practices. NCE best practices in the area of KTEE, including tools and resources, should also be developed and shared broadly among the networks to embed and maximize translation of network research to meet partner needs. Knowledge translation is an area of strength for many networks, with tools and resources being developed by several networks to encourage mobilization of research results which could be shared and adopted by other networks.
4. **A review of the reporting requirements, with particular emphasis on the record keeping of the participation of researchers, partners and HQP in the NCE program should be undertaken to improve accuracy and consistency across networks.** Assessment of the networked approach is based, in part, on how and to what extent researchers and partners are engaged by the network. As such, these data templates should be populated with a higher degree of reliability and currency. The conduct of the survey of researchers and partners was hampered by outdated lists of program participants and would have benefited from a validation phase with the networks. Improved post-project HQP employment data would be beneficial to demonstrate NCE's role in supporting the federal government's "People Pillar."[3] Any modifications to reporting requirements will need to be balanced with a need to keep burden to a minimum, as there were lower levels of satisfaction with reporting requirements among both partners and researchers.

[3] Government of Canada (2014). *Seizing Canada's Moment: Moving Forward in Science Technology and Innovations.* Ottawa: Industry Canada.

1.0 Introduction

The purpose of this document is to present the findings from the evaluation of the Networks of Centres of Excellence (NCE) program. The evaluation contributes to meeting the coverage requirements of Treasury Board's *Policy on Evaluation (2009)* and the requirements of the *Financial Administration Act.*

1.1 Program Description

The NCE program was established in 1989 as a joint initiative of the Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC), the Canadian Institutes of Health Research (CIHR), Industry Canada and Health Canada. The NCE program is one of a suite of four programs managed by the NCE Secretariat to create virtual multidisciplinary and multisectoral networks to address challenges that matter to Canadians.[4] Although, the Knowledge Mobilization NCEs and Canada-India Research Centres of Excellence initiatives fall under the Terms and Conditions of the NCE program, these are not within the scope of this evaluation. The program aims to mobilize Canada's research talent in the academic, private and public sectors to benefit the Canadian economy and improve the quality of life of Canadians by funding academically-led research networks that directly impact researchers and organizations in universities, affiliated hospitals, affiliated institutes and industry consortia.[5] The overall NCE program goal is accomplished by investing in national research networks that stimulate internationally competitive, leading-edge, multidisciplinary research; developing and retaining world-class researchers and research mobilization capabilities; creating nation-wide and international research partnerships; accelerating the exchange and utilization of research results; and increasing Canada's international visibility and reputation.

Funded networks must comprise a Board of Directors, a research management committee and other board committees, academic partners and researchers, and public and private sector partners that have provided a letter of support and/or contribution to the network. Network funding dollars can be used to support research, knowledge and technology exchange/exploitation, development of highly qualified personnel (HQP), communications and networking activities and administrative costs. The NCE program is governed by the NCE Steering Committee and the NCE Management Committee, both of which are composed of senior officials from the tri-agencies, Industry Canada and Health Canada.

[4] Three other programs in the suite are the Business-led Networks of Centres of Excellence (BL-NCE), the Centres of Excellence for Commercialization and Research (CECR) program, and the Industrial Research and Development Internship (IRDI) program.

[5] The BL-NCE and CECR programs involve the private sector: BL-NCE networks must be led by a not-for-profit consortium of industrial partners.

In total, 45 networks have received funding during the life of the program and 14 are currently funded. Among the NCEs that received funding during 2013-14, 13 are included within the scope of the evaluation. Following a revision to the NCE program's Terms and Conditions, networks funded since 2008 have been funded for a five-year cycle with the possibility of renewed funding for up to two further five-year cycles (for the purposes of the report referred to as neo-classic networks); previous networks (classic networks) were funded for seven years with potential for another seven-year grant. The NCE program budget currently stands at $62.1 million annually. Total grant amounts were between $19.6 million and $113.2 million. Selected networks included a mix of networks based on: funding regime (classic network, 2 x 7-year term at the end of their second term and neo classic network, 3 x 5-year term at the end of their first term); science and technology (S&T) priority area/ research domain; Funding amount (<$25M, $25M^{+}) and; geographic location.

Exhibit 1.1 NCE Networks Included in the Study

Network Name	Funding Period	Funding Amount
Seven-year cycle NCEs		
GEOmatics for Informed Decisions Network – GEOIDE	1999-2013*	$45.4M
Canadian Photonic Industry Consortium – CPIC (previously called CIPI)	1999-2013*	$52.8M
Canadian Arthritis Network – CAN	1999-2014*	$55.0M
Mprime Network Inc. (previously called MITACS)	1999-2014*	$64.5M
Canadian Stroke Network – CSN	2000-2014*	$77.7M
Canadian Water Network – CWN	2001-2015	$61.0M
Stem Cell Network – SCN	2001-2015	$82.8M
AUTO21 Network of Centres of Excellence	2001-2015	$81.1M
ArcticNet	2003-2018	$113.2M
Allergy, Genes and Environment Network – AllerGen	2004-2019	$74.4M
Five-year cycle NCEs		
NeuroDevNet**	2009-2014	$19.6M
Carbon Management Canada – CMC **	2009-2013	$20.8M
Graphics, Animation and New Media Canada – Grand**	2009-2014	$23.3M

* Networks in receipt of NCE management funds to 2013-2014.

**Networks included as comparators in the 2012 Evaluation of the BL-NCE program

1.2 Objectives and Scope of the Evaluation

The evaluation of the NCE program was undertaken to: meet the information needs of program management and delivery personnel (i.e., the NCE Secretariat) and to comply with the Treasury Board *Policy on Evaluation* (2009) and *Financial Administration Act* regarding evaluation coverage. A previous evaluation of the program was undertaken in 2013: NCE Review of Relevance and Effectiveness. The evaluation builds on the previous study with a focus on the

achievement of both immediate and intermediate outcomes. The period under study is 2008-09 to 2012-13, although some of the networks that were included in the study were funded in 1999.[6] The evaluation was overseen by the Interagency Evaluation Steering Committee and managed by the NSERC- SSHRC Evaluation Division in collaboration with the CIHR Evaluation Unit, Industry Canada and the NCE Secretariat.

The evaluation adhered to the *Policy on Evaluation* and its associated Directive and Standards relating to the core evaluation issues of relevance and performance. Five evaluation questions covering Treasury Board's five core issues under the *Policy* were defined for the NCE evaluation. The evaluation questions are presented in Exhibit 1.2.

Exhibit 1.2: Evaluation Questions

1. To what extent is there a continued need for the NCE program to fund a network approach to research, development and innovation?
1.1 Is there a necessary role for the federal government in providing the NCE program?
1.2 To what extent is the NCE program aligned with federal government priorities and granting agencies' strategic outcomes?
2. To what extent has the NCE program enhanced research, development and innovation in the areas of funded networks?
2.1 To what extent has the NCE program facilitated multidisciplinary, multisectoral and international collaborations between the research community and partner organizations to address research challenges?
2.2 To what extent does the research undertaken by the NCE networks meet the needs of partner organizations?
2.3 What has been the impact of the change in duration and possible number of funding cycles on the NCE networks?
3. What impact has the NCE program had on the attraction, training, retention and employment of highly qualified personnel (HQP)?
3.1 To what extent have HQP acquired skills and experience (research, professional and international) relevant to the private, public and/or not-for-profit sectors?
3.2 To what extent are HQP employed in user sectors and research areas of the NCE networks?
4. To what extent has the NCE program resulted in long-term economic, social, health and environmental benefits to Canada?
4.1 To what extent has knowledge and/or technology been mobilized by partner organizations?
4.2 What impact has the NCE program had on partner organizations and the user sector?
5. To what extent are efficient and effective means being used to deliver the program?

[6] Note that the evaluation of the NCE program was conducted as part of a joint evaluation which included the Business-led Networks of Centres of Excellence (BL-NCE) program. Findings from the evaluation of the BL-NCE program are submitted under separate cover.

1.3 Methodology

A total of six methods were employed for the evaluation of the NCE program by a hybrid evaluation team composed of the NSERC-SSHRC Evaluation Division and an external consultant, including:

- **Document Review.** A review of NSERC-SSHRC compiled and publically available documents as well as of secondary literature.
- **Administrative Data Analysis**: Analysis of NCE financial and other data.
- **Key Informant Interviews.** Twelve key informant interviews and one group interview were conducted with program management and staff, expert panel members (including the monitoring and evaluation committee), Industry Canada, and external experts.
- **Web-based Surveys**: Surveys were conducted with NCE researchers, representatives from partner organizations[7] and highly qualified personnel (HQP) well as with their counterparts in comparator networks funded by NSERC and SSHRC. [8]
- **Case Studies**: Seven case studies were conducted. Selection criteria included funding regime (classic and neo-classic networks) and amount, S&T priority area and geographic location. Case studies consisted of a document review; integration of key administrative data; a network website review (if available); a review of available papers, articles and grey literature; and interviews with five to seven network members (lead and partners, staff, researchers and HQP).
- **Analysis of allocative efficiency:** Five illustrations were developed to provide examples of the monetized benefits of network research for NCE partner firms/spin-off companies for two case study networks.

The methodology for the evaluation of the NCE program included a comparative design component with similar programs: the BL-NCE program, the NSERC Strategic Network Grants (SNG) program and the SSHRC Major Collaborative Research Initiative and Community University Research Alliance programs. Researchers, partners (NCE and SNG only) and HQP that participated in each of these network programs were included in the web-based survey.[9]

[7] The NCE Secretariat defines a partner as an organization that helps the NCE-funded organization carry out its mandate. Partners include contributors and all other organizations that assist in other ways (i.e. research collaborations).

[8] Note that in reporting impacts of the networks, researchers responded in terms of their most recently completed/most recent research project funded by the network. Unless otherwise stated, partners responded in terms of the impact of the network overall.

[9] Comparisons across the network programs are presented in more detail in the NCE evaluation technical reports.

2.0 Key Findings

2.1 Relevance

2.1.1 Continued Need

QUESTION 1: To what extent is there a continued need for the NCE program to fund a network approach to research, development and innovation?

Key Finding: All lines of evidence support the continued need for the NCE program to fund research networks to continue to foster innovation which, in turn, drives competitiveness and quality of life. The network approach is widely perceived by key informants to have many advantages and is consistent with literature on the efficacy of the research collaborations.

The R&D and Innovation Environment

Innovation has been recognized by the federal government as being critical to productivity growth which, in turn, drives the long-term competitiveness of businesses and the quality of life of Canadians[10] and R&D "is increasingly recognized worldwide as a critical contributor to citizens' social and economic well-being"[11]. While investments in higher education R&D compare favourably to other countries and have increased since the early 2000s, commercial outcomes such as patents and licensing have not risen in tandem, suggesting that the productivity of technology transfer may be weak and declining.[12] Moreover, Canada's gross domestic expenditures on R&D have been declining, pushing its rank down from 16th position in 2006 to 17th in 2008 and to 23rd in 2011 (among 41 economies).

The overarching aim of the federal NCE programs is to mobilize Canada's best R&D talent through collaborative networks to build a more advanced, healthy, competitive and prosperous country. The programs, including the NCE networks, are thus situated at the intersection of a deficit that has been the focus of recent concern and attention.

Advantages of the Network Approach

The documentary and key informant evidence suggests that the research network approach that is a distinguishing feature of the NCE program has many advantages. The 2011 *Review of Federal*

[10] Government of Canada (2011). Innovation Canada: A Call to Action: Review of Federal Support to Research and Development – Expert Panel Report. Retrieved August 27, 2013 from: http://rd-review.ca/eic/site/033.nsf/vwapj/R-D_InnovationCanada_Final-eng.pdf/$FILE/R-D_InnovationCanada_Final-eng.pdf.

[11] Association of Universities and Colleges of Canada (2008). Momentum: The 2008 Report on University Research and Knowledge Mobilization. Retrieved August 28, 2013 from: http://www.aucc.ca/wp-content/uploads/2011/05/momentum_2008.pdf.

[12] Council of Canadian Academies. The State of Industrial R&D in Canada. The Expert Panel on the State of Industrial R&D in Canada, 2013. OECD (Organisation for Economic Co-Operation and Development). OECD Economic Surveys: Canada. Paris, France: OECD, 2012.

Support to Industrial Research and Development, for example, calls for greater collaboration among businesses, governments and the higher education sector thereby enhancing knowledge exchange, R&D risk-sharing, human resources skill-sharing, commercialization and improving access to new markets.[13] The *Federal Review* recommendation reflects broader trends evident in the literature on R&D and innovation, which commonly cites linkages between higher education institutions and other sectors as a fruitful area of effective research collaboration. Partnerships in this area are seen to allow for reduced financial risks for universities and businesses, greater research opportunities for university faculty and staff, better understanding of skills development by the private sector, and greater access to cutting edge research by competitive businesses.

Nichols *et al.* (2013) note that strong collaborative relationships between and among institutional, community, non-profit and business actors "are seen as important drivers of social change." This is in part because these collaborations bring the diversity of experience and perspectives necessary to address complex and multi-dimensional problems. These partnerships are also seen to maximize resources, reduce inter-institutional fragmentation, reduce duplication and increase overall engagement.[14] Boudreau *et al.* (2014) review of scientific advances notes that novel departures often "draw on existing knowledge, but tend to then recombine and reconfigure this knowledge in unprecedented ways, perhaps while drawing on elements of knowledge from outside domains".[15]

Key informants are of the opinion that the NCE program is contributing to Canadian R&D and innovation by providing a necessary catalyst and financial means and incentive for research collaborations to occur across sectors, disciplines and across Canada's geographically dispersed research communities, and agree that the network approach fosters synergies and unique solutions to complex research problems that could not be achieved by individual researchers working in isolation. This sentiment was confirmed in the case studies and, in particular, by the feedback from the expert panels reviewing the NCE networks.

[13] Government of Canada (2011). Innovation Canada: A Call to Action: Review of Federal Support to Research and Development – Expert Panel Report. Retrieved August 27, 2013 from: http://rd-review.ca/eic/site/033.nsf/vwapj/R-D_InnovationCanada_Final-eng.pdf/$FILE/R-D_InnovationCanada_Final-eng.pdf.

[14] Nichols, N., Phipps, D.J., Provençal, J. & Hewitt, A. (2013). Knowledge Mobilization, Collaboration, and Social Innovation: Leveraging Investments in Higher Education. Canadian Journal of Nonprofit and Social Economy Research, 4(1), 25-42.

[15] Bourdrea, K. *et al.* Looking Across and Looking Beyond the Knowledge Frontier: Intellectual Distance and Resource Allocation in Science, Accessed November 2014 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2478627

Overlap/Duplication

Key Finding: The NCE network funding program is distinguished in terms of the size and stability of the network grant, national scale and multidisciplinary and multisectoral approach. The research networks and projects funded by the networks are unlikely to have occurred in the absence of the NCE program.

In addition to the NCE program, the research funding landscape in Canada includes various other programs that fund research networks, including within the tri-agencies themselves (e.g., BL-NCE, SNG). There are also other examples of network or sector-focused research programs both federally and at the provincial level. Previous evaluations of the NCE (2013) and the BL-NCE (2012) programs found that there was limited duplication across research funding programs. Key informants confirmed that other research team/collaboration funding programs do not duplicate the NCE. According to key informants, the NCE Secretariat programs are distinguished from other programs by their size, duration, national scale, inclusion of all tri-agency research domains and focus on relevance to industry and other end users. Potential duplication and overlap among the granting programs of the tri-agencies is also addressed through their distinctive program terms and conditions.

External interviewees and staff were of the view that NCE networks would not have been established without NCE funding. Key informants argued that the geographic scale, research scope and progress of the work, as well as, the involvement of HQP would not occur at the same level in the absence of the NCE funding and administrative resources. At the level of network-funded projects, the vast majority of NCE researchers indicated that if funding had not been available for their project, it would have had a major negative impact on their project or it would not have proceeded.

Interest in the Program

Data suggests that there is a high level of interest in the NCE program within Canada's R&D community. NCE funding competition announcements have generated a significant and increasing number of Letters of Interest (LOI): the NCE competition received 32 LOIs in 2012 and 83 LOIs in 2015. (The lower number of LOIs in 2012 is likely attributable to the fact that it was a targeted call for S&T priority areas; the 2015 call did not target specific areas.)

2.1.2 Necessary Role for Federal Government

QUESTION 1.1: Is there a necessary role for the federal government in providing the NCE program?

Key Finding: Documentary and key informant evidence support the importance of the federal government role in funding research and development to foster innovation and economic growth. The federal role in funding research networks is consistent with approaches used internationally.

Canada's most recent and thorough examination of the federal role in research funding programs such as the NCE is the *Review of Federal Support to Industrial Research and* Development (2011). This report calls for the establishment of a "clear federal voice for innovation". A key recommendation of the report was for the federal government to include in its suite of supports, funding public sector or non-profit bodies conducting research of relevance to the private sector. These criteria are consistent with the characteristics of the NCE program.

The federal government recently released an updated Science, Technology and Innovation Strategy, in December 2014, to guide federal investments and priorities: *Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation 2014*.[16] The Strategy builds on the 2007 framework *Mobilizing Science and Technology to Canada's Advantage*[17], signaling a continued federal role and commitment to "keep science, technology and innovation at the forefront of government policy" in the coming years.

The updated Strategy continues to emphasize the importance of partnerships; among its tangible commitments is "support across the full spectrum of research endeavours in universities, colleges and polytechnics, including the enhancement of established networks and the fostering of new collaborations among post-secondary institutions, researchers and companies, as well as government scientists and engineers" to increase research excellence in post-secondary institutions. The NCE is specifically cited within the 2014 strategy as a key conduit for the federal government's commitment to "Enhancing public and private linkages with global innovation networks".

All external key informants agree the federal government has the mandate, neutral position and capacity to create large scale, national research networks, and must continue to play a role in research funding programs such as the NCE, recommending continued, if not increased, investment in the programs. In addition, some respondents added that the NCE program enables federal level policy priorities to be brought into research (e.g., the Arctic, environmental issues), including areas that industry itself does not fulfill.

[16] http://www.pm.gc.ca/eng/news/2014/12/04/canadas-science-technology-and-innovation-strategy

[17] Government of Canada (2007). *Mobilizing Science and Technology to Canada's Advantage: Summary*. Ottawa: Public Works and Government Services Canada.

Expert key informants noted that Canada is not alone in the national research network approach, citing examples of similar national-in-scale multidisciplinary, multi-institution or multisectoral research network programs including the Australian Research Council's Centres of Excellence, New Zealand Centres of Research Excellence, and European Union Knowledge and Innovation Communities.

2.1.3 Alignment with Federal Priorities

QUESTION 1.2: To what extent is the NCE program aligned with federal government priorities and granting agencies' strategic outcomes?

Key Finding: The objectives of the NCE program are consistent and aligned with federal government priorities and strategic outcomes of the tri-agencies.

The 2007 S&T Strategy, released as a blueprint to achieve the R&D goals outlined in the federal government's 2006 strategic economic plan, *Advantage Canada: Building a Strong Economy for* Canadians[18], aimed to foster three distinct Canadian S&T advantages: an *Entrepreneurial Advantage*, whereby knowledge is translated into commercial applications that deliver benefits to Canadians; a *Knowledge Advantage*, whereby Canadians are on the cutting edge of knowledge development and acquisition; and a *People Advantage*, which involves Canada's attractiveness as a destination of choice in the modern global economy[19]. The 2014 Strategy builds on the 2007 framework, retaining the *People* and *Knowledge* pillars from the earlier framework, and broadening the *Entrepreneurial* pillar to encompass *Innovation*.

Through investments in R&D, training of HQP and knowledge mobilization, the NCE program contributes to the Knowledge, People and Entrepreneurial/Innovation Advantages outlined in the 2007 and 2014 Strategies to varying degrees. Notably, the updated research priorities identified in the 2014 Strategy, which added a fifth priority area, advanced manufacturing, to the previously established priorities of natural resources and energy, health and life sciences, information and communications technologies and the environment priority align very well with the sectoral foci of the current NCE networks. All 13 NCE networks included in the study are aligned with one of those S&T priority areas to some degree.[20]

Successive *Speeches from the Throne* have reiterated the federal priority on R&D and innovation that is the *raison d'etre* of the NCE program. Federal Budgets have underscored that priority: in 2010, the Budget acknowledged that improvements were still needed in the

[18] Department of Finance (2006). *Advantage Canada: Building a Strong Economy for Canadians*. Retrieved August 28, 2013 from: http://www.fin.gc.ca/ec2006/pdf/plane.pdf

[19] Government of Canada (2007). *Mobilizing Science and Technology to Canada's Advantage: Summary*. Ottawa: Public Works and Government Services Canada.

[20] Five networks are aligned with the health and life sciences priority, two in information and communications, three in environmental science and technologies, and three in manufacturing/engineering. (AUTO21, which focuses on a new method of design and production using new, lighter materials for vehicles, is a prime example of advanced manufacturing.

translation/commercialization of research discoveries[21] and increased the annual budgets of the tri-agencies by an additional $32 million per year. Budget 2011 announced the creation of the Canada-India Research Centre of Excellence (CIRCE) initiative under the NCE program. Budget 2013 stressed the importance of strengthened industry-academic collaboration, a key tenet of the NCE program.[22]. Budget 2014 further confirmed the government's commitment to "world-leading research"[23], and *Economic Action Plan 2014* outlined investment in advanced research and innovation among other economic initiatives[24].

Each of the tri-agencies has a mandate that aligns with the NCE program. The NCE program addresses the innovation and knowledge translation mandates of each of the agencies and specifically falls under the following program areas of the tri-agencies: Innovation: Research Partnerships (Program 1.3) (NSERC); Connection: Mobilization of Social Sciences and Humanities Knowledge (Program 1.3) (SSHRC); and Health Research Commercialization (Program 1.3) (CIHR).

2.2 Effectiveness

2.2.1 Enhanced R&D and Innovation

QUESTION 2.0: To what extent has the NCE program enhanced research, development and innovation in the areas of funded networks?

Key Finding: The 13 funded NCE networks have leveraged and expended approximately $639M during the study period toward research and development through the engagement of over 1,000 researchers annually. The networks have put in place criteria and mechanisms to invest funding in research that is assessed by external expert panels to be of high quality. Research is leading to the creation or extension of knowledge.

NCE grant expenditures on research (including networking, communications and knowledge translation) during the study period were $292M; with partner cash and in-kind contributions of $346M, the total NCE network investment in research and development was $639M. Together, the NCE networks included in the study funded between 1,204 and 1,554 researchers annually; case studies suggest that network funding portfolios attracted PhD and Master's level researchers and professional academics to Canadian research institutes.

[21] Government of Canada (2010). Budget 2010: Leading the Way on Jobs and Growth. Retrieved August 27, 2013 from: http://www.budget.gc.ca/2010/pdf/budget-planbudgetaire-eng.pdf.

[22] Government of Canada (2010). Budget 2010: Leading the Way on Jobs and Growth. Retrieved August 27, 2013 from: http://www.budget.gc.ca/2010/pdf/budget-planbudgetaire-eng.pdf.

[23] Government of Canada (2014). Budget 2014: The Road to Balance. Retrieved February 18, 2015 from: http://www.budget.gc.ca/2014/home-accueil-eng.html

[24] Government of Canada (2014). Economic Action Plan 2014. Retrieved February 18, 2015 from: http://actionplan.gc.ca/en/blog/economic-action-plan-2014

The case studies found that the excellence of NCE network research was assured through various mechanisms, including development of comprehensive strategic plans, performance monitoring, and employing a peer review process for project selection and research publications. Some networks included international expertise to act in a scientific advisory or peer review capacity (e.g., CWN, GEOIDE, MPrime). Expert panel reviews of the networks conducted during the study period provided confirmation of NCE networks demonstrating research excellence and knowledge translation which have, realized or contributed to important economic, social and health outcomes.

Internationally recognized examples of research excellence generated and promoted through NCE networks included: the Canadian mathematics and statistics research base developed by MPrime, ranked ninth in the world; the geomatic model at NRCan, produced through GEOIDE; and a new technology in joint regeneration called BST-CarGel, developed by CAN.

NCE researchers confirmed that their network research project resulted in the creation of new knowledge (87% stated that their project resulted in this outcome) or extension/application of existing knowledge (82%).[25] While partner ratings of the impacts of the network are somewhat weaker overall, they also are most likely to indicate results in these two areas.

2.2.2 Collaborations

QUESTION 2.1: To what extent has the NCE program facilitated multidisciplinary, multisectoral and international collaborations?

Key Finding: There is strong evidence that the NCE program facilitated collaborations involving researchers from multiple disciplines to address research challenges, including representation from the social sciences. NCE collaborations are multisectoral; during the study period, over 1,700 partners from private, public, and not-for-profit sectors were engaged annually. Many NCE collaborations involved organizations that had not worked together previously. International collaborations were facilitated, enhancing the international visibility and reputation of network researchers. Collaborations are generally viewed as being successful and seeding partner interest in further collaborations with academic researchers.

Consistent with program guidelines, surveyed NCE network researchers came primarily from academia (93%). Researchers most often reported being from natural sciences and engineering disciplines (65%), followed by health sciences (31%) and social sciences and humanities (20%) (multiple responses permitted). The profile of NCE partners and HQP by discipline was similarly distributed.

Eighty per cent of surveyed researchers said that their NCE network-funded research project had resulted in multidisciplinary collaborations; a higher proportion than researchers involved in

[25] In the survey, researchers were asked about their research project that was funded by the network. For researchers that had been funded by the network for more than one project, they were asked to refer to their most recently completed project (or project nearest completion, if none of their projects were complete).

comparator network programs. A number of NCEs placed a particular emphasis on identifying and addressing social/legal/ethical challenges in their fields which they achieved through supporting social/legal/ethical issues as a discrete area of research, funding cross-cutting panels or providing researcher/HQP capacity development in this area through workshops or training.

On average, NCE network-funded research projects involved collaborations with seven organizations, drawn from a wide variety of organizations and sectors. NCE network-funded projects almost always involved collaborations among universities (98% of researchers identified a university(ies) as being involved in their project, their own and/or others), while more than one-half of researchers indicated their project involved collaboration with the private sector (53%). In some cases, the research collaborations also included Canadian governments (36%), hospitals or health care providers (28%), not-for-profits (19%), and foreign governments (a small but significant 5%). There is also evidence that *new* collaborations were established as a result of the NCE project; six in ten surveyed NCE researchers (58%) indicated that they had previously worked with only some of the organizations they were collaborating with, and approximately one-quarter (23%) indicated they had not previously worked with any of the organizations with which they were collaborating.

Based on records maintained by the networks on their network partners, during the study period, over 700 industry partners and over 1,000 partners from other sectors (e.g., hospitals, non-governmental organizations, municipal organizations) were engaged in NCE networks annually. In the case studies, it was evident that the number of partners increased for most networks over time, which, in the case of industry partners, also resulted in an important growth in partner contributions. Case study evidence revealed that NCE networks employed numerous approaches to promote collaborative research, including: organizing attractive networking opportunities such as large conferences, to attract leading researchers and industry partners; requiring that projects include a multidisciplinary research team in order to be eligible for network funding; actively seeking and establishing partnerships with industry groups and other related research organizations in Canada and abroad; requiring project leads to also co-lead on other projects in order to encourage cross-project collaboration; and forming collaborations, including joint-projects, across NCEs (e.g., between GRAND and NeuroDevNet).

In its most recent funding cycles, Canadian Water Network adopted a consortium model that more effectively linked the network, researchers and partners to improve communication, awareness and uptake of findings. A study concluded that the consortia program had a higher potential for change and innovation, and for knowledge transfer across different groups of network participants. As well, a partner-to-researcher matching forum (a secure online discussion area) was launched in which potential partners could view proposed research project summaries, discuss projects with researchers and signal their interest in co-funding. The model has allowed CWN to achieve higher leveraging ratios for research projects.

Many international collaborations were fostered by the NCE networks: half of surveyed NCE researchers (51%) and partners (48%) indicated that their project/the network had resulted in

international collaborations. Case studies indicate that NCEs actively developed international collaboration opportunities through membership in global organizations and coalitions, joint-sponsorship of international conferences, funding of international-collaborative research projects in areas of mutual interest, and funding HQPs to conduct research abroad.

The international visibility of numerous NCE network researchers was enhanced because of these collaborations; 80% of researchers indicated that their NCE network research project resulted in increased visibility and reputation of researchers involved in the project (slightly higher than comparator networks).

Overall, most NCE researchers and partners indicated that their collaborations with partner organizations were successful. Researchers indicated that the university is the lead partner for most NCE-funded project phases. The exception is during the mobilization phase when private sector and Canadian government partners – as well as hospital or other health providers and not-for-profit organizations in networks in which they are involved – played a much more prominent role. Partners indicated they played a comparatively greater involvement in the early definition phases of the project, as well as in the latter phases of the project.

2.2.3 Meeting the Needs of Partner Organizations

QUESTION 2.2: To what extent does the research undertaken by the NCE networks meet the needs of partner organizations?

Key Finding: NCE networks have put in place mechanisms to engage and identify the needs of partners by including them in their research projects in innovative and meaningful ways. Universities lead all phases of NCE network research projects; the private sector, government partners and hospitals or other health providers play a more prominent role during the mobilization stage. Networks are more apt to be seen as meeting public and non-profit needs as compared to business needs, and there is a segment of partners that do not feel the network has met their needs due to a lack of alignment with their interests or longer-term research focus of the networks.

During the study period, NCE networks included in the study engaged over 1,700 partners from private, public and not-for-profit sectors each year, including industry and other sectors (e.g., Canadian government, hospital and other health care providers and other partners), with industry partners accounting for one-quarter to one-third of network partners and the remainder drawn from other sectors. In order to foster success, networks actively sought to engage with their partners in a variety of ways. The NCE guidelines, for example, require partner representation on key governance committees. Some networks sought to bolster their industry input through the creation of committees designed to exploit partner expertise (and engage partners in a significant way), such as commercialization committees to help identify and move research to market (e.g., NeuroDevNet, CAN, MPrime, GEOIDE). Life Sciences NCE's regularly included representation of consumers and or patients in their governance structure (e.g., CAN).

According to surveyed NCE partners, just over one-half agree that the network they were involved in addressed significant research challenges that met public or non-profit organization needs (54%) and, somewhat fewer agree that the network addressed significant research challenges that met business needs (45%) (although one-quarter of partners didn't know). Almost one-half of NCE partners (47%) stated that the network addressed their organization's needs to a good or great extent. Of those who indicated the needs of their organization had not been met (n=96), partners indicated this was due to the network's limited funding, the scope of the network/network priorities did not align with their interests, or that industry/partners were not truly engaged in the network. Note that the expert panel assessments noted there were challenges for some networks in engaging certain types of industry partners such as small- and medium-sized enterprises (SMEs).

QUESTION 2.3 WHAT HAS BEEN THE IMPACT OF THE CHANGE IN DURATION AND POSSIBLE NUMBER OF FUNDING CYCLES ON THE NCE NETWORKS?

Key Finding: The evidence is limited on the impact of the change in duration and number of NCE funding cycles. Some key informants believe the initial phase should be longer. Some neo-classic network representatives stated the shorter funding cycle facilitated early planning for mobilization.

Some key informants indicated that the new five-year funding cycle created challenges for networks in their initial stage, limiting their ability to plan and establish effectively; several suggested increasing the initial funding cycle timeframe to seven years to address this challenge. Program staff also suggested extending the first cycle and re-framing the total funding period (to 7-5-3 or 6-5-4 years). Representatives from neo-classic networks included in case studies, however, were of the view that the five-year timeframe stimulated rapid start-up and early planning for renewal.

2.2.4 Impact on HQP

QUESTION 3: What impact has the NCE program had on the attraction, training, retention and employment of highly qualified personnel (HQP)?

Participation of and Opportunities for HQP

Key Finding: The NCE program trains thousands of HQP each year, typically at the Master's and PhD level. The networks have put in place varied engagement, research funding and training and development opportunities to enhance HQP research and professional skills; several networks highlight their HQP program among their greatest achievements. Researchers and HQP approve of the quality of training opportunities; researchers indicate the NCE program provides superior training in many areas.

Within the NCE program, virtually all researchers indicated that their projects had resulted in the training of HQP. Over the five-year scope of this review (note HQP data are not available for

2008-09), thousands of HQP have been engaged in NCE network-funded training opportunities; annual participation ranges from 3,071 to 4,773 students.[26]

According to NCE Secretariat administrative data, the majority of NCE HQP – approximately three-quarters – was comprised of Master's level or PhD students in each of the four years for which data was available. The remainder (between 15 to 18% each year) was comprised of post-doctoral fellows and approximately one in ten was an undergraduate student. Men were slightly overrepresented among NCE HQP, comprising between 59% and 66% of participating HQP each year during the study period;[27] BL-NCE HQP were comparatively less balanced between men and women, with men comprising between 71% - 76% of HQP annually. Approximately one-third of NCE HQP held foreign citizenship.

NCE network researchers reported that the NCE program, in comparison to other research projects they have been involved in, offers superior HQP training opportunities to conduct multidisciplinary, multisectoral research (57% indicated NCE HQP had more or much more opportunity in this area compared to other research projects) and in developing enhanced job readiness for employment with partner organizations or elsewhere in their field (50%). Almost one-half of NCE researchers (45%) felt NCE network training offered more or much more opportunity to conduct research relevant to the private sector and to interact with other HQP and opportunity to interact with private sector researchers and with university researchers (both 43%).

Case study evidence indicated most networks offered their students numerous opportunities to develop their professional skills. HQP were involved in workshops, courses, and speaker series (including online), mentorship programs, scholarships, and grants; and they attended network conferences and had exposure to consumers and internships. Some NCE HQP opportunities included international travel, and some were invited to sit on Boards of Directors in an *ex-officio* capacity. Training of HQP was seen to be a strength of the NCE program as per the reviews of the networks undertaken by expert panels.

[26] HQP are identified as undergraduate, Master's level and doctoral students, and postdoctoral fellows.

[27] This finding is consistent with the profile of NCE researchers; the majority of NCE researchers are drawn from natural sciences and engineering disciplines in which there has historically been an underrepresentation of women.

Acquisition of Skills and Experience from the HQP Perspective

QUESTION 3.1: To what extent have HQP acquired skills and experience (research, professional and international) relevant to the private, public and/or not-for-profit sectors?

Key Finding: Through their training with the NCE networks, HQP were able to participate in numerous activities that developed their research and professional skills; notable opportunities were related to multidisciplinary collaborations, the creation of new knowledge, knowledge translation and networking.

Two-thirds of NCE HQP or more indicated that their training resulted in participation in multidisciplinary research collaborations (72%) and opportunities to work with other academic researchers in the research network (67%). Almost one-half reported having opportunities to work with other students or post-doctoral fellow researchers in the research network (48%), and with other researchers in the research network (private sector partners, hospital, not-for-profit or government) (45%).

Two-thirds of NCE HQP indicated that their training gave them the opportunity to participate in projects leading to the creation of new knowledge (67%) and projects leading to the extension/application of existing knowledge (66%). NCE HQP were less likely to report having the opportunity participate in projects leading to the extension/application of existing technology (36%), projects leading to the creation of new technology (28%), and to have opportunities to contribute to economic growth for Canada (21%).

Most NCE HQP indicated that their participation in an NCE network project allowed them to develop a variety of skills including research skills, implementation of data collection/research implementation, professional skills, interpretation of findings, undertaking knowledge translation/mobilization activities and development of research protocols/methods. The qualitative data collection with HQP in case studies confirmed that through their training they were able to develop their research and soft skills, expand their knowledge, and network with fellow students, academics and industry representatives.

Overall, most NCE HQP were very positive about the quality of their research experience, rating it to be of excellent (55%) or very good (28%) quality.

Employment

QUESTION 3.2: To what extent are HQP employed in user sectors and research areas of the NCE networks?

Key Finding: Of HQP who were employed at the time of the survey, many are employed by industry. Most HQP are using the skills acquired through their NCE research project in their current positions, and about one-half say there is a good match between their current job and their field of study.

Within the NCE program almost one-half of researchers and partners (both 47%) indicated that their project (researchers) or the networks (partners) had resulted in HQP being hired by network organizations. Among surveyed NCE HQP who were no longer working on their NCE network project,[28] one-half were currently employed – many for the private sector. Most HQP indicated they were using skills acquired through participation in the network and that participation in the research network assisted them in obtaining their current position. Fifty-two percent indicated that their position was a good match with their field of study and 43% indicated their position was a good match with the network research project Among NCE partners that indicated hiring network HQP, 95% indicated they were satisfied with the overall job readiness of HQP who were trained by the network.

2.2.5 Mobilization

QUESTION 4.1: TO WHAT EXTENT HAS KNOWLEDGE AND/OR TECHNOLOGY BEEN MOBILIZED BY PARTNER ORGANIZATIONS?

Key Finding: There is broad dissemination of network research through traditional and other means (specialized publications, social media). Mobilization activities are also taking place mostly through patenting and "other" knowledge and technology exploitation and exchange (KTEE) activities, facilitated through various mechanisms and activities of the networks.

Most NCE researchers and many partners agree that the NCE network with which they are affiliated accelerated the exchange of research results among members of the network (75% and 66% respectively). Almost all NCE researchers have shared the results of their project with network organizations. Sharing of results occurs through a broad array of channels, but for NCE researchers, occurs most often through traditional media such as conferences, informal discussions, meetings and presentations (mentioned by about three-quarters of researchers or more). Two-thirds of NCE partners mentioned similar sharing channels. NCE partners indicated they were aware of sharing of results through direct involvement of personnel from network organizations in the project more often than did NCE researchers (43% vs. 33%).

[28] Note that the number of surveyed HQP that had completed their NCE projects is small (n=58) and, therefore, employment results should be interpreted with caution.

Refereed publications are by far the most often mentioned means of knowledge translation (KT) by NCE researchers (91%) and partners (54%). Indeed, during the study period, 16,498 refereed contributions were published. NCE researchers also commonly transfer their research results through non-refereed publications (51%) and, less often, through joint refereed publications (29%). Interestingly, social media as a means of knowledge translation was mentioned by 18% of NCE researchers. Researchers were less likely to indicate that their research had resulted in intellectual property agreements, patents and licenses (mentioned by 11%, 5% and 4% respectively). NCE researchers who are mobilizing their research results are working primarily with universities (92%) and to a lesser extent with private sector (35%), government (34%), not-for-profit organizations (23%) and hospital and other health providers (19%).

At the network level, one in five NCE partners indicated their network mobilized research though a network agreement regarding IP (19%), while fewer were aware of execution of non-disclosure or confidentiality agreements (14%), license agreements (6%) or patents (5%).[29]

During the period under review, NCEs recorded between 56 and 89 patents on file annually (some double-counting across years may occur as patents may be on file for more than a fiscal year prior to issue). In total, 80 patents were issued during the study period. Sixty-three licenses to industry were also granted during the study period. As well, 28 start-up companies can be traced to NCE research and development carried out during the study period.

Eight start-up companies had their genesis with GEOIDE: GeoTango, Intelli3, Lim Geomatics, MioVision, NSim, Scene Sharp Technologies, SimActive, and Trusted Positioning. GeoTango, arguably the network's biggest success story, specialized in 3D visualization and content development tools. The company was acquired by Microsoft in 2005.

The case studies showed that NCEs have designed and implemented a variety of resources to support KT including developing KT tools, workshops on KT for HQP and, in one case, an international conference focused on KT. The expert panel reviews of the networks also identified processes/models used to produce and/or mobilize knowledge as a strength of many networks, including: selection of partners with appropriate capacity, development of tools for KT, use of workshops and other events to bring researchers and partners together, use of media to communicate research results and student interns as knowledge brokers for industry.

[29] Please refer to the technical report for more specific details on translation/mobilization. See Exhibits 6.15 and 6.16.

2.2.6 Impacts on Partner Organizations

QUESTION 4.2: WHAT IMPACT HAS THE NCE PROGRAM HAD ON PARTNER ORGANIZATIONS AND THE USER SECTOR?

Key Finding: The NCE program increased the knowledge base of partner organizations and had a positive impact on R&D capacity and investment. Impacts on network organizations' products and services and processes or practices are also occurring.

NCE partners indicated that the most common impacts of the NCE networks were to increase the knowledge base of network organizations (69% of partners indicated their network resulted in this outcome). Partners also indicated that their network had a positive impact on increasing R&D capacity of network organizations (49%), and network research had led to impacts on products or services (45%), and processes or practices of network organizations (43%). NCE researchers, similarly, indicated that the most common impacts of their NCE research projects were to increase the knowledge base of the organization (62%) and R&D (35%). Interestingly, 36% of NCE partners and 42% of researchers did not indicate any further impacts on network organizations beyond increasing their knowledge base, suggesting that benefits to network organizations may be indirect or that medium- and longer-term impacts may not yet have materialized.

Qualitative evidence from the case studies pointed to numerous examples of impacts on private and public partner organizations and end users in a variety of sectors. This ranged from helping industry develop new products and processes (e.g., an enabling technology/small component of a commercializable product, or a more efficient and effective production process), to helping organizations develop more informed decisions and policies (e.g. about water management).

2.2.7 Long-term Benefits

QUESTION 4: TO WHAT EXTENT HAS THE NCE PROGRAM RESULTED IN LONG-TERM ECONOMIC, SOCIAL, HEALTH AND ENVIRONMENTAL BENEFITS TO CANADA?

Key Finding: While longer-term benefits are less likely to be evident during the study period, there are illustrations of these kinds of benefits from mature networks.

Surveyed network partners were less apt to indicate that network impacts of a longer-term nature had occurred in terms of policy, environmental or health benefits (22%-28%) than they were impacts on knowledge base and R&D (see Section 2.2.6). Partners and researchers that indicated that the network/their research project had led to longer-term economic, social, health or environmental outcomes were asked to describe these outcomes. The responses indicated a high degree of variety in the nature of impacts and reflected the breadth of research and network entities funded by the NCE program. Some examples are included in Exhibit 2.1.

Exhibit 2.1: Examples of Economic, Social, Health, Environmental Impacts

Type of Impact	Illustrations
Elevated the profile of an issue or sector (including awareness among the general public, clinicians/practitioners, policy makers)	Improved knowledge of the general public about stroke / prevention / risk factors Increased awareness among educators, school boards, parents of allergens in the environment and strategies to control them Improved environmental awareness around wildlife habitat use
Improved products/services/ processes/ practices	New technologies to measure pain, improved pain measurement processes New diagnostic tools for Fetal Alcohol Spectrum Disorder permitting earlier intervention Improved mapping of the Arctic Technological advances in manufacturing leading to productivity increases / decreased unit costs (automotive) Cost savings from innovations related to protection of property (auto theft) and resources (wildfire forest management)
Improved environmental outcomes	Better land reclamation process for oil sands mining Increased understanding and reduced environment impact of development in the Arctic Potential for safe reduction in CO_2 emissions to the atmosphere
Improved health outcomes	Improved practices for treatment of Autism Spectrum Disorder Reduced infection in hospitals that have adopted the technology developed leading to significant savings to the health care system Development of an alternative to donor corneas that are in short supply worldwide Evidence-based clinical practice in stroke resulting in tangible, measurable improvements in stroke care and improved quality of life for caregivers and survivors
Public policy / other outcomes	Protection of drinking water / improved management of water for First Nations (avoid costly sourcing of other water) Developed federal guidance documents / policies pertaining to regulatory requirements for cell therapy and gene therapy products, advanced therapy medicinal products and manufacturing processes for stem cell products and therapies. Contributed greatly to the public health policy during 2009 H1N1, building pandemic warning systems for infectious diseases.

Case study evidence confirms a variety of impacts including the creation of spin-off companies, contribution to the development of new products or services or improved productivity (GEOIDE, CPIC), and development of new treatment models or therapies (CAN). Although difficult to monetize, a series of five illustrations of the impacts of research projects funded by GEOIDE and CPIC revealed substantial actual and potential benefits in terms of direct benefits (sales, jobs / salary benefits from spin-off companies created as a result of NCE-funded innovation).

A series of more in-depth illustrations were conducted of companies that were started by or benefited from network research, These flourishing enterprises are generating economic benefits in the form of annual sales and salaries (in the order of millions of dollars annually). As well, companies are creating economic benefits indirectly through positive productivity impacts or operational savings for companies making use innovative geospatial technologies. Even greater

indirect benefits were evident in potential cost savings in the health care realm due to reduced morbidity from improved care leading to associated health care system savings. When widely applied and multiplied across the health care system, these savings can be in the order of hundreds of millions.

Finally, long-term benefits of the network are also visible in terms of off-shoot organizations that have their origins in the NCEs. This includes other research entities (consortia funded by Strategic Network Grants) and commercialization networks (GEOIDE was a pre-cursor to Tecterra). MITACS, which was originally funded as an NCE, evolved into a highly successful organization providing researcher internships and collaborations across academic, industry and government partners.

To assess return on its research investments, NeuroDevNet commissioned University of Calgary researchers to conduct a socio-economic analysis to estimate the collective annual socio-economic burden of neurodevelopmental disorders that are the focus of the network. The research suggests that the high prevalence of these disorders along with substantial lifetime needs over and above those of children without these conditions means that NeuroDevNet investments have large potential returns to society. Economic evaluations of the network's priority commercialization projects were also conducted to establish their value proposition. The return on investment of a tool for early diagnosis of Fetal Alcohol Spectrum Disorders was conservatively estimated to be more than the five-year funding of the network, if there is widespread take-up of the tool.

2.3 Efficiency and Economy

QUESTION 5: TO WHAT EXTENT ARE EFFICIENT AND EFFECTIVE MEANS BEING USED TO DELIVER THE PROGRAM?

Key Finding: The NCE program is delivered efficiently, with a low and relatively stable administrative cost. Networks leverage contributions from partners to expand their scope and research productivity. The evidence on return on investment for partners is mixed for NCE partners.

Efficiency and economy of the NCE program were examined using analyses of administrative efficiency, leveraging of partner contributions and perceptions of program stakeholders about the efficiency and effectiveness of the delivery of the program.

2.3.1 Administrative Efficiency

The ratio of operating expenses relative to the total amount of grants is a common method to evaluate the operational effectiveness of grant programs. This ratio represents the cost to deliver one dollar of grant funds awarded. Funding agencies have also commonly calculated their operating expenses as a percentage of total program expenditures.

Exhibit 2.2 summarizes the estimated operating expenses under the NCE program for fiscal years 2008-2009 to 2012-2013. The actual operating expenditures of the NCE program are not available because some expenses are assessed at the level of the NCE Secretariat, which manages four programs. The proportion of the operating costs of the NCE Secretariat which is

attributed to the NCE program was estimated using the percentage of the total NCE grant compared with the total grant NCE Secretariat.

Exhibit 2.2: Estimated Operating Expenditures of the NCE Program

Expenditures (in $)	2008-09	2009-10	2010-11	2011-12	2012-13	Total
Total Direct	$1,272,935	$1,743,363	$1,491,923	$1,826,442	$1,329,970	$7,664,633
Direct Salary	*$681,032*	*$970,738*	*$909,883*	*$900,502*	*$791,945*	*$4,254,100*
Direct Non-Salary	*$591,903*	*$772,625*	*$582,040*	*$925,940*	*$538,025*	*$3,410,533*
Indirect + Direct Non-Attributable	$854,113	$1,024,858	$983,965	$903,367	$943,060	$4,709,363
Total Admin Cost	$2,127,048	$2,768,221	$2,475,888	$2,729,809	$2,273,030	$12,373,996
Grant Funds Awarded	$68,909,490	$79,500,000	$78,171,500	$77,059,000	$68,300,000	$371,939,990
Total Program Expenditures	$71,036,538	$82,268,221	$80,647,388	$79,788,809	$70,573,030	$384,313,986
Operating Ratio (¢:$1) Expenditures to Grant Funds awarded	*3.09¢*	*3.48¢*	*3.17¢*	*3.54¢*	*3.33¢*	*3.33¢*
Operating Expenditure as a percentage of Total Program Expenditure	*2.99%*	*3.36%*	*3.07%*	*3.42%*	*3.22%*	*3.22%*

Program data indicate that the funds available for the NCE program are $371,939,990 for the funding period 2008-2009 to 2012-2013. For the same period, administrative expenses NCE are estimated at $12,373,996, or 3.3 cents per $1 of grants available.

At up to 3.3 cents per grant dollar, administrative costs of NCE are very low and similar to other programs administered by the NCE Secretariat. At up to 3.2% of total program expenditures, operational expenses are also low and similar to those of other programs administered by the NCE Secretariat. The following table shows the comparative administrative ratios for the BL-NCE, NCE and SNG.

Exhibit 2.3: Comparative Data NCE, BL-NCE and SNG Programs

Program	Administrative expenditure (in $)	Grant Expenditures (in $)	Total Administrative and Grant Expenditures (in $)	Operating Ratio (¢:$1)	Operating Expenditure (in %)
NCE	$12,373,996	$371,939,990	$384,313,986	3.3¢	3.2%
BL-NCE	$2,661,004	$48,162,343	$50,823,347	5.5¢	5.2%
SNG	$8,423,633	$165,378,989	$173,802,622	5.1¢	4.8%

2.3.2 Leveraging

Leveraging is defined as the value of the contributions made by partners in relation to funding provided by the NCE grant. The Terms and Conditions for the NCE program do not require that matching funds be obtained from partners (i.e., not pre-determined targets are set), however, partner contributions are both expected and encouraged.

For the purposes of this analysis, partner contributions during the period under study were compared to network research and administrative expenditures during this time. The amount of partner contributions leveraged by the NCE networks during the period under study is

summarized in Exhibit 2.3. These data indicate that NCE networks have leveraged partner contributions in a ratio of approximately $1:$1.2.

Exhibit 2.4: Cash and In-Kind Contributions to NCE Networks (2008-09 to 2012-13)

Program	Cash	In-Kind	Total
NCE Total Partner Contributions 2008-09 to 2012-13)	$200.7M	$145.5M	$346.2M
NCE Total Network Expenditures (Research and related (networking, commercialization, knowledge translation))			$292.6M
NCE Leveraging ratio			1.2

In terms of the return on the investment for partners, 45% of NCE partners indicated that participation in the network had been a worthwhile investment for their organization to a good or great extent. One in five (19%) said their investment had been worthwhile to some extent and 26% only to a low extent.

2.3.3 Perceptions of Efficiency and Effectiveness

Key Finding: At the network level, most partners view the NCE networks to be successful and a number of factors of success can be identified, with network leadership being key. Researchers and partners are generally less familiar with the NCE program and, therefore, satisfaction levels with the program are moderate. Management of IP was identified as a challenge.

Stakeholder Satisfaction with the Program

Based on results of the networks to date, 71% of NCE partners considered their network to be successful to a great or good extent. The large majority of NCE researchers (87%) considered their project to be successful to a good or great extent.

Among researchers and partners who indicated some familiarity with the NCE program *per se* (as opposed to the network)[30] there was limited detailed knowledge of specific aspects of the program and only modest levels of satisfaction (higher among researchers compared to partners). Between 39 and 71% of researchers and partners were satisfied with the accessibility and advice of Secretariat staff and between 39 and 70% were satisfied with the governance and financial administration guidelines. There is less satisfaction among both respondent groups with reporting

[30] NCE program satisfaction questions were administered only those researchers who were involved in network governance or committees and to partners who indicated in a screening question that they were at least somewhat familiar with the program. Nevertheless, there was a high proportion of respondents (between 6 and 19% of researchers and 34 and 48% of partners for each item) who did not provide a rating (i.e., responded "don't know").

requirements (58% and 42% of researchers and partners) and guidelines for the management of intellectual property (43% and 30%).

According to surveyed NCE researchers and partners, factors that have facilitated the performance of the network include: network leadership, network design, network project selection process and network governance structure. Management of intellectual property was least apt to be rated a facilitating factor. Notably, negotiating IP agreements was also identified as a challenge by the networks included in the case studies. The findings from the key informants and the case studies echo the survey responses, identifying success factors such as leadership and governance as well as industry-relevant project selection processes, effective integration of HQP and strategic planning/priority setting, among others.

While key informants generally perceived the NCE program to be working well, they provided a number of suggestions for improvement to the program that were echoed by surveyed researchers and partners, including a greater focus/emphasis on KT, as well as on international collaborations. Expert panels saw a need for some networks to improve reporting metrics for performance (to assess research performance, for HQP outcomes, measure mobilization), and had some suggestions for the administration of the program including: increased staffing of the NCE Secretariat, increased funding and better best practice sharing.

3.0 Conclusions and Recommendations

Following are the conclusions and recommendations based on the findings from the evaluation of the NCE program.

3.1 Relevance

As the broad R&D and innovation environment and program funding landscape has remained stable over the last five years, the evaluation confirms the continued need for the NCE program. Demand for the program has remained strong with an increased number of applications for funding in the most recent competitions, and the network approach to research funding was found to have many advantages, fostering synergies and unique solutions to complex research problems that could not be achieved by individual researchers working in isolation. There was no evidence of problematic duplication with other funding programs: the program is distinguished by geographic reach, scale and length of funding, and program design features. The research networks and projects funded by the networks are unlikely to have occurred in the absence of the NCE program.

The federal government role in funding research and development to foster innovation and economic growth was found to be important considering Canada's small and geographically dispersed research and industrial communities, and consistent with approaches used

internationally. The NCE program was found to be consistent with government priorities that highlight the ongoing federal commitment to R&D and innovation as key drivers of prosperity. The 2014 ST&I Strategy signals the continued federal role and priority for these investments, and underscores the NCE program's specific role in supporting the government's ST&I Strategy core principles as well as its research priorities. The program also aligns well with the strategic outcomes of the tri-agencies.

3.2 Performance: Effectiveness

The evaluation evidence indicates that the NCE program is achieving its intended outcomes.

Research, development and innovation. NCE networks have engaged many researchers and partners from various sectors. The leveraged contributions from partners (at a ratio of 1:1.2 for the NCE) demonstrate partner interest in the networks and have enhanced the overall investment of the networks in research projects. The program and the networks themselves have put in place rigorous project selection and monitoring mechanisms to ensure the excellence of research which is judged by external expert panels to be of high quality. According to researchers and partners, projects funded by the NCE networks are leading to the creation or extension of knowledge.

Multidisciplinary, multisectoral and international collaborations. Multidisciplinary collaborations are actively fostered by NCE networks; NCE researchers are apt to be drawn from disciplines across the tri-agency domains. Many NCEs engage social scientists and have created discrete research areas devoted to addressing social science issues. The evaluation indicates that multisectoral collaborations, often with organizations that researchers had never worked with before, were established and included NCE partners drawn from collaborations with other universities and other sectors including government, health, and non-profit and from the private sector. The collaborations are generally seen to be successful. According to the survey of NCE partners, involvement in the network and, for some partners, seeded interest in future further collaborations with universities on research projects. NCE networks are more likely than comparator networks to feature international collaborations; NCE researchers are apt to indicate an impact on the international visibility and reputation of their research teams.

Meeting the needs of partner organizations. The NCE networks have put in place mechanisms to engage and identify the needs of partners through their governance, planning and networking activities. When they are involved in network research projects, partners are typically involved in the research definition phase and in dissemination and mobilization. A minority of network partners (about 1 in 4) do not feel their needs are being met the network, often due to the network's finite funding/defined scope or targeting of funding, or because the longer-term horizon for network research endeavours is not compatible with industry partners' shorter-term focus. Key informant and expert panel members, while acknowledging the high quality of

network-funded research, also observed that some projects may lack a strong and demonstrated linkage or benefit to policy or partner innovations.

Impacts on the attraction, training, retention and employment of HQP. For the NCE, the impact of HQP is significant and a key focus for the networks. Researchers and HQP agree that participation in the network provides benefits in terms of opportunities to conduct multidisciplinary/multisectoral research, knowledge creation and translation and to network and interact with other researchers. There is a slight underrepresentation of women among NCE HQP, though students do not indicate any participation barriers inherent to the program: during the study period, between 59% and 66% of NCE HQP each year were men. Impacts of employment could not be rigorously assessed given the sampling approach and small sample size, however case studies indicate that opportunities provided by the networks have helped many students launch careers both in academia and industry, suggesting more rigorous data collection on HQP employment is warranted.

Knowledge and/or technology mobilization by partner organizations. The NCE networks demonstrate broad dissemination of network research through traditional means (publications, conferences) and other means (specialized publications, social media) and researchers and partners agree that the networks accelerate the exchange of these results. Commercialization activities are also taking place mostly through patenting and licensing and almost 30 start-up companies can be traced to NCE research and development carried out during the study period.

Impacts on partner organizations and the user sector. Increasing the knowledge base of network organizations is by far the most common impact of network research and some researchers and partners (approximately 4 in 10) did not indicate any additional impacts on partners beyond increasing the knowledge base of network organizations. Approximately half of NCE network partners indicated that network research had a positive impact on R&D capacity and investment, and, somewhat less often, on network organizations' products and services and on processes or practices. (Slightly fewer researchers indicated these impacts from their network-funded research project.) Qualitative evidence from the case studies captured numerous examples of impacts on partner organizations and end users, including providing highly sought-after, new information, tools and processes, which advanced research and practice.

Long-term economic, social, health and environmental benefits to Canada. While a minority of partners and researchers (fewer than one in three partners and one in five researchers) was aware of impacts of network research of a longer-term nature that had already happened, there were a number of illustrations offered of economic, social, health and environmental benefits. These included, for example, economic impacts from start-up companies and new products or services, innovative solutions applied to natural hazards, public health, transportation, and patient treatment, and better informed policy discussions or development. The networks have also themselves produced offspring in the form of other research entities, networks and in the

case of MITACS, a highly successful organization providing researcher internships and collaborations across academic, industry and government partners.

3.3 Performance: Efficiency and Economy

The administrative efficiency of the program is high and has been stable since the previous evaluation, suggesting that significant efficiency improvements are not required (although some concerns were expressed about the insufficient capacity of Secretariat to support the networks which was perceived to be due to turnover and understaffing during the period under study). Leveraging from partners is significant (1:1.2) and demonstrates that the network research is of interest to partners.

There is overall positive feedback on the success of the networks, particularly when there is strong and engaged leadership in place, a compelling niche that attracts breadth and balance of partners and researchers, and robust engagement of industry/partners. Key informants viewed the long-standing NCE program to be working well, although among the network researcher and partner communities, knowledge of program delivery is limited and there are only moderate levels of satisfaction (particularly among partners). Management of IP and reporting burden were often raised as challenges. Suggestions for improvement often focused on greater efforts for KTEE and enhanced communications (e.g., sharing of success stories more broadly with external audiences, sharing of best practices among the NCE networks, and enhanced communications within the network).

The impact of the recent transition of the NCE program from a seven-year to a five-year funding cycle could not be definitively assessed. The change in the duration of the funding cycle is relatively new and while some observers feel the timing is too short for NCEs to demonstrate their impact, the networks currently operating under this new regime are only now submitting their applications for renewal. The outcome of these applications, and the relative success/challenges of networks operating within the new funding cycle (as compared to the previous seven-year cycle), will contribute more evidence over time.

3.4 Recommendations

1. **The NCE program is relevant and achieving its objectives and should therefore be considered for continued support at the federal level.** The NCE program is addressing a continued need using a network approach that has been shown to have many advantages. Demand for the program is strong.
2. **The impact of the recent (i.e., 2009) program change from a seven-year funding to a five-year funding cycle should continue to be monitored.** While there are mixed views about this adjustment to the program implementation, there is still a lack of evidence to assess the impact and to recommend any change to the current five-year funding cycle.

3. **The sharing of best practices among networks is recommended in two areas: the management of IP; and knowledge and technology exploitation and exchange (KTEE).** There are lower levels of less satisfaction with the management of IP and as it was identified as an area that is challenging for networks, it could be better supported through the sharing of best practices. NCE best practices in the area of KTEE, including tools and resources, should also be developed and shared broadly among the networks to embed and maximize translation of network research to meet partner needs. Knowledge translation is an area of strength for many networks, with tools and resources being developed by several networks to encourage mobilization of research results which could be shared and adopted by other networks.
4. **A review of the reporting requirements, with particular emphasis on the record keeping of the participation of researchers, partners and HQP in the NCE program should be undertaken to improve accuracy and consistency across networks.** Assessment of the networked approach is based, in part, on how and to what extent researchers and partners are engaged by the network. As such, these data templates should be populated with a higher degree of reliability and currency. The conduct of the survey of researchers and partners was hampered by outdated lists of program participants and would have benefited from a validation phase with the networks. Improved post-project HQP employment data would be beneficial to demonstrate NCE's role in supporting the federal government's "People Pillar."[31] Any modifications to reporting requirements will need to be balanced with a need to keep burden to a minimum, as there were lower levels of satisfaction with reporting requirements among both partners and researchers.

[31] Government of Canada (2014). *Seizing Canada's Moment: Moving Forward in Science Technology and Innovations.* Ottawa: Industry Canada.